# Modelling the Risk of Spread of Emerald Ash Borer in Ohio

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## Talk Outline

- Quick background of EAB
- Overview of EAB spread so far
- Background/review of the modelling technique
- Model weighting issues
- Modelled risk maps for Ohio
- Discuss utility vs. validation issues

I'll start by giving a brief background of EAB

# Background

- First discovered in North America in June 2002 killing trees in Detroit and neighboring Windsor, Ontario
- Native to Russia, China, Japan, Korea
- Perhaps imported in ash crating or pallets to Detroit in the early 1990s
- Moves long distances in ash logs, firewood, and nursery stock and maybe even cars
- Kills stressed or healthy ash trees in 2-4 years

Many of you may know most of these….

These are the visible symptoms of infestation…

Reduced foliage leading to the death of the ash tree.

# Our Role in EAB Research

- Estimating ash quantity in the eastern US
- Estimating EAB abundance by year
- Modelling the risk of spread
- Quantification of visual parameters to assess ash health

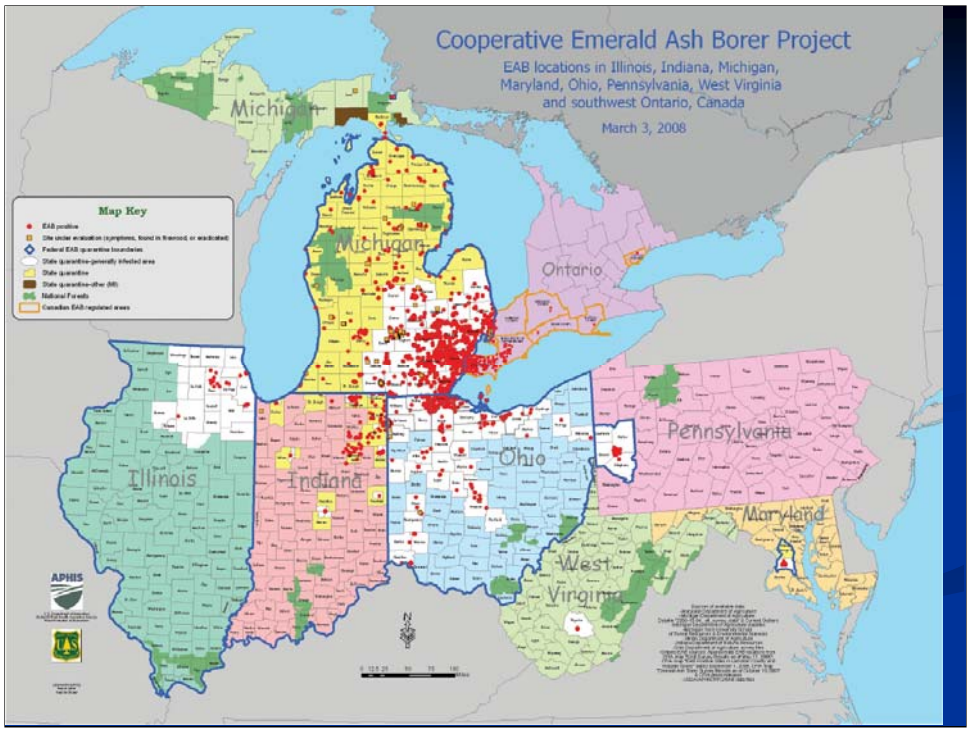
Lot of resources have been put to controlling this beast with limited success. Our role in EAB ….

…of spread – which I'll be primarily talking about today…

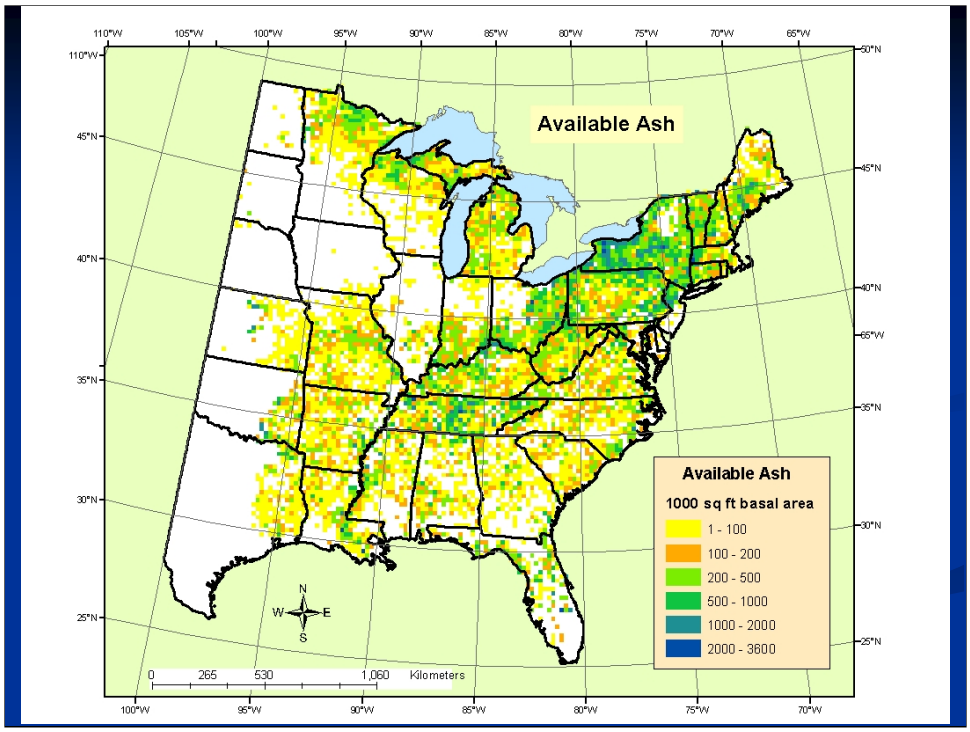
Matt Peters who is here, has worked on scoring symptoms…

So far assessment of health of infested trees are based on subjective visual surveys….this effort

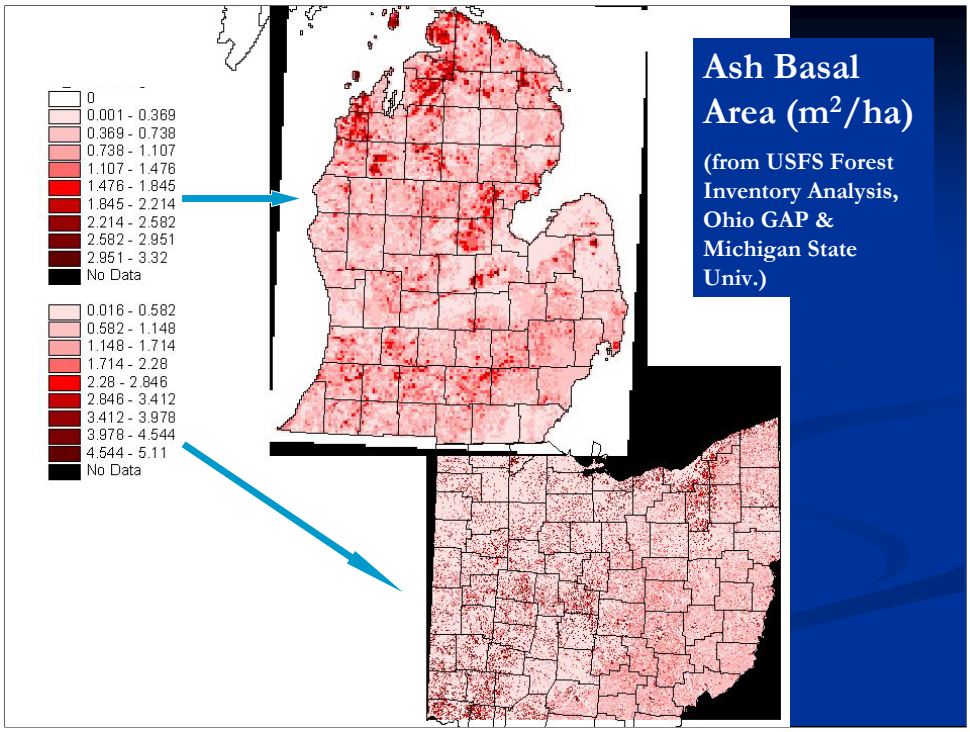
rates tree health based on quantification of visual parameters. (Degree of EAB Infestation) -> For urban streets/parks (not dense stands)



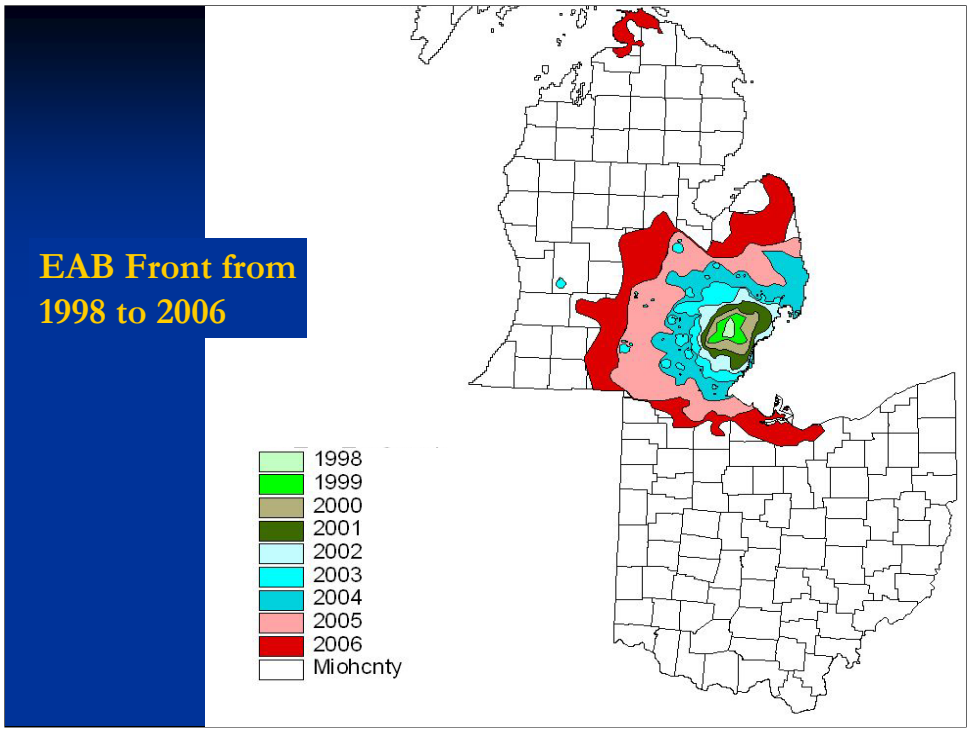

Well where are the bugs are known to be at present - has spread and made some leaps..




There is not much chance that EAB will run out of food in the eastern US. Based on FIA data, we were able to estimate the basal area of ash in the eastern US. This is potentially the food available to EAB.




We compiled the ash basal area, an input to our model on a finer scale for Ohio and Michigan using finer scale FIA data, Ohio GAP analysis and data from Michigan State.

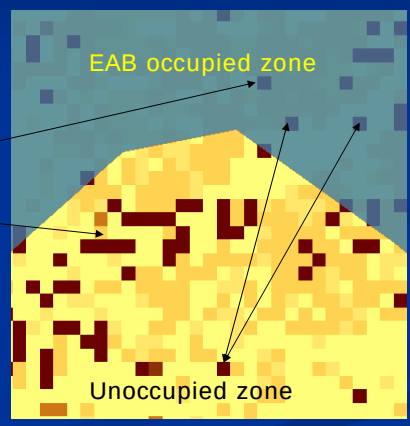



We are tracking the movement of the EAB front from which we estimate years since colonization which gives us an estimate of EAB abundance - we have compiled the front from 1998 to 2006

# SHIFT model for EAB spread

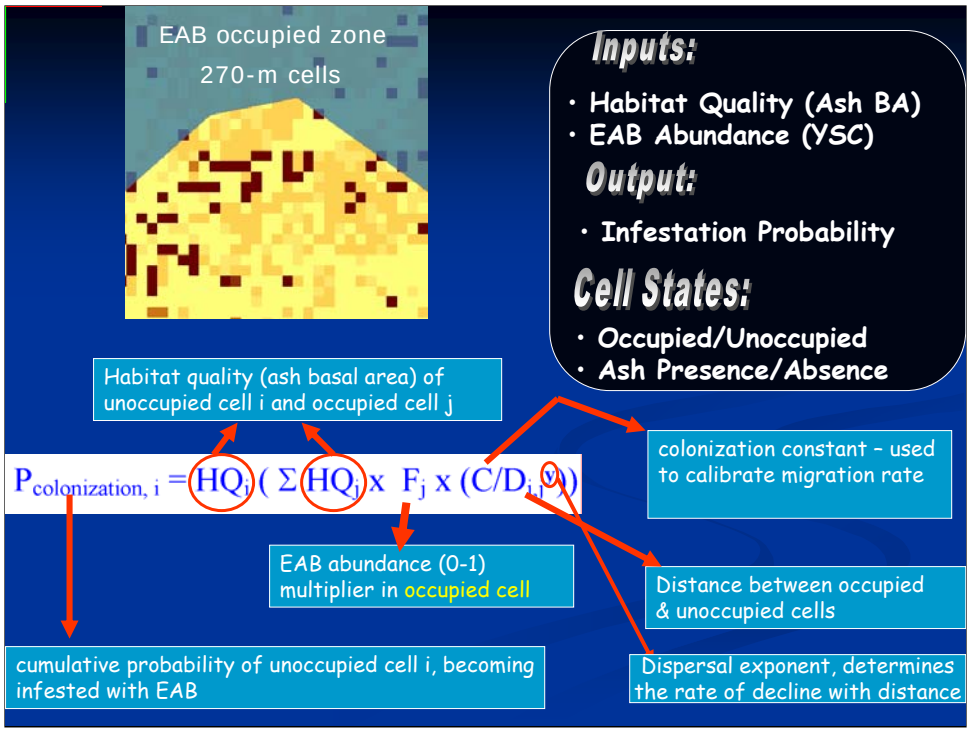
## (spatially explicit cell-based model, with an element of stochasticity)

- Calculates the probability of infestation of currently unoccupied cells based on:
- abundance of EAB in occupied cells,
- habitat availability of ash, and
- distance between all occupied and unoccupied cells in a search window (40-400 km in our example)




270-m cells

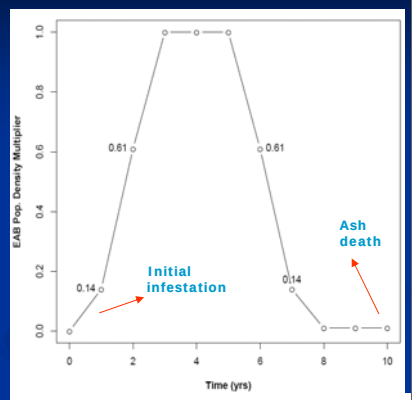
Ash basal area and the EAB abundance are inputs to our spatially explicit cell based model of EAB spread….



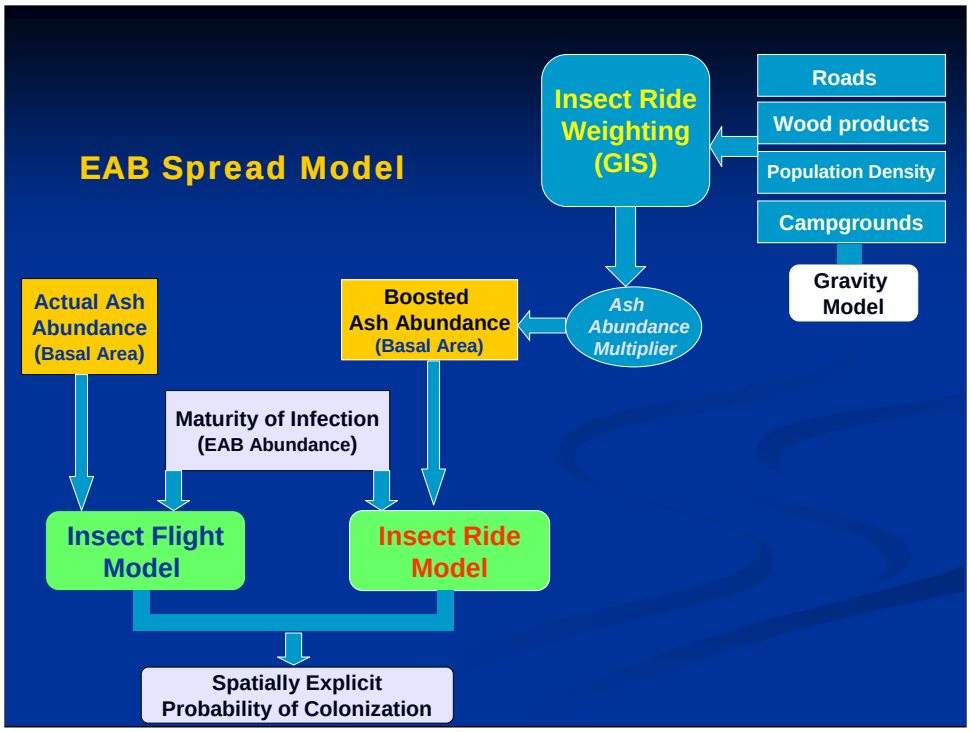

Some more details about our model ….we have the habitat quality

## Updating EAB Abundance

- Update EAB abundance and infestation probability each year (one generation) based on an assumption of an 10-year cycle between initial infestation and complete death of ash
- Start the infestation counter when cell has detectable EAB and use a search window to look for occupied cells
- Once infested, the cell starts a 10 year EAB cycle until ash dies out
- The infestation probability (0-1) for each unoccupied cell is summed across all occupied cells within the search window at each generation. If cell gets > 1, it is considered infested
- For cells with < 1, a random number between 0-1 is chosen and the cell is declared infested if that number is > than the cell sum, adding an element of stochasticity
- These newly infested cells contribute to the infestation prob. of unoccupied cells in the next generation



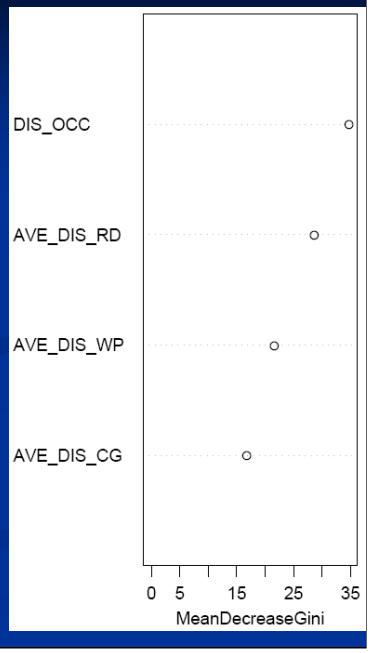

$$P_{colonization,\,i} = HQ_i\,(\,\Sigma\, HQ_j \times F_j \times (C/D_{i,j}^{y}))$$



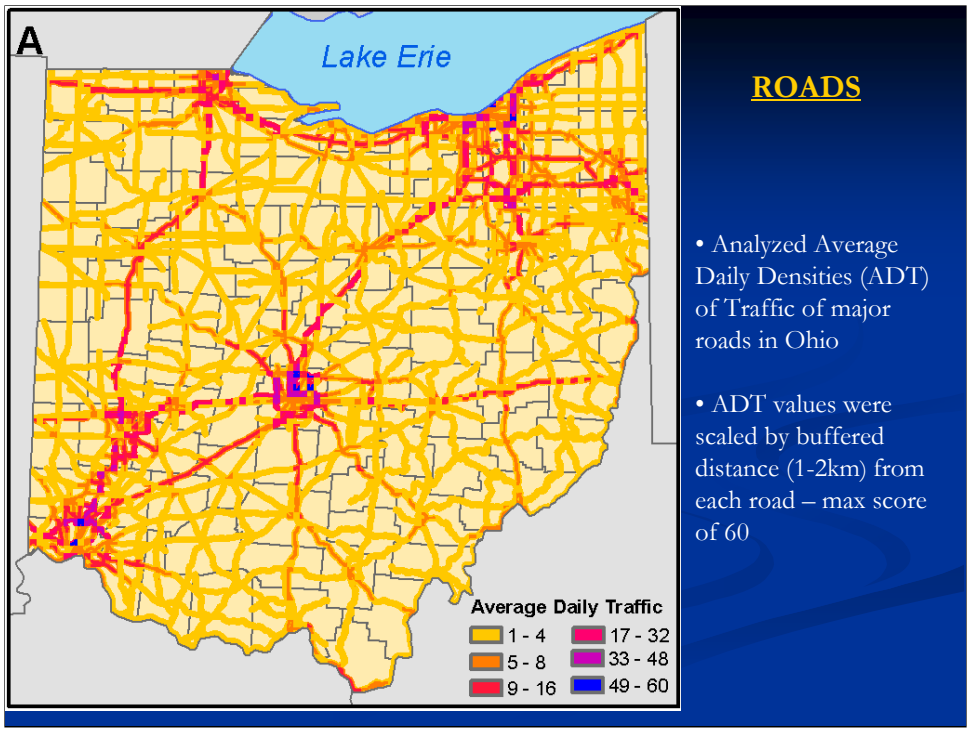

Our spread model has of two major components -> the insect flight model that spreads EAB according to the flight characteristics of the insect and the Insect Ride model where the insects spread is facilitated by various human agents like roads, … The inputs to the model are ash abundance (ash basal area) and the EAB abundance. These insect ride agents are weighted in a GIS and modifies the ash abundance thru a multiplier. The output is the probability of colonization in each cell. It is common knowledge that the EAB spread are being facilitated by these human agents and our model estimates the risk of spread in these non-core or outlier areas in addition to the core area that the insect flight estimates. Our major challenge was how to weight these components. I'll discuss that in the next few slides….

# Insect Ride Weighting Scheme

- Get average distance to roads, wood products, campgrounds and occupied (core area) zone from the both the EAB positive trees and non-positive detection trees for the outlier (non-core) zone.
- Take a stratified random sample by each county for the outlier positives (255) and a random sample of non-positive detection trees (9964) in a 1:3 ratio.
- Do a decision-tree based "RandomForest" statistical classification and test the importance of these predictors
- Test significance of these factors for insect spread and obtain some weighting guidelines.




Our hypothesis demanded that we test the importance and weight the various human agents facilitating the spread.




So how did we weight the insect ride components?
Based on the RF analysis, distance to “core” infected area is important .

To explore the importance of primary traffic patterns wrt the spread of outlier colonies…

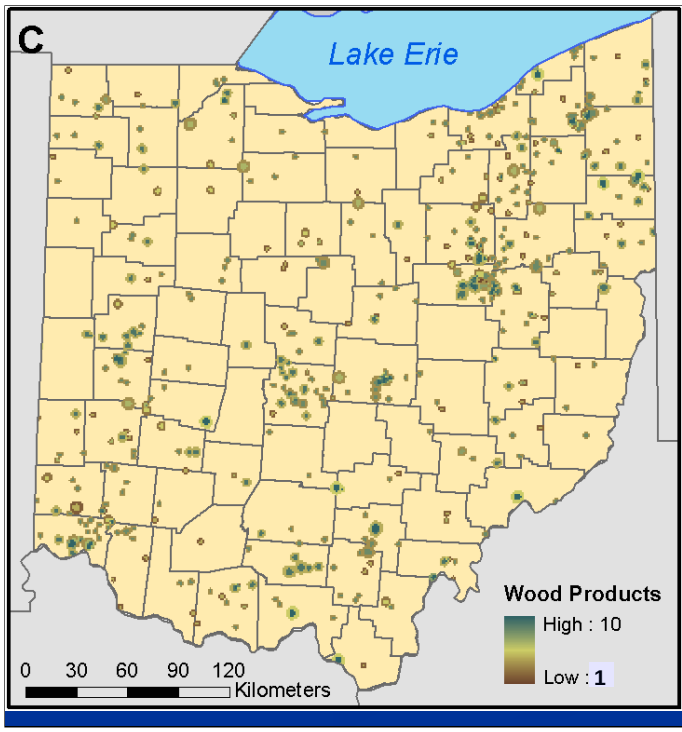
There are 8 major highways leaving the core EAB area. We allowed drivers to take one turn off to any major roads along this route…

**CAMPGROUNDS**

- Gravity model is used to assess people's movement to campgrounds (241) based on the distance and number of sites from EAB infested zip codes.
- We scaled the gravity model's weights by buffering the campgrounds (0-4km) based on the number of campsites – max weight of 20

Campgrounds assist EAB through movement of firewood….

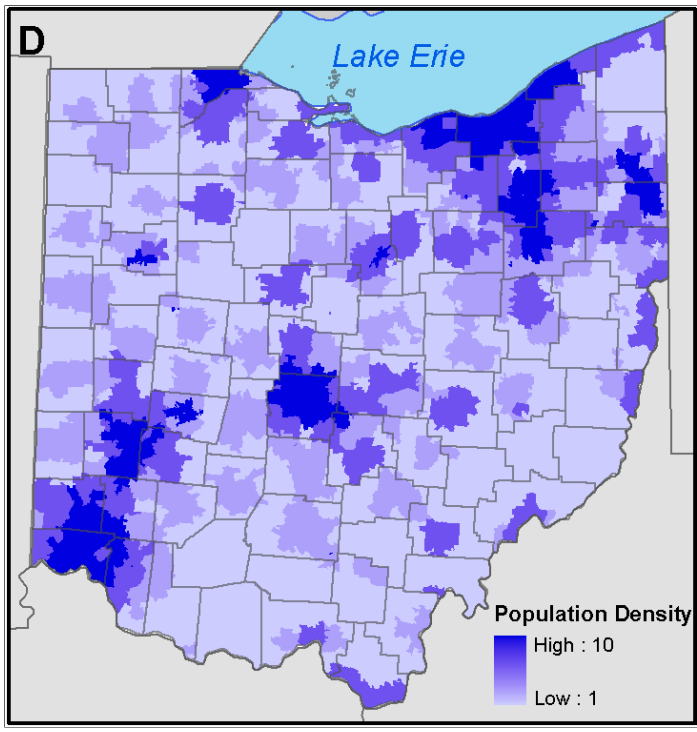
Campgrounds are increasingly well regulated




**WOOD PRODUCT INDUSTRIES**

- Assessed industries based on the amount and status of ash used and scaled the weights by buffering sites (0-4km) based on the size of the facility.

Historically very important source of EAB infection…
Unlikely to be a major source as these industries are tightly regulated – score of 10.

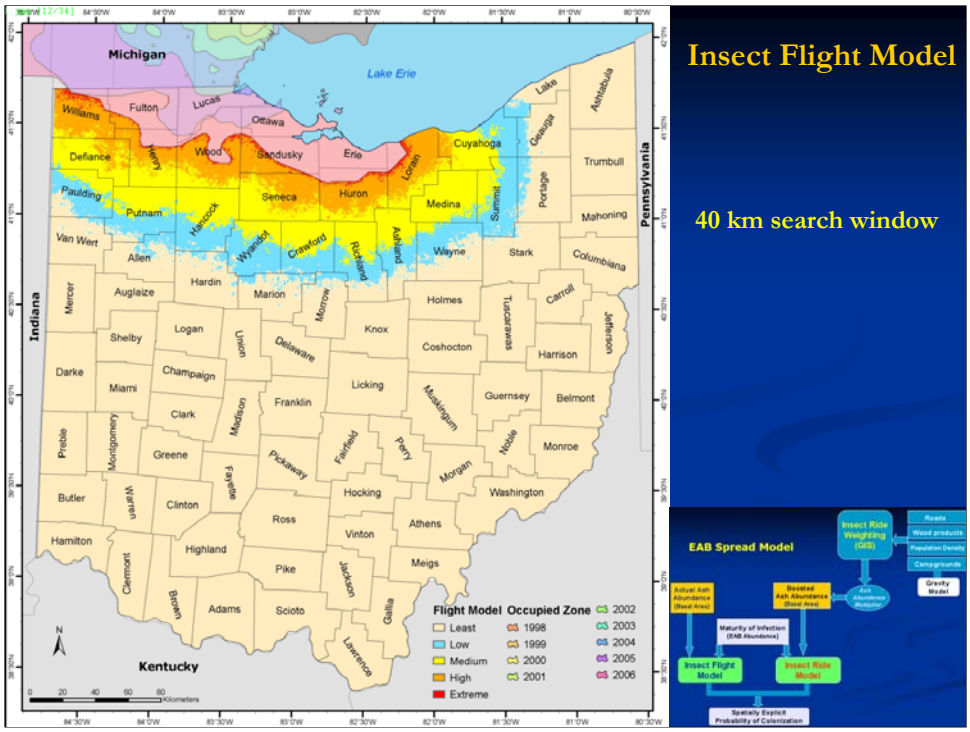



## POPULATION DENSITY

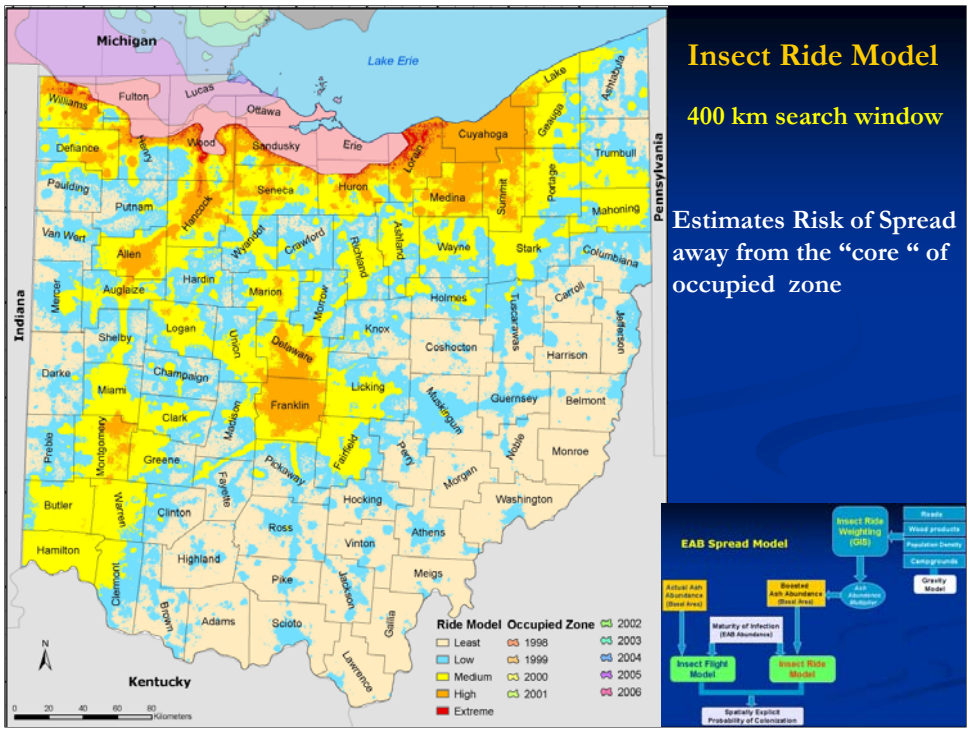
- Although road densities and ADT are good surrogates for pop. density, we used it to capture areas where they do not reflect human assisted movements.
- Max. score of 10

## Quarantined Counties in Ohio (in pink)

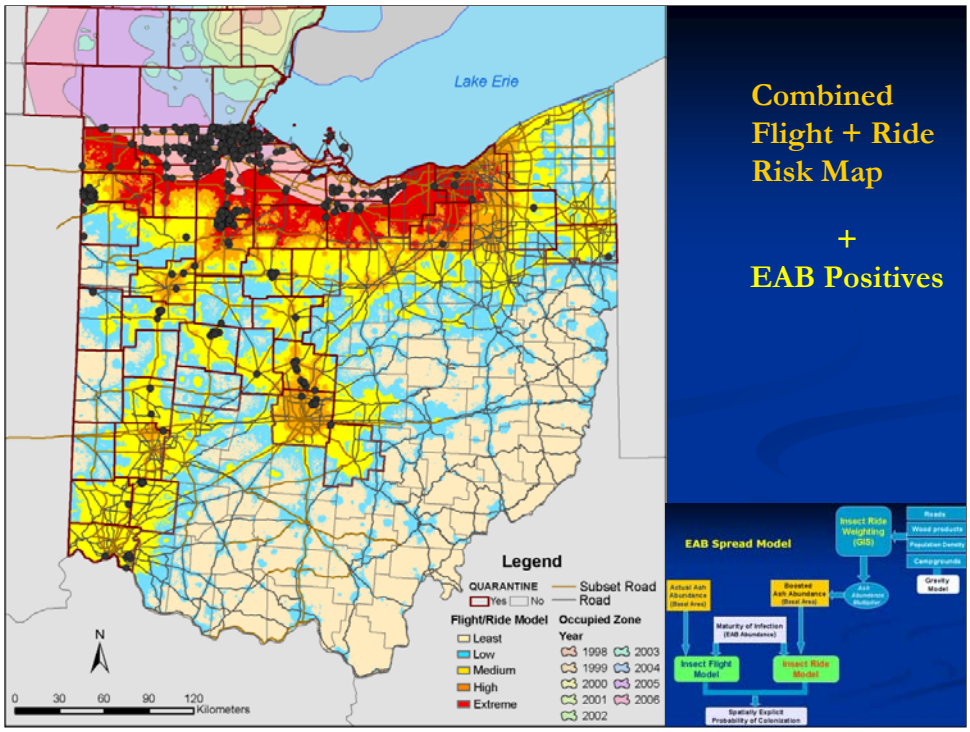
- Once county is quarantined, ash is legally allowed to be moved only within the county or to any other adjacent quarantined counties.
- We modelled the risk of spread within quarantined counties to be twice that of non-quarantined counties



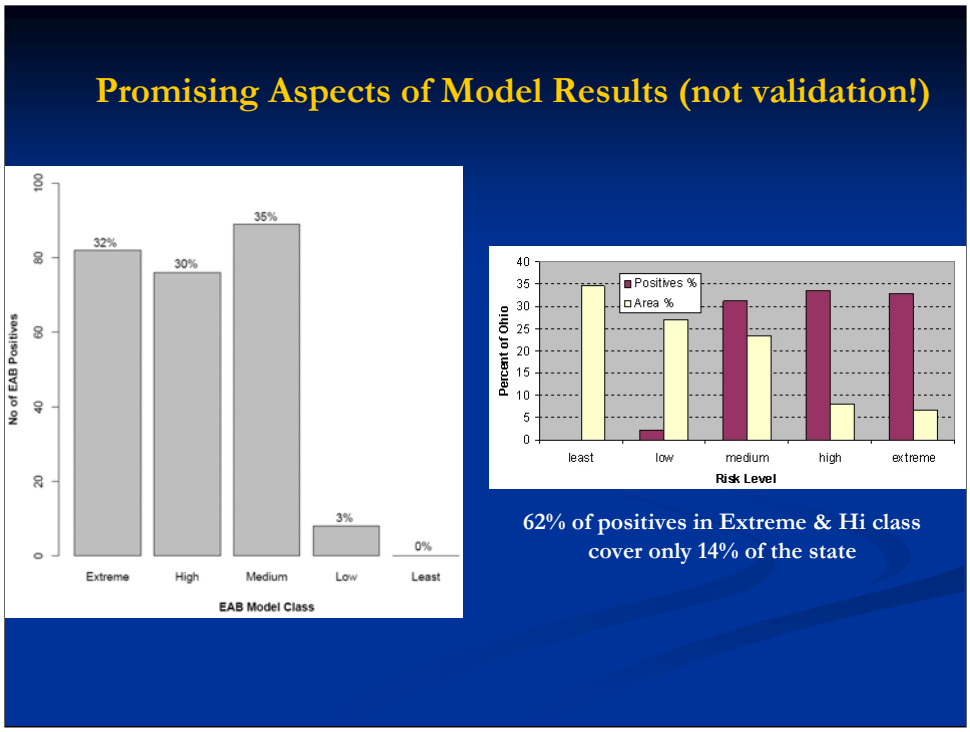

Left to its own resources, this is perhaps close to what the spread would be…



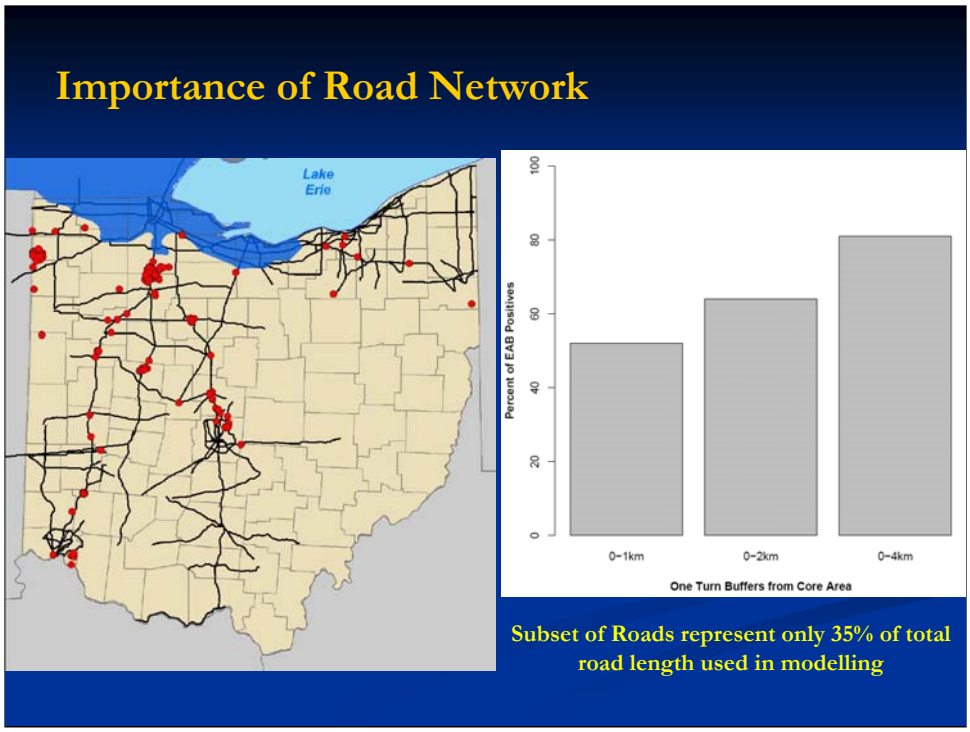

With the insect ride, the risk spreads farther. Notice that the dark reds = extreme are confined mainly to the core infested areas….




More dark red when we add the two….




Now, here are some nice….I'm tempted to call this is validation …but it is not strictly so…




We want to highlight and stress the importance of road networks to EAB movement

Our RandomForest analysis showed the importance of Distance to Occupied zone…so we

In order to explore the importance of primary traffic patterns wrt to the spread of the outlier eab, we subset 8 major highwas leaving the core area from Detroit. We allowed drivers to take one turn to any major road along this route….

## Validation vs. Utility

- Aspects of our model results are artifacts of our "EAB-positive-location" influenced weighting scheme - problematic to validate.
- However, we used a robust statistical technique, RF to test the importance & give insights for weighting the ride model.
- Currently creating a wall-to-wall map of risk in Ohio based just on the RF model to compare it to EAB-SHIFT – show "cell-based-front-moving-model-incorporating stochasticity" is better than just a robust statistical model for predicting EAB positives.
- Run EAB-SHIFT backwards in time to test if the model is predicting infestation better than more subjective/simple methods.
- Model is very CPU intensive – takes a 3-4 days to run just 10 reps with 10 different computers!

- We strongly believe that our model is of practical use to on-the-ground folks trying to deal with this menace based on uncertain information.
- Our model helps locate areas of high risk and allow managers to focus on areas where the infection is most likely to occur.
- Will give state/county agencies some basis to decide where to locate traps or detection trees.
- Hopefully will help researchers in sample design.
- Will validate/un-validate itself over the years as EAB inevitably spreads across the U.S!

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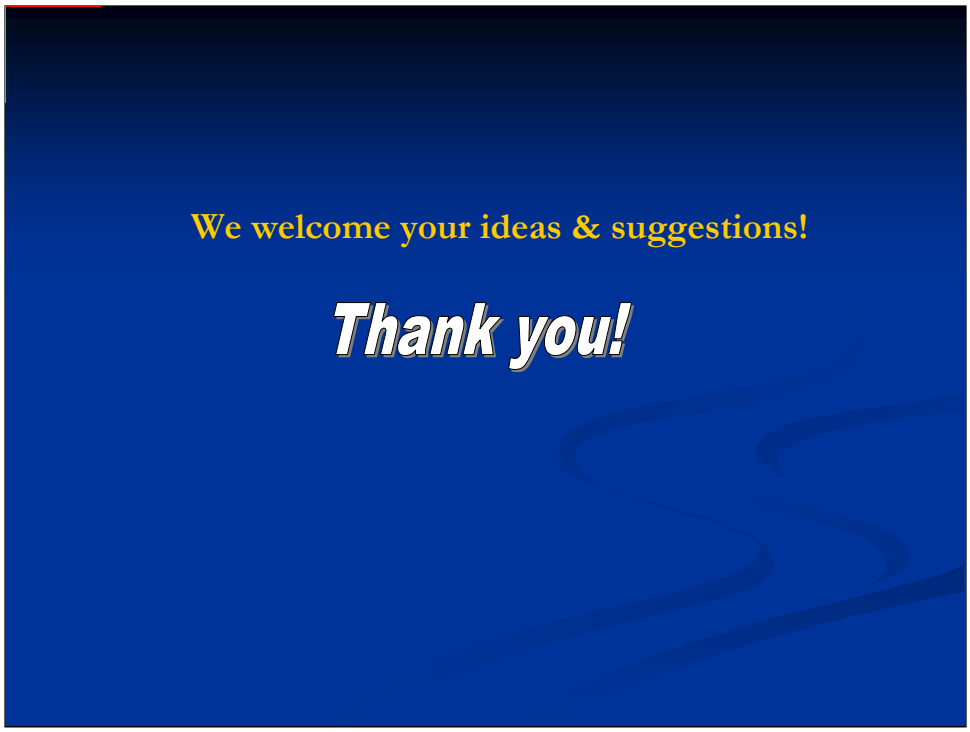


Well, that’s it folks…any questions?