2021 MCM
Problem C: Confirming the Buzz about Hornets

In September 2019, a colony of Vespa mandarinia (also known as the Asian giant hornet) was discovered on Vancouver Island in British Columbia, Canada. The nest was quickly destroyed, but the news of the event spread rapidly throughout the area. Since that time, several confirmed sightings of the pest have occurred in neighboring Washington State, as well as a multitude of mistaken sightings. See **Figure 1** below for a map of detections, hornet watches, and public sightings.

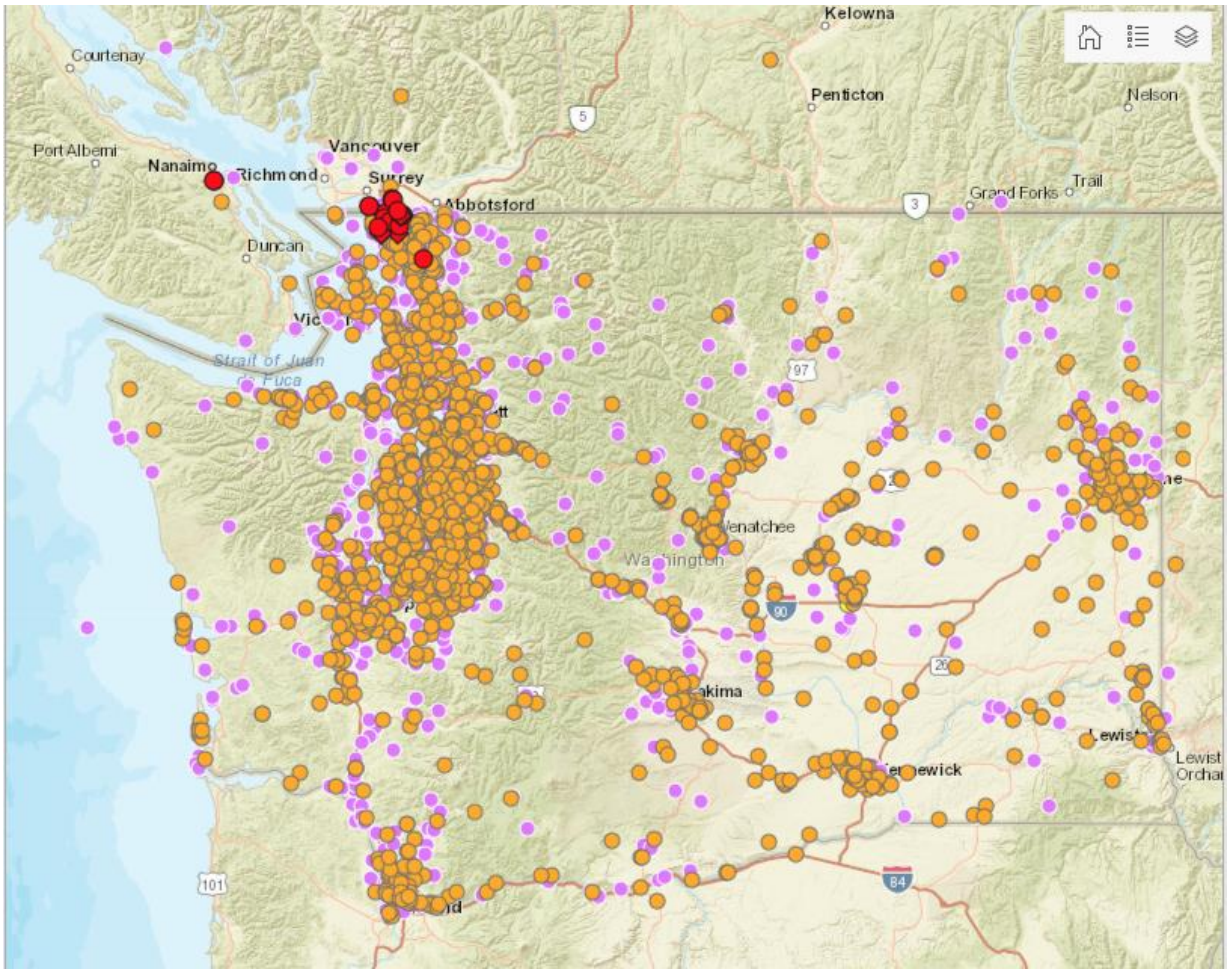

Figure 1: Map depicting Asian Giant Hornet Detections, as well as Hornet Watch and Public Siting locations.[1]

Vespa mandarinia is the largest species of hornet in the world, and the occurrence of the nest was alarming. Additionally, the giant hornet is a predator of European honeybees, invading and destroying their nests. A small number of the hornets are capable of destroying a whole colony of European honeybees in a short time. At the same time, they are voracious predators of other insects that are considered agricultural pests.

The life cycle of this hornet is similar to many other wasps. Fertilized queens emerge in the spring and begin a new colony. In the fall, new queens leave the nest and will spend the winter in the soil waiting for the spring. A new queen has a range estimated at 30km for establishing her nest. More detailed information on Asian hornets is included in the problem attachments and can also be found online.

Due to the potential severe impact on local honeybee populations, the presence of Vespa mandarinia can cause a good deal of anxiety. The State of Washington has created helplines and a website for people to report sightings of these hornets. Based on these reports from the public, the state must decide how to prioritize its limited resources to follow-up with additional investigation. While some reports have been determined to be Vespa mandarinia, many other sightings have turned out to be other types of insects.

The primary questions for this problem are “How can we interpret the data provided by the public reports?” and “What strategies can we use to prioritize these public reports for additional investigation given the limited resources of government agencies?”

Your paper should explore and address the following aspects:

- Address and discuss whether or not the spread of this pest over time can be predicted, and with what level of precision.
- Most reported sightings mistake other hornets for the Vespa mandarinia. Use only the data set file provided, and (possibly) the image files provided, to create, analyze, and discuss a model that predicts the likelihood of a mistaken classification.
- Use your model to discuss how your classification analyses leads to prioritizing investigation of the reports most likely to be positive sightings.
- Address how you could update your model given additional new reports over time, and how often the updates should occur.
- Using your model, what would constitute evidence that the pest has been eradicated in Washington State?

Finally, your report should include a two-page memorandum that summarizes your results for the Washington State Department of Agriculture.

Your PDF solution of no more than 25 total pages should include:

- One-page Summary Sheet.
- Table of Contents.
- Your complete solution.
- Two-page Memorandum.
- References list.

Note: The MCM Contest now has a 25 page limit. All aspects of your submission count toward the 25 page limit (Summary Sheet, Table of Contents, Reference List and any Appendices).

You should not make use of unauthorized images and materials whose use is restricted by copyright laws. Ensure you cite the sources for your ideas and the materials used in your report.

General Guidelines for Problem C

In addition to the specific requirements listed above please keep in mind that this is a statistical modeling exercise. Submissions are expected to adhere to best practices associated with the use of data. Some examples of these expectations include but are not limited to the following:

- Define all metrics and cost functions that you use.
- Any estimate of a parameter should include an interval estimate.
- Any result should include estimates with respect to the goodness of fit of the results.
- All assumptions should be clearly stated especially with respect to distributions associated with the data or errors.
- All assumptions associated with the data should be checked, and the robustness of a technique with respect to those assumptions should be examined.
- All assumptions associated with an approach or technique should be clearly stated.

Attachments

We provide the four following materials for this problem. THE DATA FILES PROVIDED CONTAIN THE ONLY DATA YOU SHOULD USE FOR THIS PROBLEM.

1. **2021MCM_ProblemC_Vespamandarinia.pdf**

Background information from Pennsylvania State University Extension that describes the insect.

2. **2021MCM_ProblemC_DataSet.xlsx**

A spreadsheet with 4440 reports of sightings with the following fields:

GlobalID: a unique label for each sighting record.
Detection Date: the reported date of the sighting.
Notes: comments provided by the person submitting the report. This can be a member of the public, or occasionally a state employee.
Lab Status: the official classification of the sighting by the state department of agriculture after analysis. *Positive ID* means it is confirmed as an Asian Giant Hornet. *Negative ID* means it is excluded. *Unprocessed* means it has not yet been classified. *Unverified* means no determination was made due to lack of information.
Lab Comments: what the state entomology lab added to the record after analysis.

Submission Date: the date the report was made to the state. This date can be significantly after the detection date.
Latitude (of sighting): these data are provided by the state after converting the address provided by the report.
Longitude (of sighting): these data are provided by the state after converting the address provided by the report.

3. **2021MCM_ProblemC_Files.rar**

A rar file with 3305 images submitted with the sighting reports.

The 662MB file can be downloaded from:
http://www.comapmath.com/MCMICM/2021MCM_ProblemC_Files.rar
A password is required to open the file: Af6SP7rdm33PxPJmDb4wZq7cw

4. **2021MCM ProblemC_ Images_by_GlobalID.xlsx**

A spreadsheet mapping the images to the sightings with the following fields:

FileName: the name of an image in the rar folder.
GlobalID: a unique label for each sighting record. This is consistent across the two spreadsheets.
FileType: Images arrive as .jpg, .pdf, .png, .jfif, octet-stream, xml open format, or .zip files. Videos arrive as .mp4 or quicktime files.

Reference

1. Washington State Department of Agriculture. 2020 Asian Giant Hornet Public Dashboard. https://agr.wa.gov/departments/insects-pests-and-weeds/insects/hornets/data Accessed 11/5/2020.