Software Requirements Specification

Brown Marmorated Stink Bug Monitoring Prioritization Application

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Overview

Our objective is to create a map ranking cities across Minnesota that should prioritize the monitoring and detection of Brown Marmorated Stink Bug (BMSB). There are several challenges to overcome while making this map including: familiarizing our team with the relevant indicators useful for detecting the spread of the stink bug, ensuring our chosen algorithm for monitoring the stink bug distribution is as accurate as possible while adjusting for sampling bias, integrating various data types (historical stink bug observations, high risk crop/cities areas, current human population distribution, etc.), consistently updating the map to reflect new stink bug observation data, and building autonomous code to constantly monitor stink bug distribution and rank cities.

This project is relevant to all academics who study the spread of invasive species, state and local government authorities who are in charge of public spaces or land, and farmers (since this stink bug is known for its negative impact on agricultural crops). This project will aid in the mitigation of the stink bug by mapping the stink bug's distribution across the state, and develop a better understanding of best practices for monitoring invasive species in general (which can then be applied to other studies). In general, our team will practice good commenting and documentation skills in all code and implement autonomous coding over 'hardcoding'.

Motivation

The Brown Marmorated Stink Bug is an invasive species which has been recently introduced to Minnesota. This species has caused damage (e.g. crop losses) in other states and is a concern in Minnesota, particularly in the agricultural sector. An automated system for prioritizing ongoing monitoring efforts to help identify cities in which monitoring efforts should be expanded is needed to efficiently and effectively track the spread of the stink bug. It is our goal to implement several models (the use of several models will boost our confidence in our prediction's accuracy) to predict both the probability of a stink bug's occurrence and its density throughout Minnesota. Based on the results of these models we intend to provide a ranked list of cities that should prioritize monitoring efforts.

The Minnesota Department of Natural Resources (MNDNR) and the Department of Agriculture has requested access to both the outcomes of our predictive stink bug models and our ranked list of cities for their users and other developers (accessible as both downloadable Geojson data and as a visual display on a map). Our team will develop this system with our point of contact, Shaul, from the MNDNR who will act as a design partner and provide other development support as needed.

Definitions

Brown Marmorated Stink Bug (BMSB): an invasive species originating from Asia which arrived in the United States in the 1990s and was first confirmed in Minnesota in 2010, has been detrimental to various crops (Hutchison et al.).
ETL: Extract, Transform, and Load. This is a data pipeline that moves data from the source(s) to the database in preparation for analysis
FAIR: Findable, Accessible, Interoperable, and Reusable data standards
MN: Minnesota
MNDNR: Minnesota Department of Natural Resources
QAQC: Quality Assurance and Quality Control: a built in method or review that ensures the data is of good quality by eliminating and preventing errors

Scope

Functional Requirements

Essential:

- ETL
    - Load data relevant for predictive stink bug models which may include but is not limited to: Stink Bug Survey Data, MN Temperature Averages, MN Census Data, MN Crop Land, MN City Boundaries, etc.
- Online system
    - Map of cities to prioritize for monitoring within MN
    - Map of predictive model(s) in state of MN
    - Display interface: need a software interface to host maps: Preferred ArcGIS Online
- GeoJSON formatted results available in real-time for other developers
    - Returns two Geojson files: the first returns:
        - Predicted Stink Bug distribution (probability predictions across MN)
        - Predicted count of bugs (density across MN)
            - By date (query any date range)
            - Returned at a spatial resolution of approximately 1km by 1km
            - Predictions will be replicated by at least 2 different models

    - The other Geojson file provides:
        - Ranked list of cities to prioritize monitoring and detection of stink Bugs within MN (with map of MN)
- Data and results are updated monthly

Nice to have:

- Map layer of current monitoring efforts and results

Optional:

- Areas of risk, factoring in at-risk natural resources such as crops

Non-Functional Requirements

- FAIR data standard
- Usable by someone with a high school education
- 95% uptime
- QAQC

Out of Scope Requirements

- Geographies outside of Minnesota
- User data inputs
- BMSB monitoring survey data from sources other than MN Department of Agriculture
- Any results format other than online system or GeoJSON data

Persona Acceptance Criteria

As a developer I …

- Require up-to-date ‘occurrence’ data on the BMSB so that I provide current model predictions for both the density and probability of a BMSB within a given area.
- Require extensive literature and/or examples of modeling Invasive species across a study extant so that I can provide accurate predictions on BMSB density and likelihood of occurrence.

As an end user I

- Require an online system which includes a map displaying predictive modeling for the current spread of BMSB and a ranked list of cities to prioritize monitoring efforts so that I can decide where to focus resources when considering where to expand monitoring programs.
- Require GeoJSON endpoints for the ranked list of cities and predictive models (presence/absence and density of BMSB by city).

Open Questions

- How to determine potential spread risks?
- Where can we find non-MN monitoring data and should it be taken into consideration?
- What crops are particularly vulnerable?
- What are the data quality standards of MN Dept. of Agriculture survey data?
- How often are MN Dept of Agriculture surveys (traps) checked and updated by users?
- What model(s) should be used for predicting distribution and density of stink bugs?
    - Maximum entropy
    - Interpolation
    - Others?
- What considerations are relevant in ranking cities by their need to monitor BMSB?
    - Number of traps already within a city?
    - Number (and proximity) of neighboring cities with confirmed stink bug presence?

Dependencies

- Google Cloud Platform
- PostGIS
- ArcGIS Pro
- ArcGIS Online
- GeoJSON endpoints (see appendix)

References

Hutchison, Bill, et al. “Brown Marmorated Stink Bug.” *Extension.umn.edu*, extension.umn.edu/yard-and-garden-insects/brown-marmorated-stink-bug. Accessed 9 Feb. 2022.

List of Potential Data:

MnGeo. Brown Marmorated Stink Bug Survey Data, Minnesota

MnGeo. MN Temperature Average (1961-1990)

MnGeo City, Township, and Unorganized Territory in Minnesota

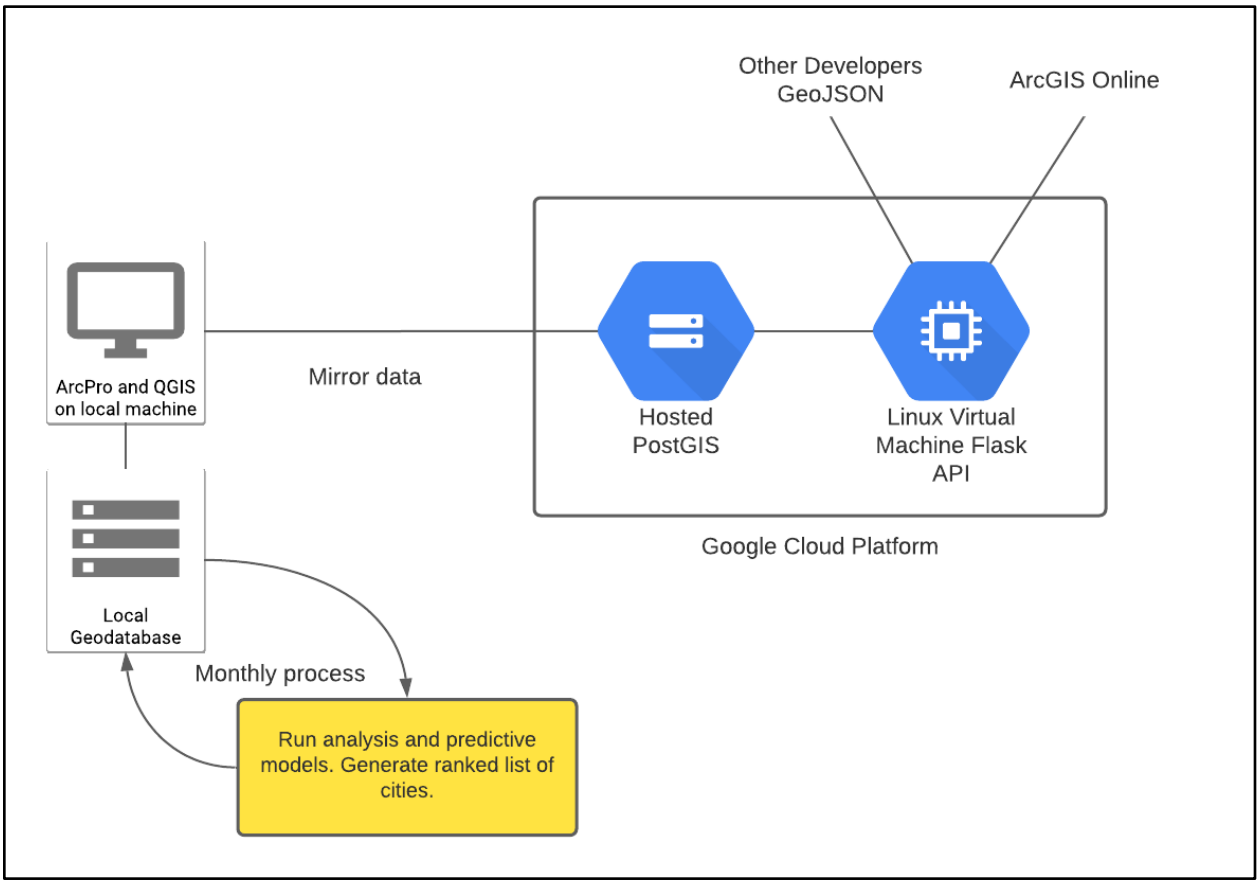
- Provides population count and boundary lines for each city and Township

MNGeo Cropland Data Layer 2020, Minnesota

- May need to locate cropland for each year since 2014 (to temporally match our stink bug data)

Appendix

Application Architecture



Example of Geojson structure

The goal for MNDNR developers is to return a group of point data that reflects the probability of a stink bug being present (‘prob_stinkbug_pres’) and the predicted density or number of stink bugs ('pred_density_stinkbug’) in a given location. All based on the results from our predictive models.

We also plan to return a list of ranked cities (ranked based on the cities that should most prioritize stink bug monitoring) in a geojson format for MNDNR developers. The structure is the same as the below example (point data with date associations, city name, and rank properties).


```
{
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {'prob_stinkbug_pres': 0.01 ,'pred_density_stinkbug': 10, ‘date’: 01-01-2022},
      "geometry": {
```

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        "type": "Point",
        "coordinates": [
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          45.04635929200553
        ]
      }
    }
  ]
}
```