Integrative Spatiotemporal Risk Maps of Fruit Flies

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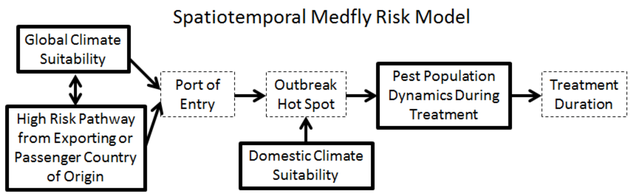
Year after year there are new fruit fly incursions in the US. Thus far in 2015 there have been 7 new incursions in California, Florida and Texas. While incursion patterns display considerable periodicity, predicting when and where pest entry and the resulting incursion is likely to occur can tremendously benefit regulatory agencies at the port of entry and in the field. We propose an integrative spatiotemporal framework to model new fruit fly incursion based on historical trends, state of the art models, and the best available data.

The Game Plan

We first came up with a conceptual model for fruit fly entry, identifying two important factors that likely drive fruit fly incursion, air passenger travel and global fruit fly populations. We then began working with

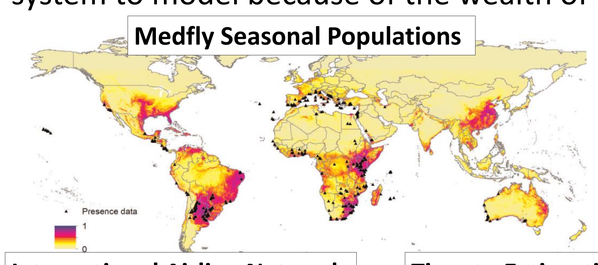


experts and datasets that could be useful for modeling and validating the incursion process:

- Spatiotemporal Pest Population Dynamics – Anna Szyniszewska
- Air Passenger Pathway Model - Anna Szyniszewska and Kevin Bigsby
- Pest Extirpation Model – Nick Manoukis
- Genetic Barcoding – Raul Ruiz

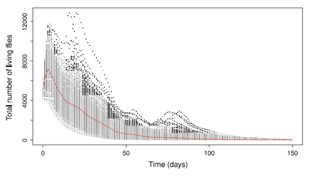
Next, we converged on Medfly as an ideal system to model because of the wealth of data.

Medfly Seasonal Populations



International Airline Network

Time to Extirpation



Spatiotemporal Pest Population Dynamics

Thus far population dynamic models have been developed for three distinct time periods throughout the year. This has been accomplished by Anna S. using observed data on Medfly from 43 countries and over 2,000 unique occurrences to model the population distribution using MaxEnt. This analysis will be revised as able to generate at least 4 distinct time periods or one population model for each month of the year. Thus, examination of additional covariates and more species occurrences are necessary. Currently the covariates are: Average LST, Average LST of the coldest month, Average LST of the warmest month, Elevation, Precipitation of the wettest month, Precipitation of the driest month, Average NDVI.

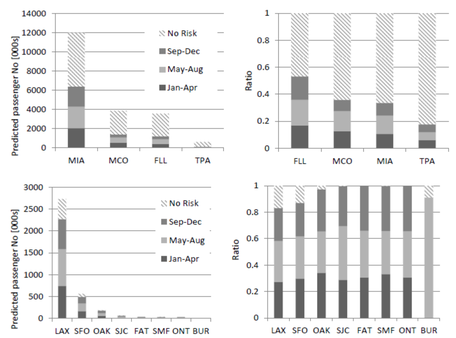
Pest Population Maps - Goals

August 2015	January 2016	October 2016
3 Distinct Periods	Analyze new data	4 Distinct Periods

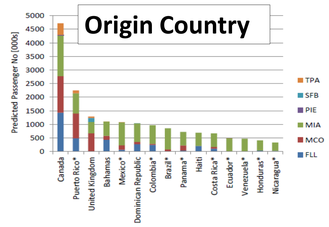
Airline Passenger Pathway

To date Anna S. has modeled the flow of airline passengers from many countries to the major airports in Florida and California for different times of the year. They provide a unique metric that captures the seasonal Medfly population levels in origin countries to create an origin risk indicator. This analysis essentially adjusts the number of passengers arriving based on the pest population in the origin country.

Passenger Volume



Origin Country

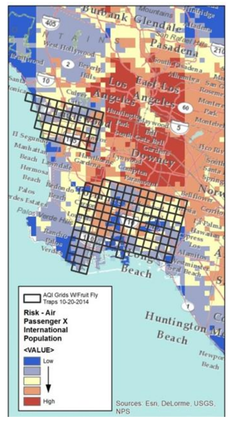


Testing Seasonal Pest Population Dynamics and Airline Passenger Pathway as the Drivers of Incursions

Even though the link between airline passenger data and global seasonal populations seems to be the main driver of new introductions, fruit fly biology and other factors could complicate this relationship. For example, there could be a time lag between the global population dynamics and new entries. To test this relationship we will generate statistical models of fruit fly entries using EAN and AQI data as the dependent variable. We will analyze the independent variables beginning with population dynamics from the same time period as the passenger volume. This analysis will be expanded to included previous time periods, the risk rating of the country, outbreak hotspot proximity to urban area, time since new introduction, competition with other fruit fly species and other factors hypothesized to correlate with entry.

Introduction Hot Spots

We will also map the likely introduction locations of Medfly using data on the location of high risk features. For example, we will build hot spot maps using data on the location of international populations, transport infrastructure, and other high risk features. This analysis will be used by fruit fly survey specialists to help better determine survey locations.



Validating the Spatiotemporal Model

Raul Ruiz and Norman Barr have developed a Medfly DNA barcoding database that identifies the world region of origin for many Medfly interceptions. This database will be used to validate the pathway model. Specifically, we will use these data to:

- Map the historic origin location of Medfly for different times of year for different years
- Compare DNA database to the Pathway Model
- Use DNA database as covariate in pathway model

Fruit Fly Forecasting Reports

Spatiotemporal risk maps will be used to identify high risk ports of entry and hotspots for different times of year. In the US there are over 150 international airports accepting foreign passengers. Customs Border Protection is responsible for inspecting passenger baggage to prevent new fruit fly incursion. The Forecasting Reports will include maps that depict the likelihood of Medfly entry for each airport, a ranking of the highest risk countries based on global pest population model and significant changes in pattern from the previous report. The primary goal of these reports is to help CBP efficiently deploy resources to meet the increased risk at particular airports at particular times of year. In addition to the ports of entry, maps will be created that identify hotspots, where introductions are likely. The Forecasting Reports will make use of live climate data and air passenger data and the best models for pest entry.

US Ports of Entry