Epidemiological Modeling: From Basics to Artificial Intelligence

Dr. Noam Ross, EcoHealth Alliance

DHS Biosurveillance Presentation Series

2019-06-19

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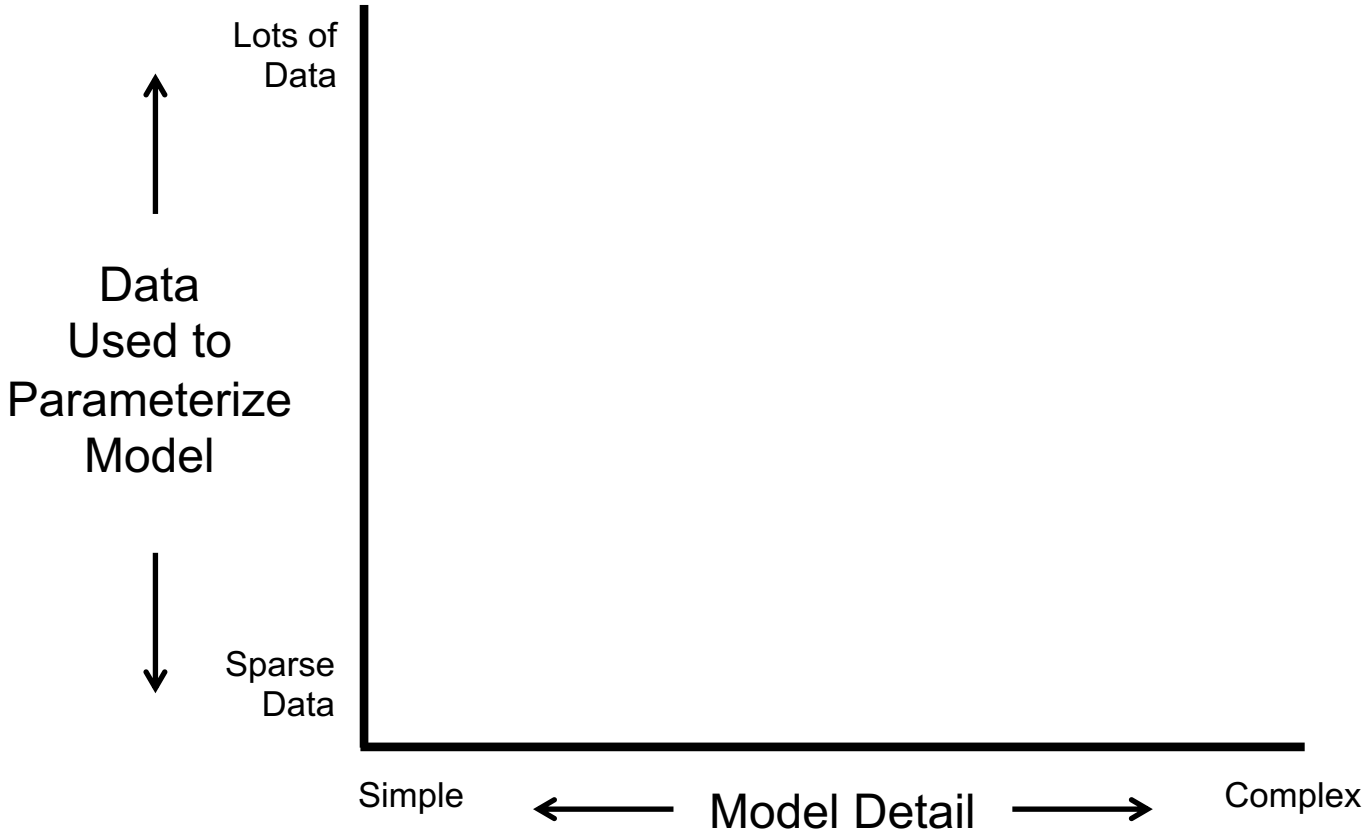
Practical Types of Epidemiological Models



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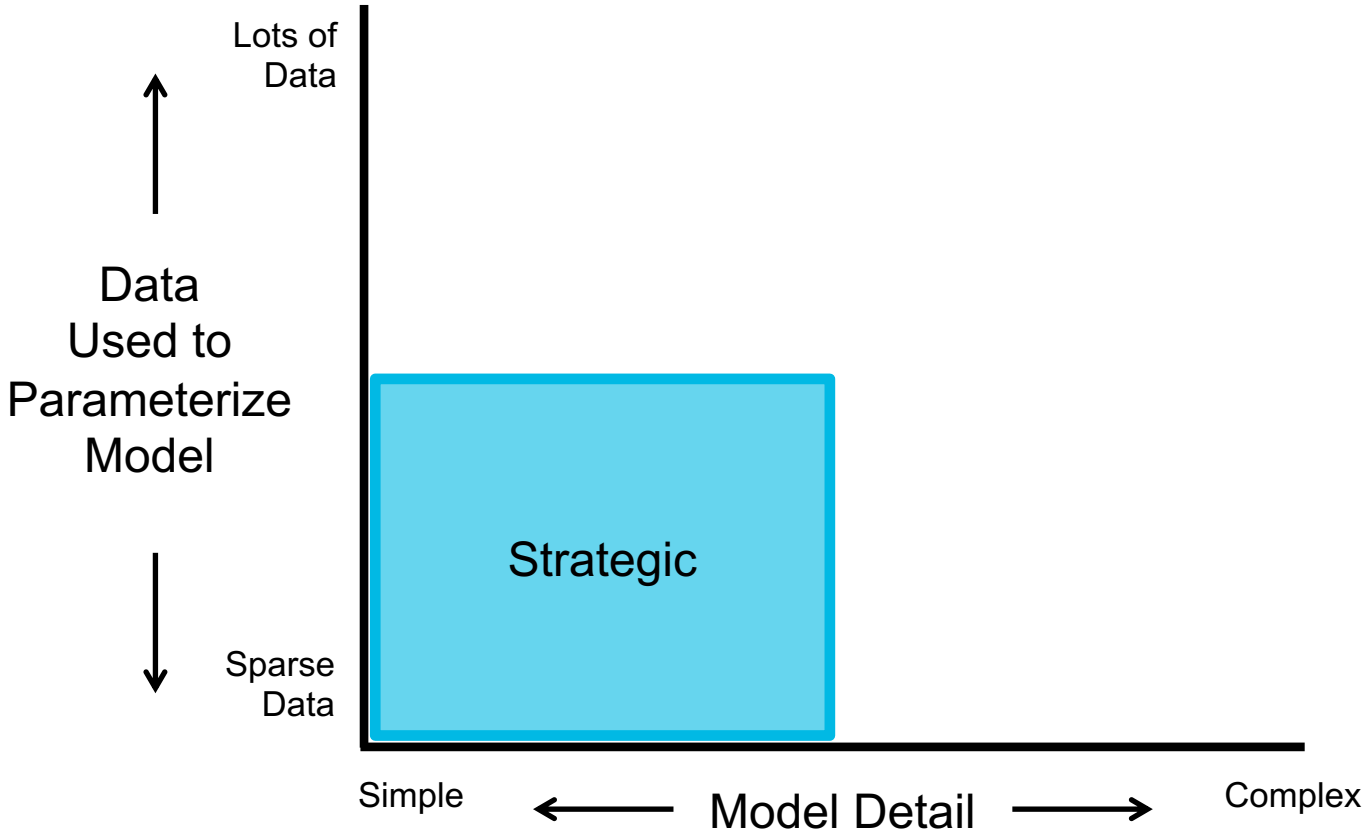
Practical Types of Epidemiological Models



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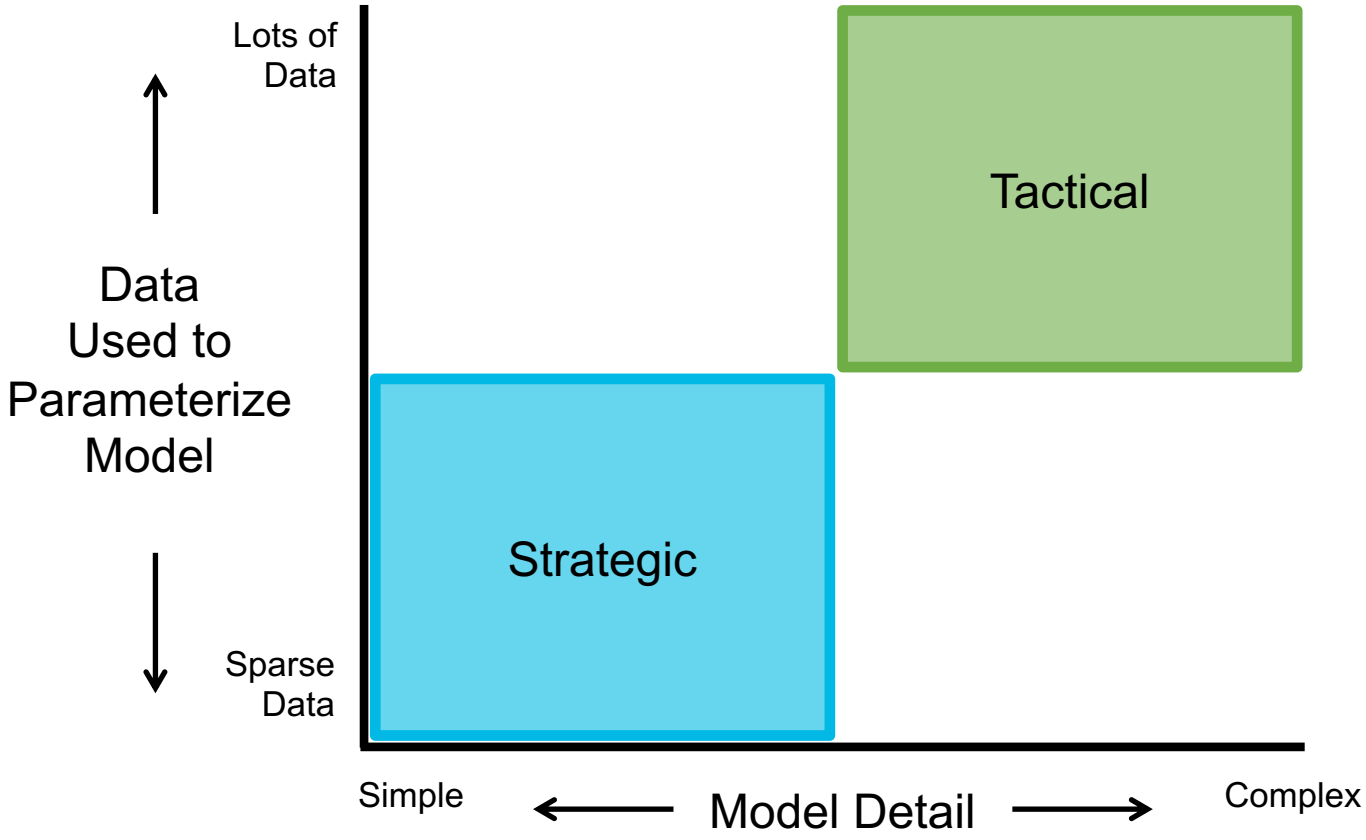

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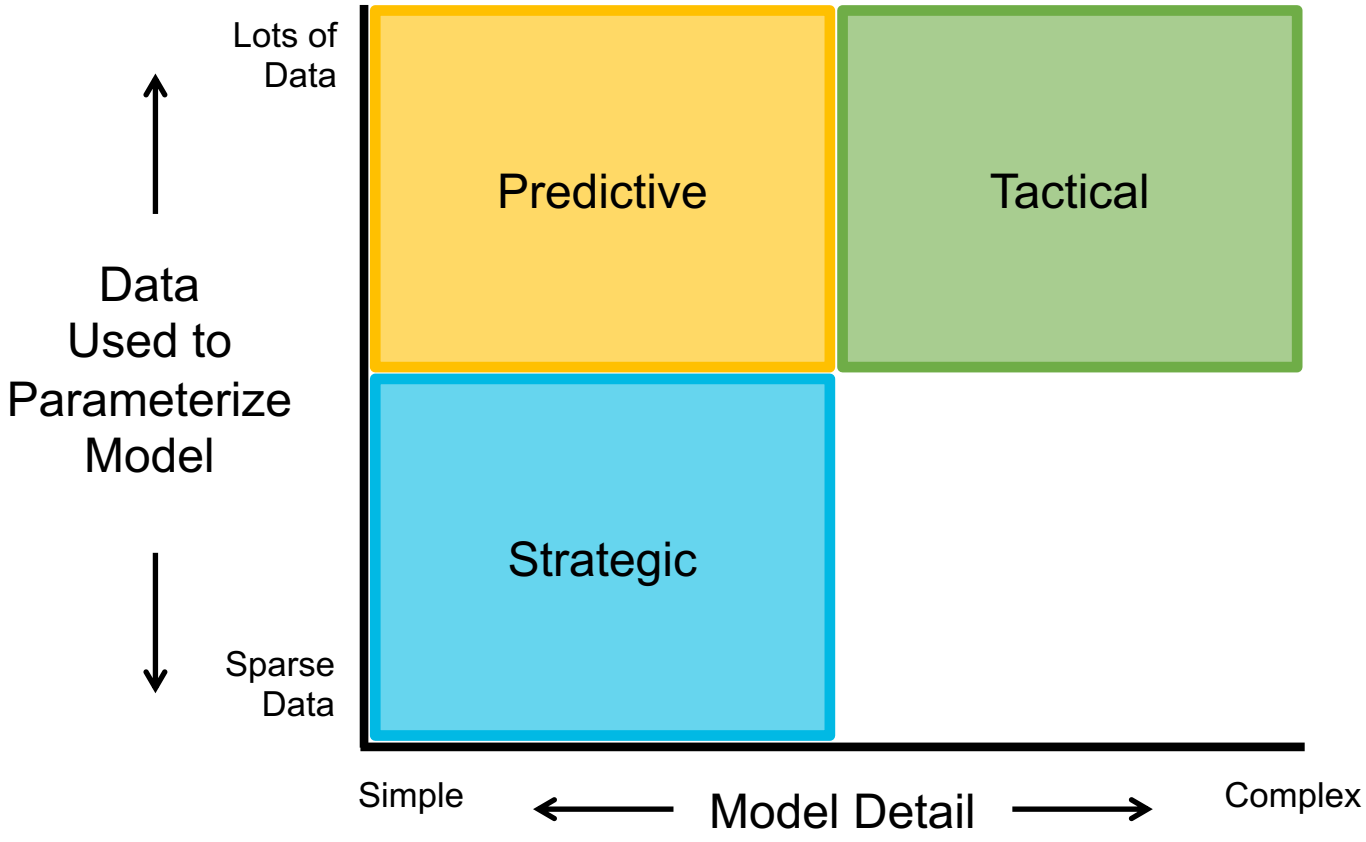

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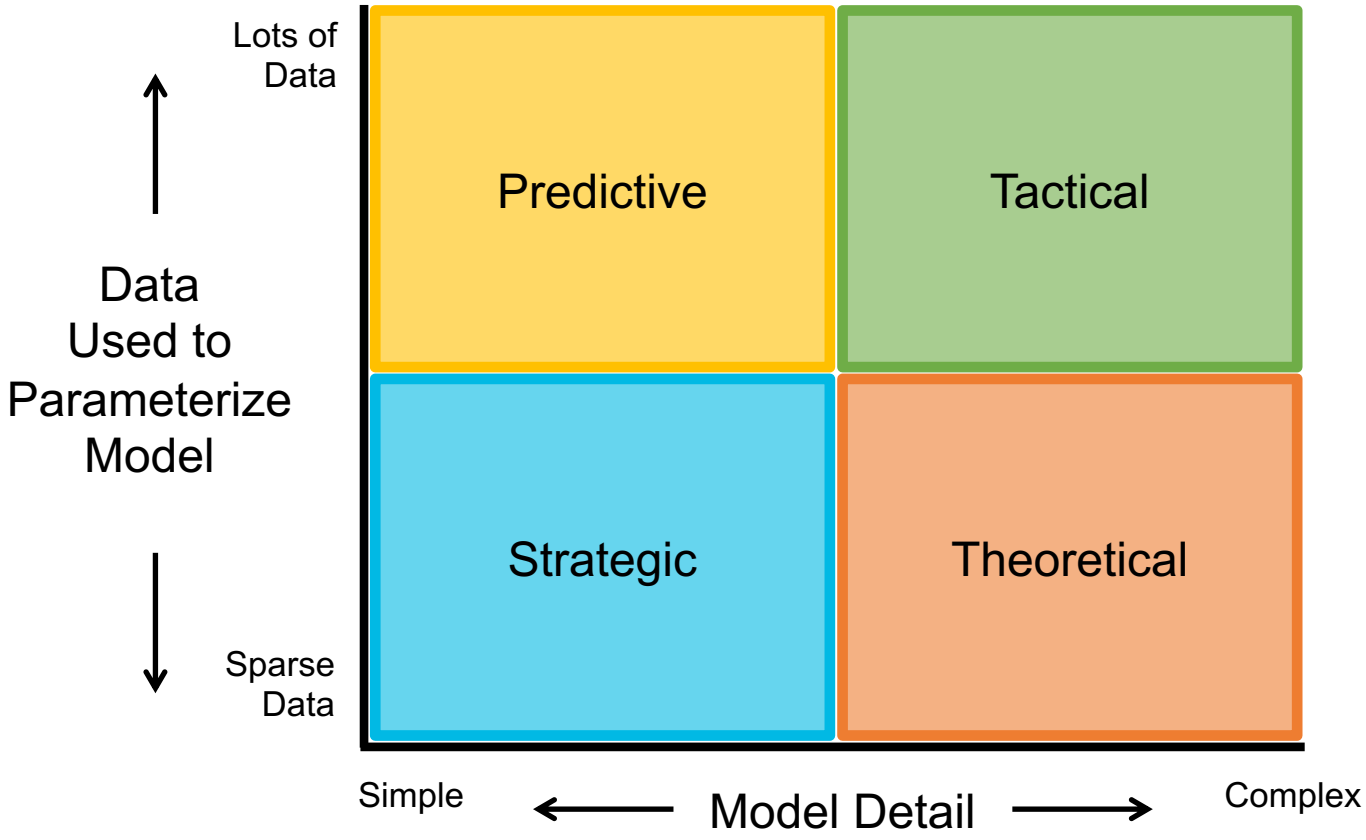

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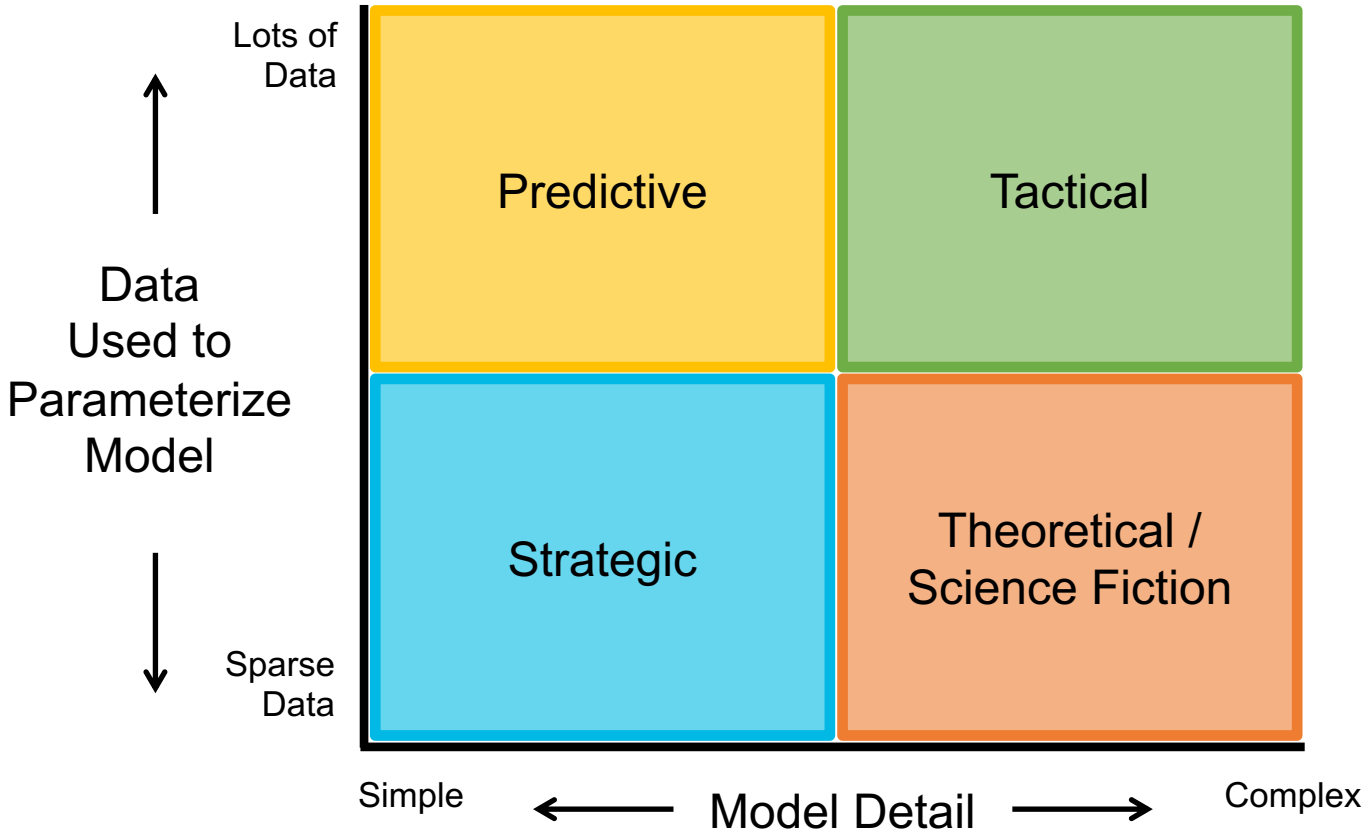

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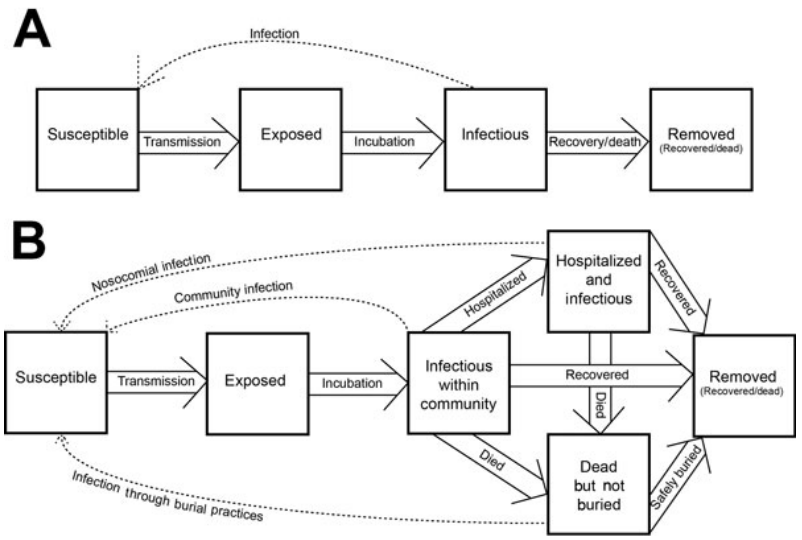
Strategic Models: Simple for Simple Questions

Strategic

- Basic, cross-system assumptions and rules, limited data
- Good for rough, early estimates of big-picture values, retrospectives
- Ask:
  - What is the uncertainty?
  - How does this change with updated data?

Example: estimating incubation time and epidemic size in early-phase Ebola outbreaks



Drake et al. (2015) https://dx.doi.org/10.3201/eid2108.141613

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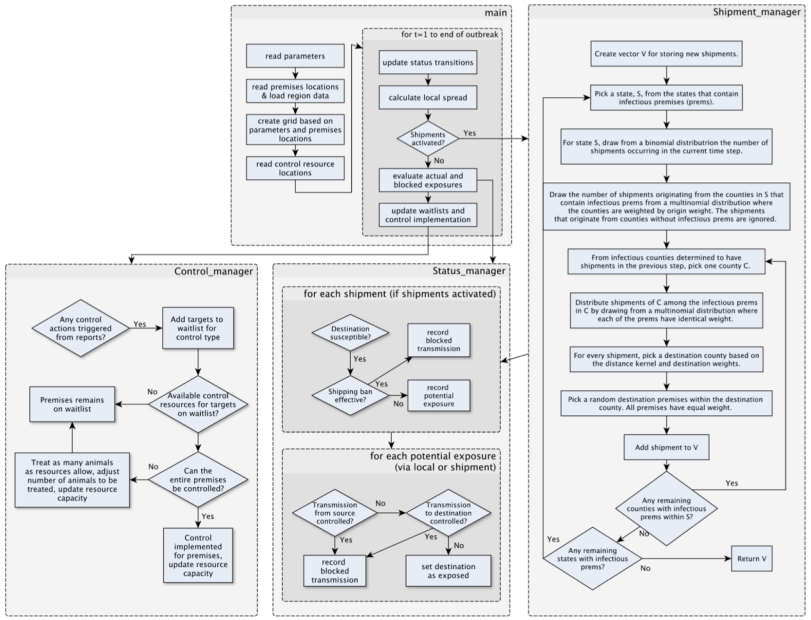
Tactical

Tactical Models: Highly Detailed Simulations

- Detailed, realistic representation of specific systems requiring lots of assumptions and data
- Good for scenario/ intervention planning ("What if?")
- Ask:
  - What are the most sensitive assumptions?
  - What results are robust across scenarios/ assumptions?

Example: U.S. Animal Movement Model / Disease Outbreak Model



Buhnerkempe et al. (2014)
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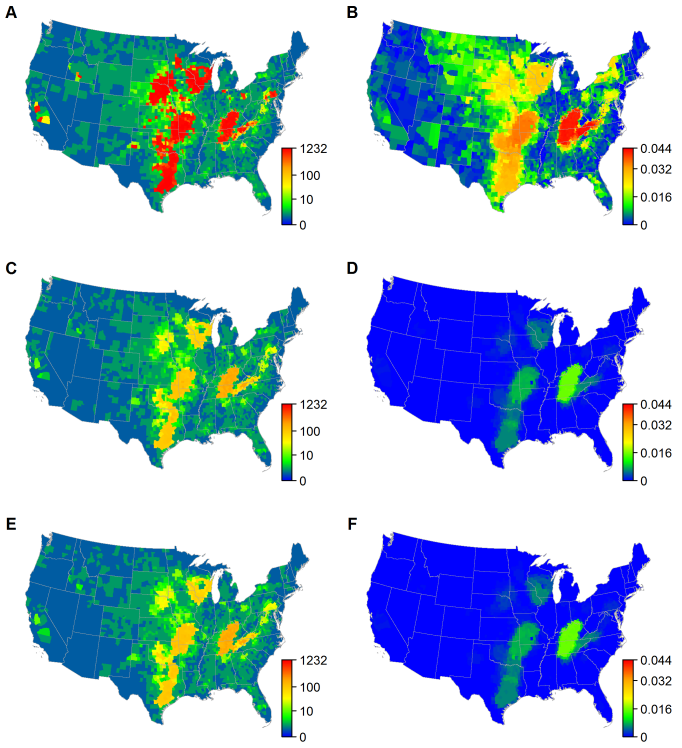

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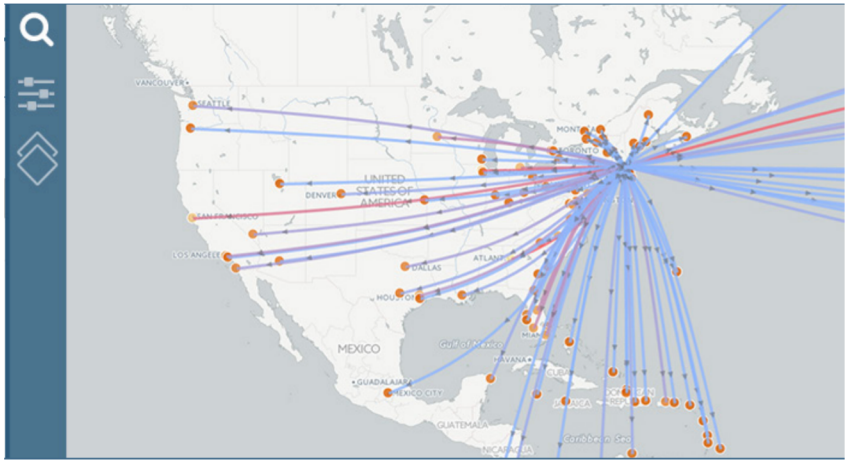
Example: Simulating disease travel with EHA's flight risk tracker



Huff et al. (2016)
https://dx.doi.org/10.1371/currents.outbreaks.711379ace737b7c04c89765342a9a8c9

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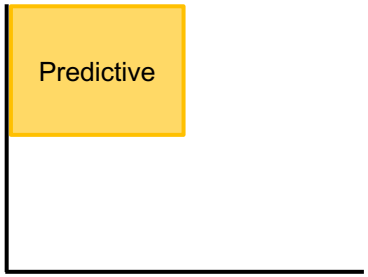
Predictive Models: It's All About the Data



- Few assumptions, data hungry
- Good for near-and-medium-term predictions
- Ask:
  - What is the *out-of-sample* uncertainty?
  - What biases and gaps are in the data?
  - What are the most influential variables?
  - How will data be updated?

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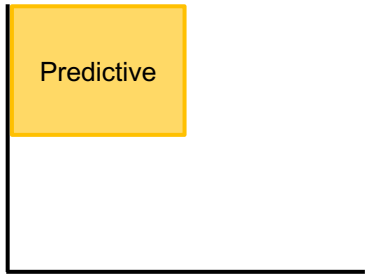
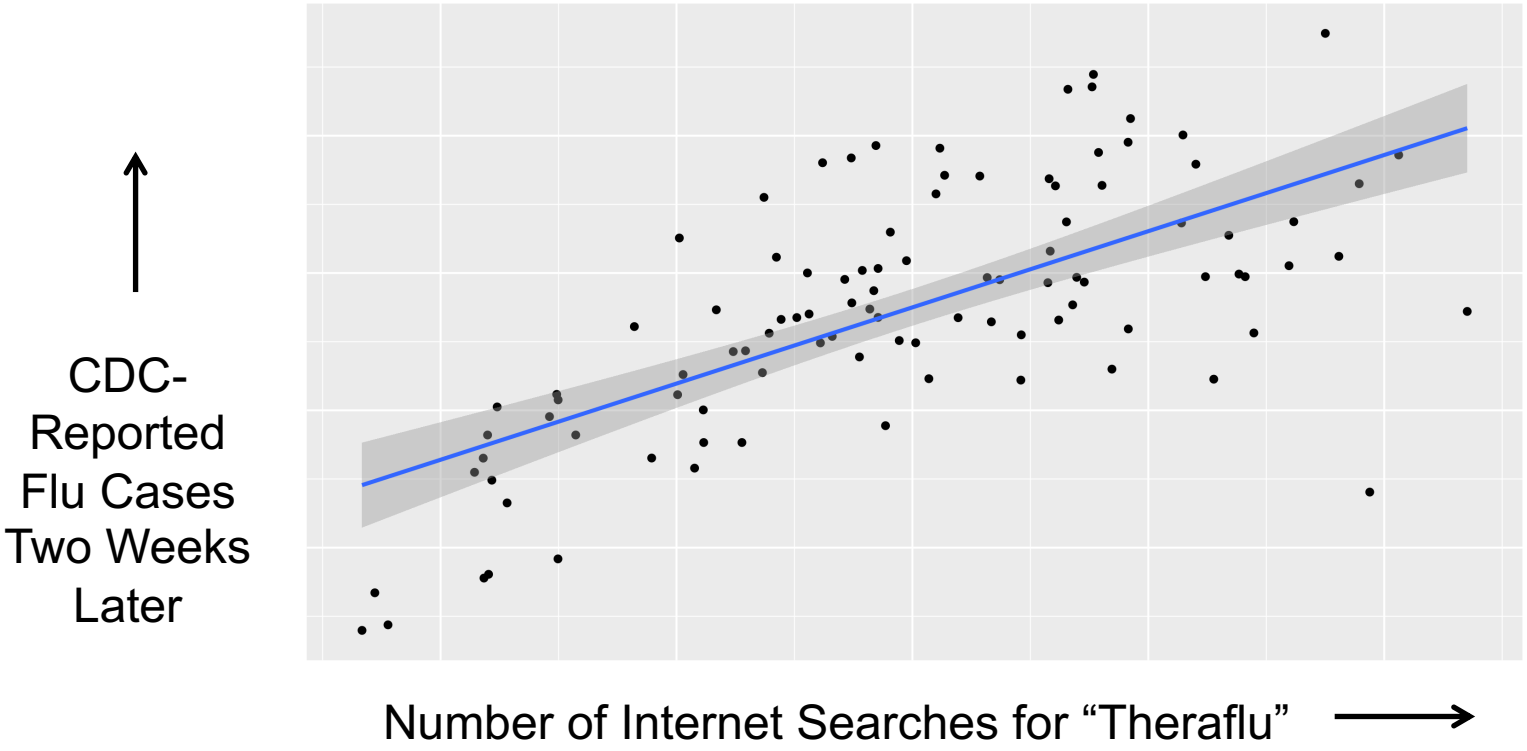
Machine Learning and Artificial Intelligence: Buzzwords for predictive models





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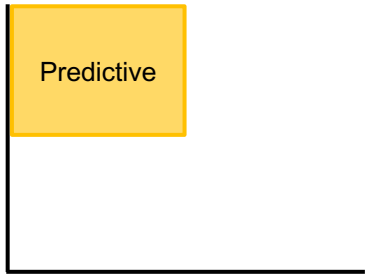

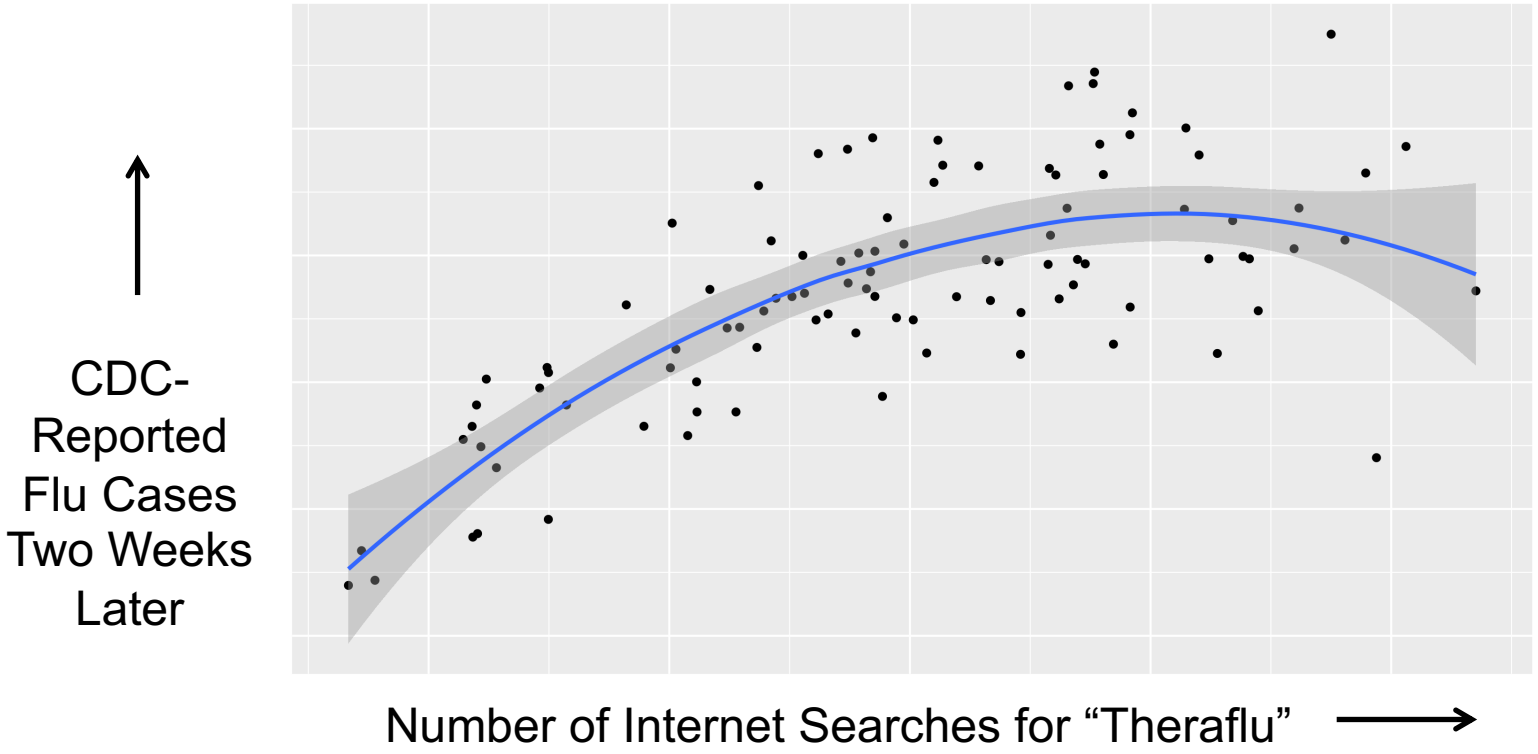

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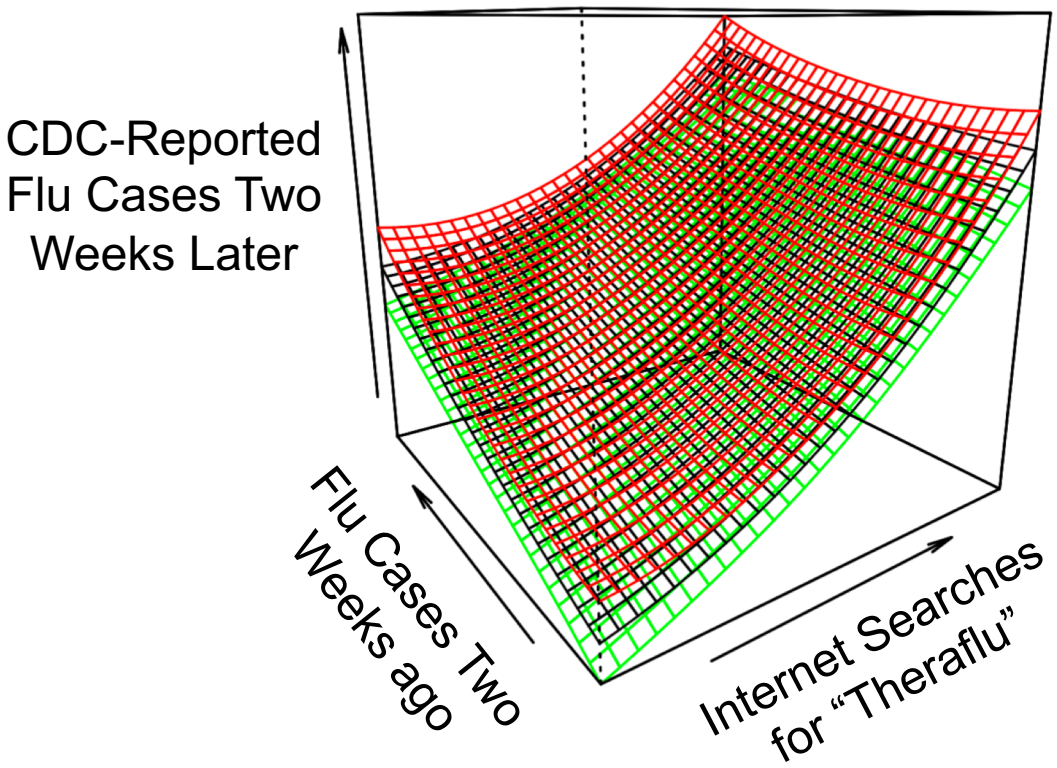

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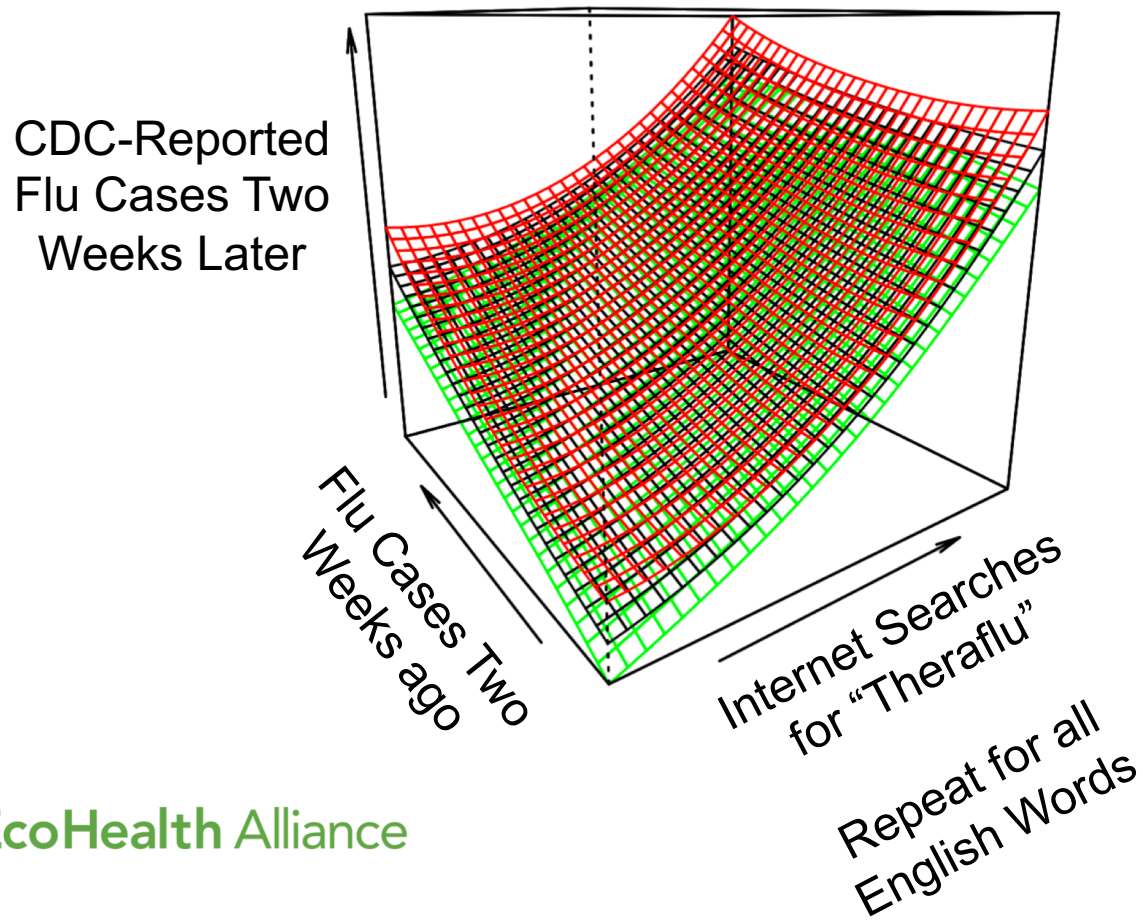

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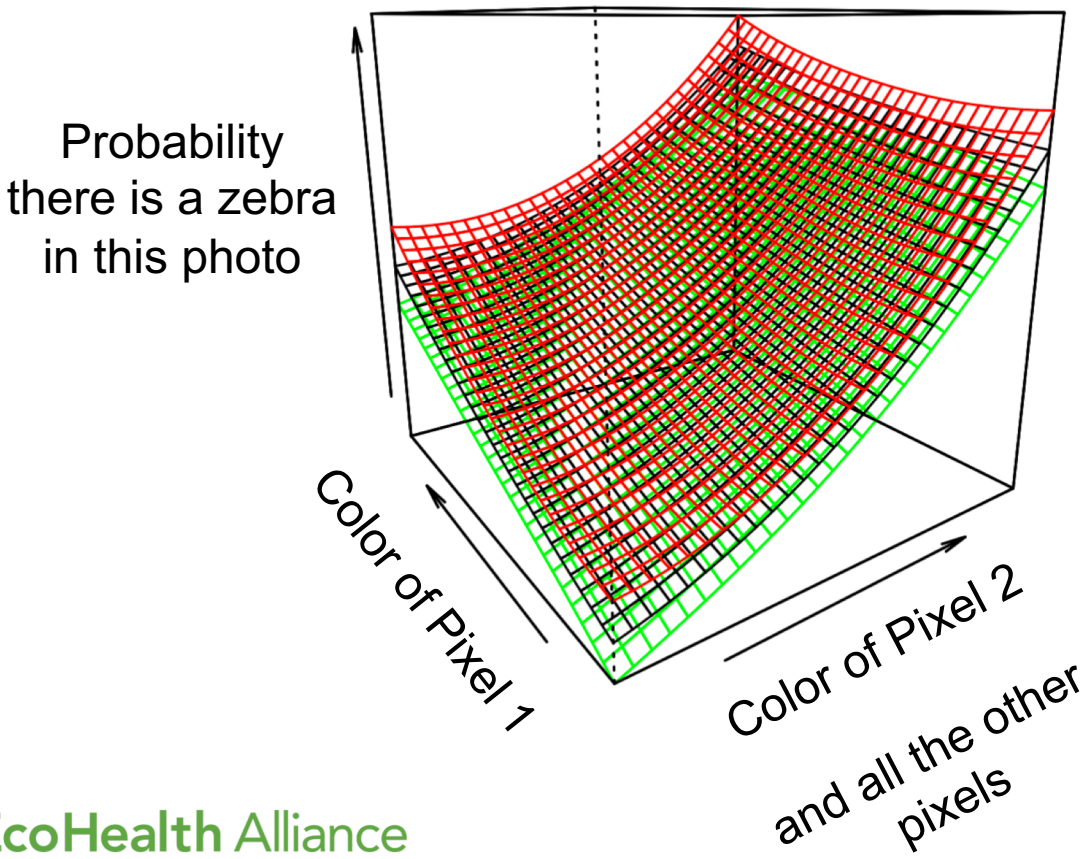

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Predictive Models: It's All About the Data

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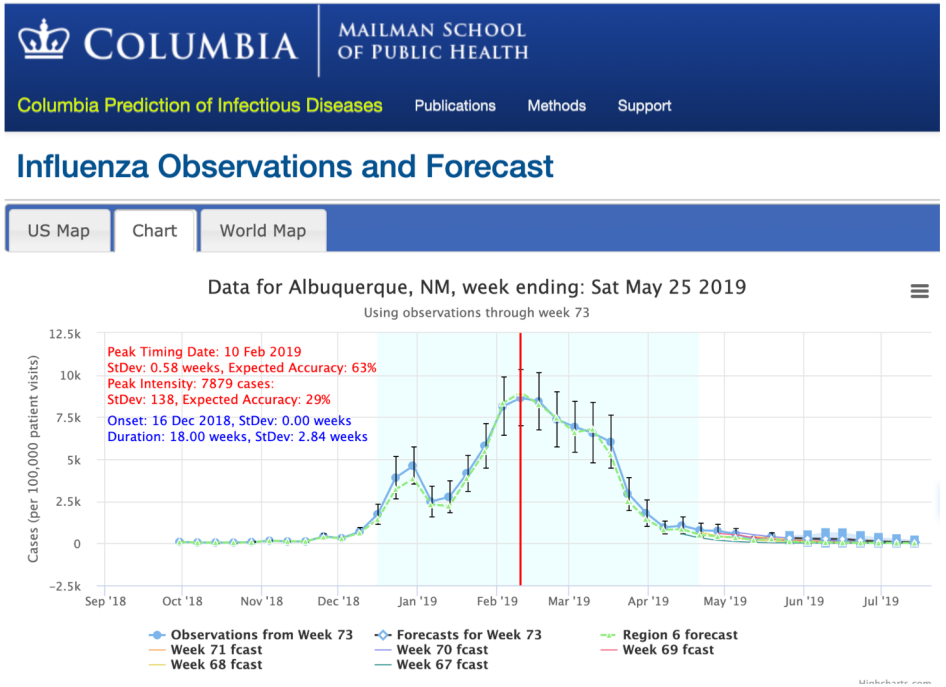
Forecasting flu outbreaks with historical data, weather, and other data



https://cpid.iri.columbia.edu/

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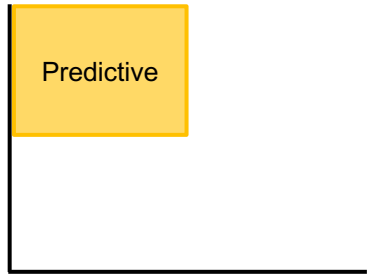
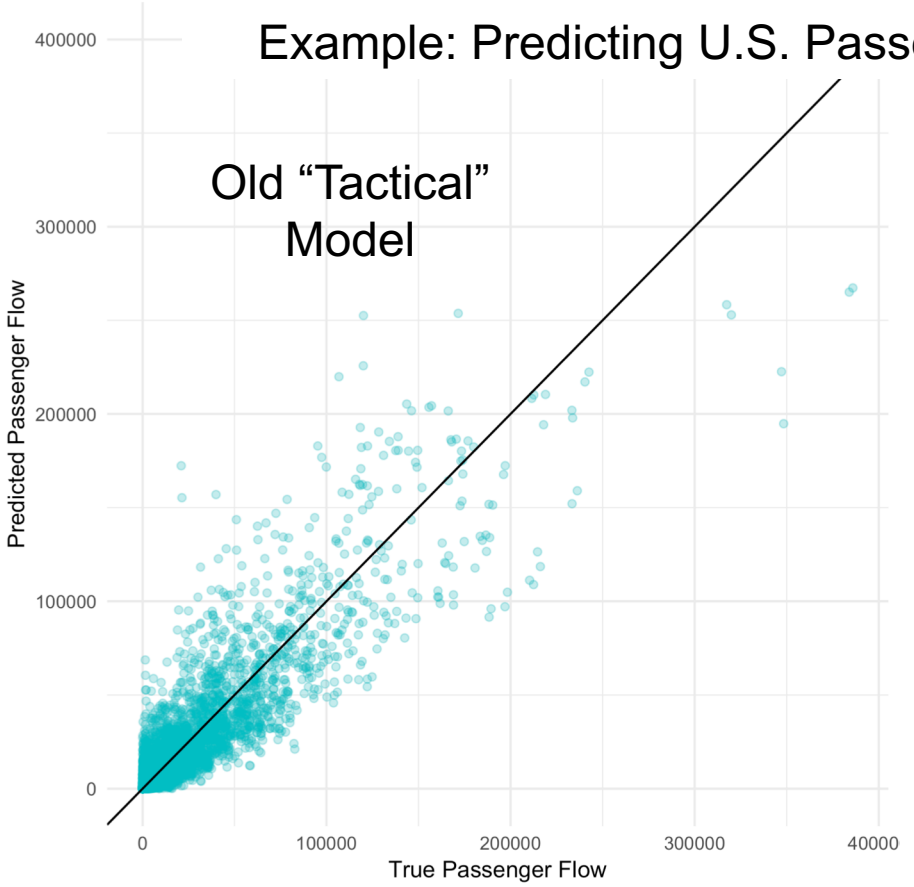
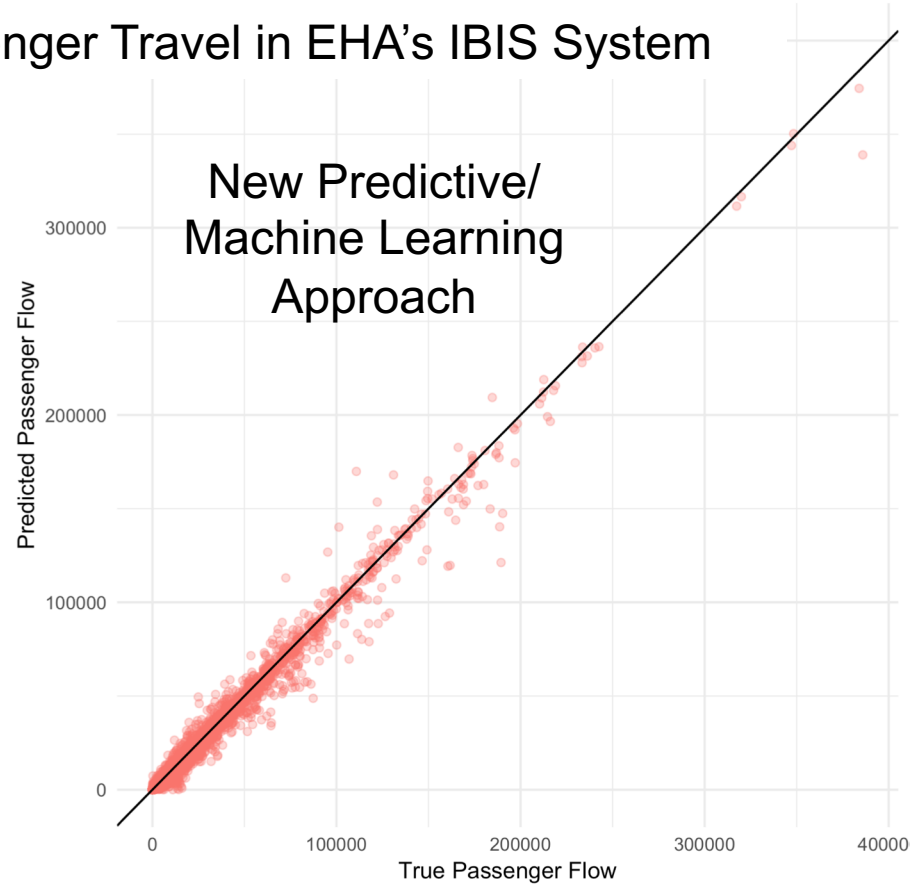


Example: Predicting U.S. Passenger Travel in EHA's IBIS System





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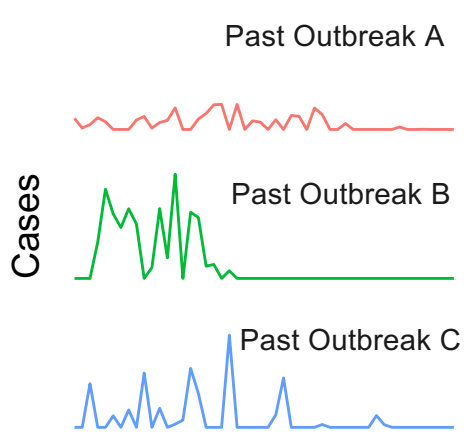
Predictive Models: It's All About the Data

Predictive

In Development at EHA:
Predicting Spread and Impact of Veterinary Disease Outbreaks

Input: Disease, Location
ASF, Ames, IA

Similarity Ranking of Disease Clusters
Japan, CSF, 2018
Russia, ASF, 2009
Benin, ASF 2013
…



Potential Severity Estimates

Total Cases
120 270 450

Time Course
44 145 180 days

Number of Farms
3 11 40

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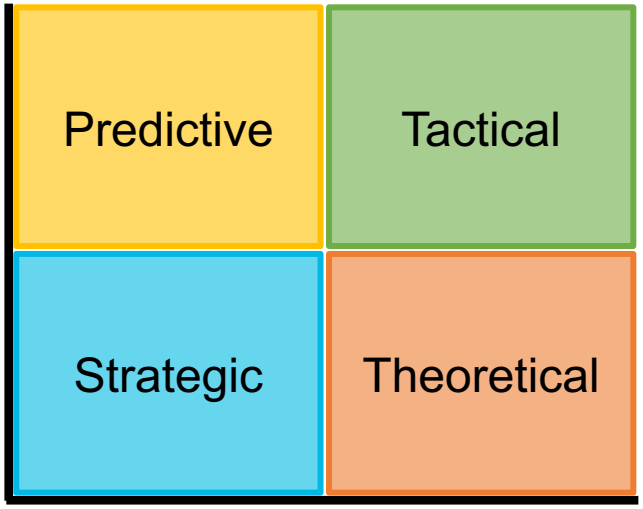
Summary

When evaluating results from epidemiological models, ask:

- Is this the right kind model for this task?
- What is the uncertainty in the results? Where does it come from?
- What in the assumptions or data do the results rest on?



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Thank You!

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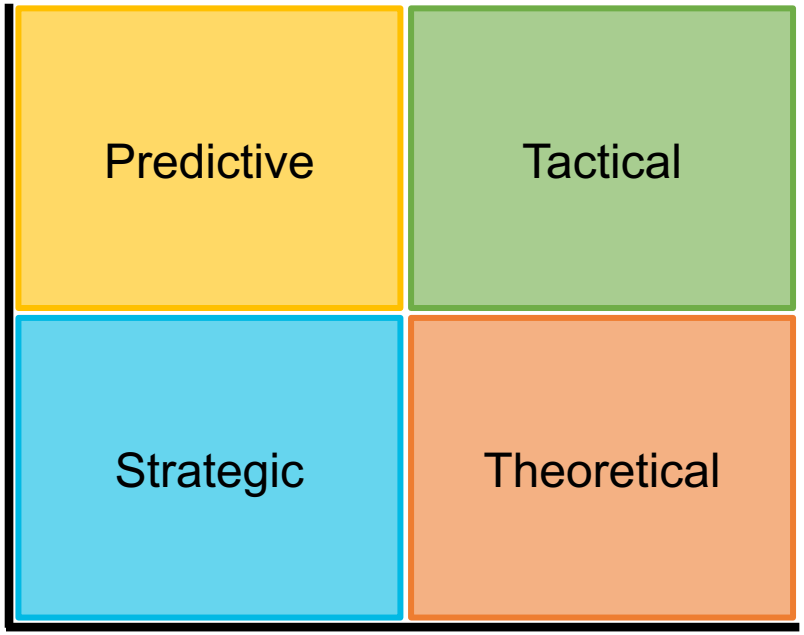
@noamross



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