Forecasting spread and impact to inform pre-import decisions.

Dr. Jonathan Bossenbroek
Lake Erie Center
Dept. of Environmental Sciences
University of Toledo

A bioeconomic framework for invasive species

- **Objectives:**
  - **1) to provide estimates of the regional economic and ecological impact an invasive species will potentially inflict;**
  - **2) to provide policy-makers with quantitative guidance for cost-effective alternative strategies to control, prevent, or slow the spread of an invasive species.**

Objective 1: to provide estimates of the regional economic impact of an invasive species.

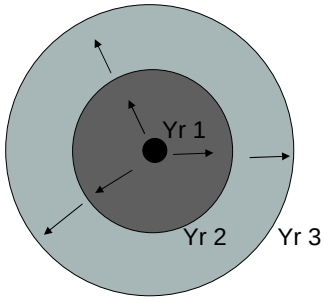
- *Estimate the potential habitat*
- *Predict the spread*
- *Estimate economic and ecological impacts*
- *Determine the regional consequences of spread through the economy and ecosystem*

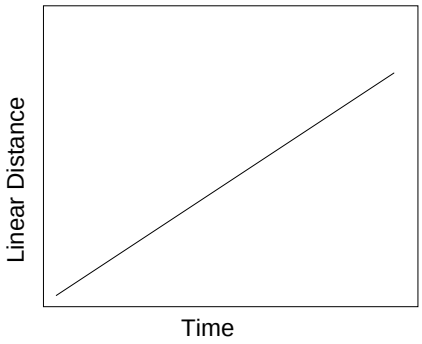
Predict the spread of imported species

- Natural Dispersal
- Human-mediated dispersal

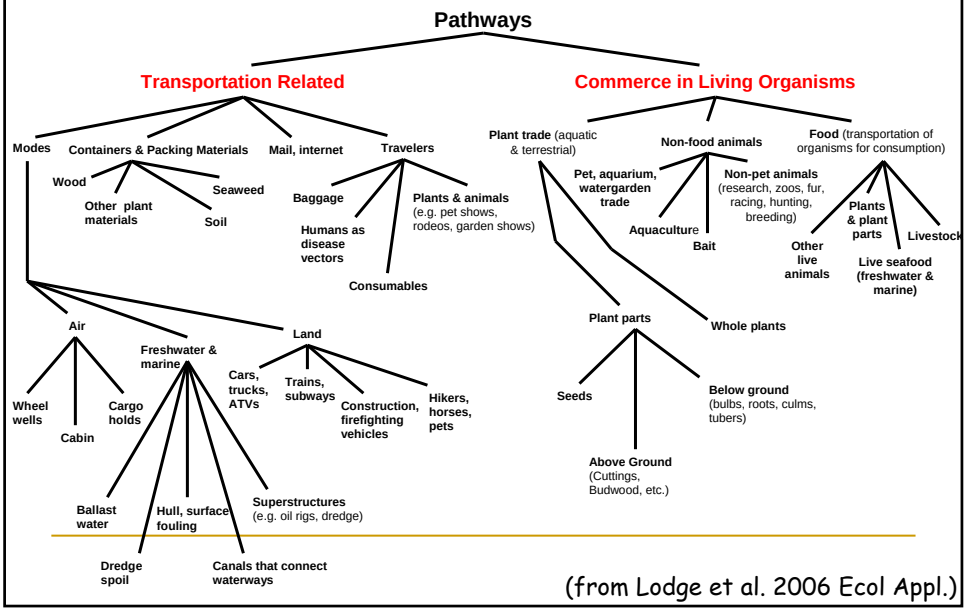
Modeling Dispersal

- Natural Spread





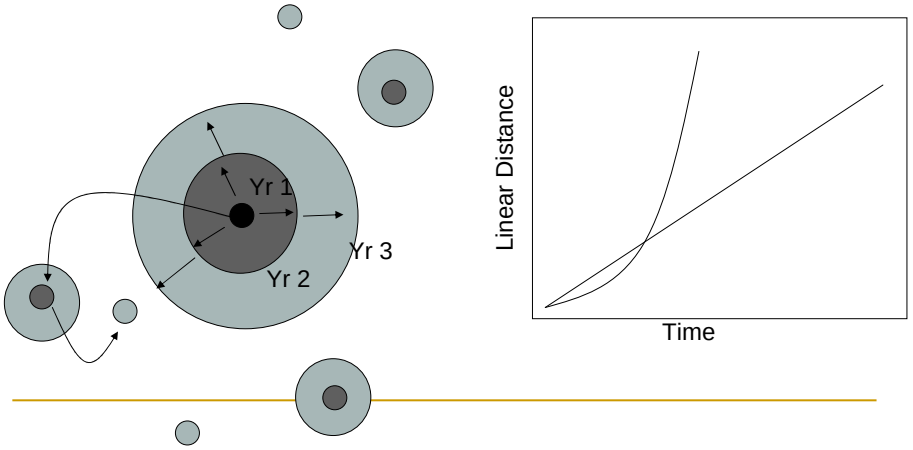
Pathways of Nonindigenous Species in the US



(from Lodge et al. 2006 Ecol Appl.)

Modeling Dispersal

- Long-distance spread

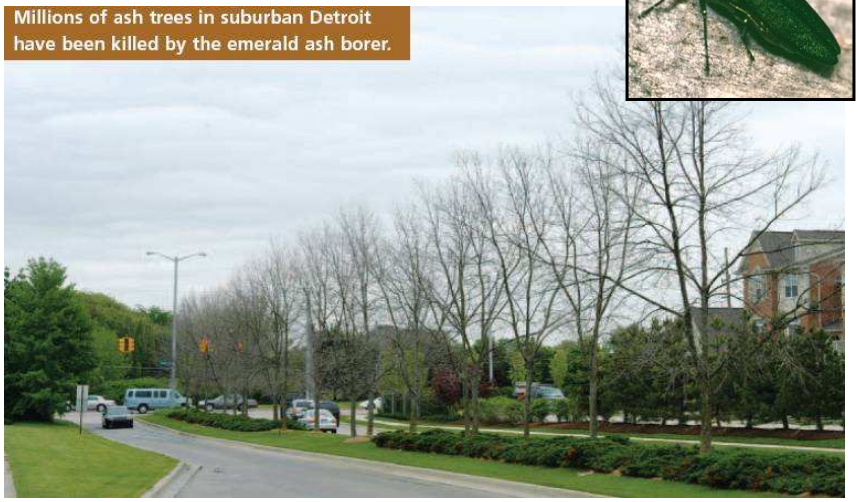


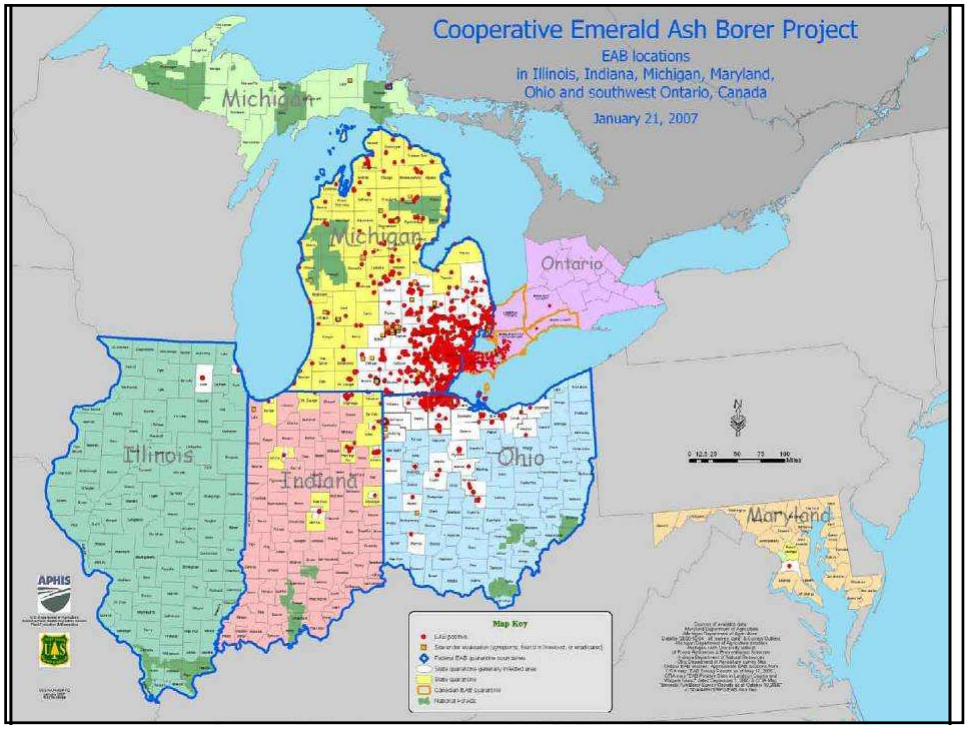
Pathways for imported species

- Many more species than pathways.
- The questions thus become:
  - What pathways are available to a particular species?
  - How effective might those pathways be in transporting the species?
- These questions may be more crucial than knowing natural dispersal rates.

Emerald Ash Borer Impacts

Millions of ash trees in suburban Detroit have been killed by the emerald ash borer.

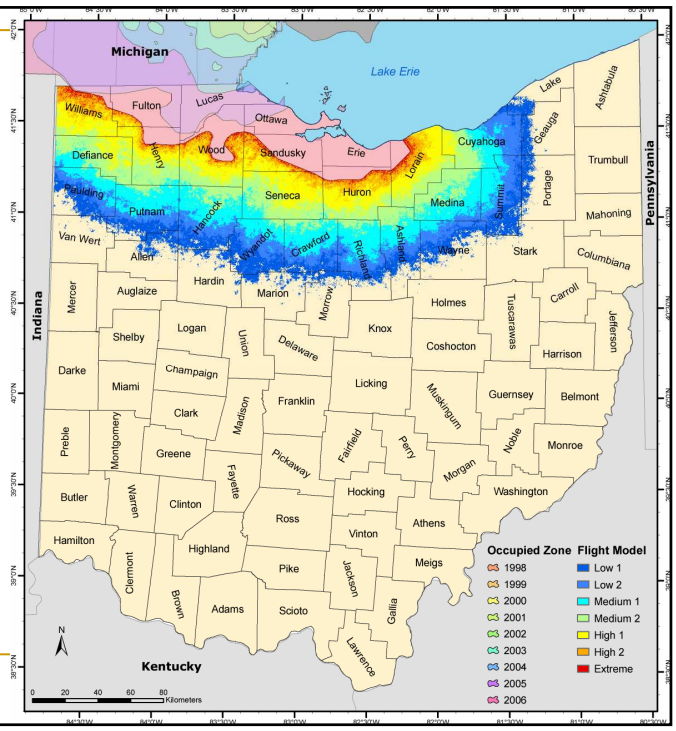




Predict the spread of emerald ash borer

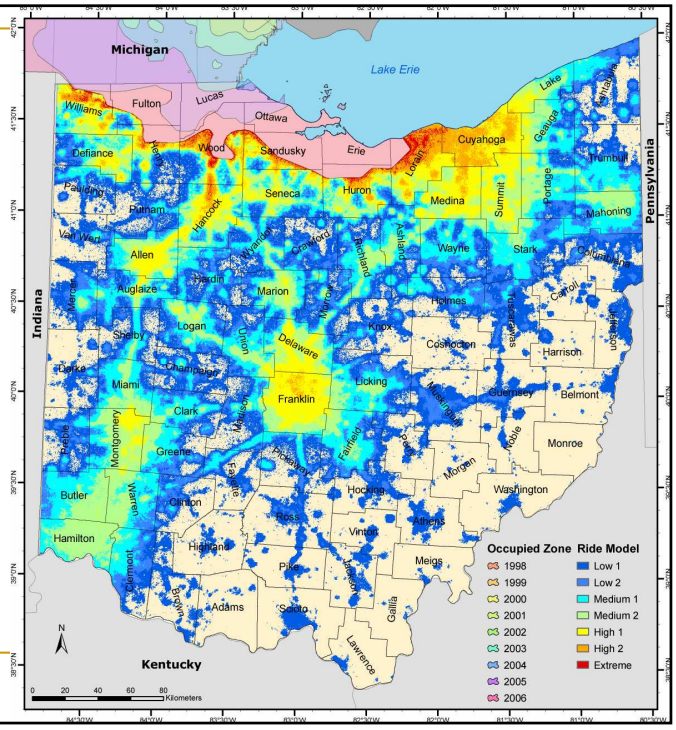
- Natural Dispersal
  - Flight (~2 km/yr)
- Human-mediated dispersal
  - Campers moving firewood
  - Hitchhikers on cars, trucks, etc.
  - Wood products industry

Natural Dispersal of EAB in Ohio



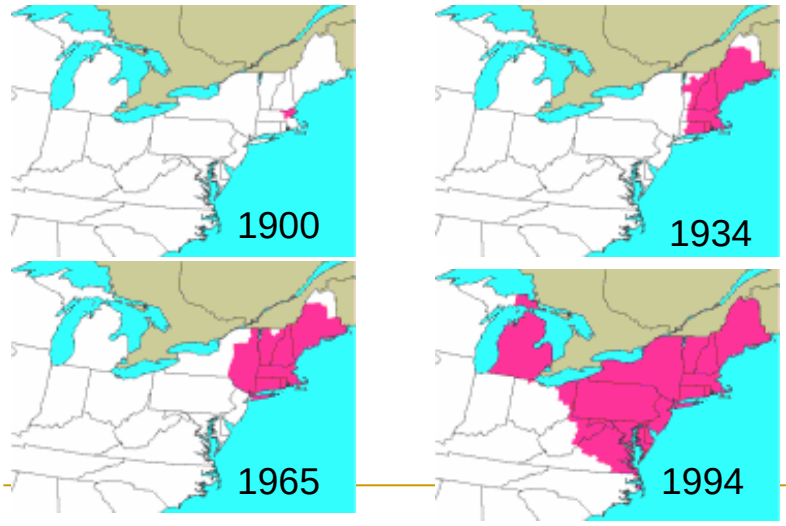
Iverson et al. unpublished data.

Natural and Human-Mediated Dispersal of EAB in Ohio



Iverson et al. unpublished data.

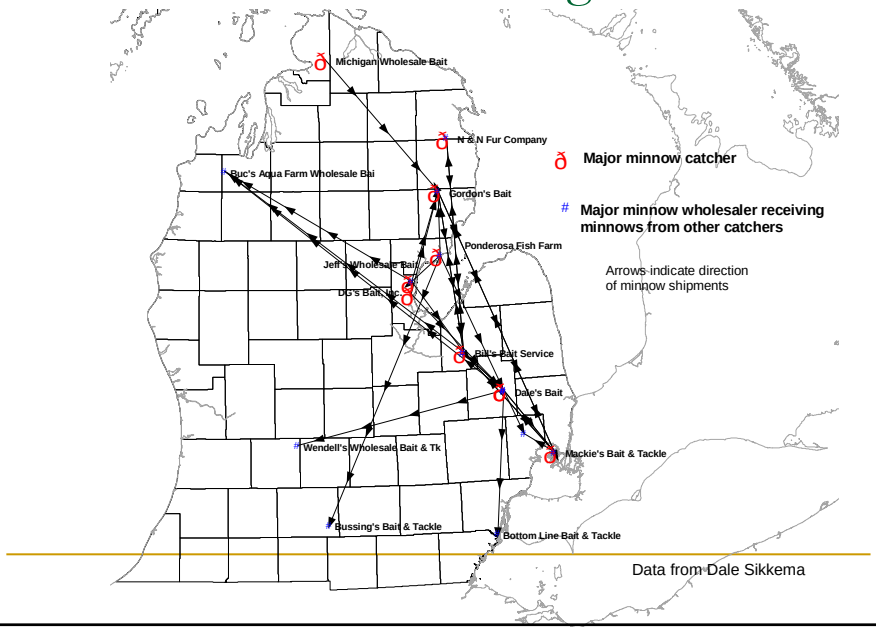
Gypsy Moth Spread – after intentional introduction in Boston in the 1860's



Viral hemorrhagic seticemia (VHS)

- Fish disease with a new freshwater strain in the Great Lakes Region.
- Has caused several large fish kills in past two years.
- Bait industry as potential vector

Bait Movements in Michigan



Understanding dispersal for pre-import decisions

- Human-mediated dispersal is increasingly being studied.
  - Pathways and networks of human movements do not change rapidly.
  - Ability of species to be spread by these pathways is, however, species specific.
  - How likely would a species of interest be transported by a particular pathway or network?
    - How important are these pathways compared to the species ability to disperse naturally?

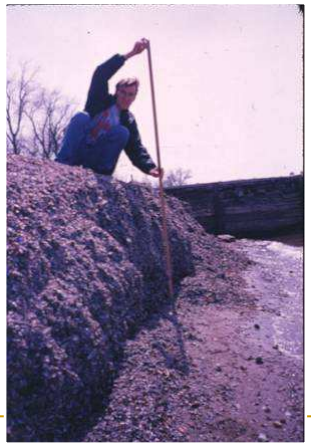
Impacts of invasive species.

- The ecological impacts:
  - effects on individuals
  - genetic effects
  - population dynamic effects
  - community effects
  - effects on ecosystem processes
- Economic impacts

How can the potential impact of imported species be predicted?

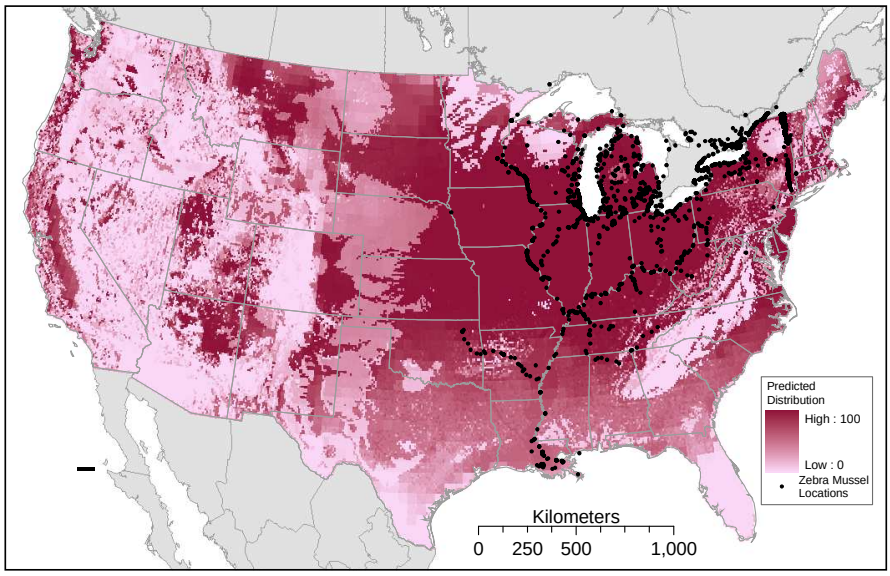
- Few guidelines measuring impact.
- One measure by Parker et al. (1999)
  - I = R x A x E
    - R – Range of the species
    - A – Abundance of the species
    - E - some measure of the impact per individual or per unit of biomass suggest that the overall impact
- Requires lots of data
  - Data which may not be even available in the native range.

Mussel Beach

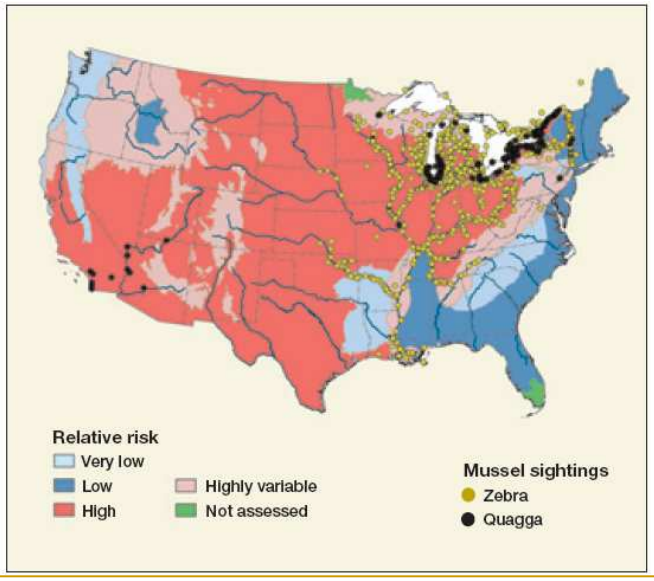


Courtesy of Dr. Clifford Kraft

Potential distribution of zebra mussels

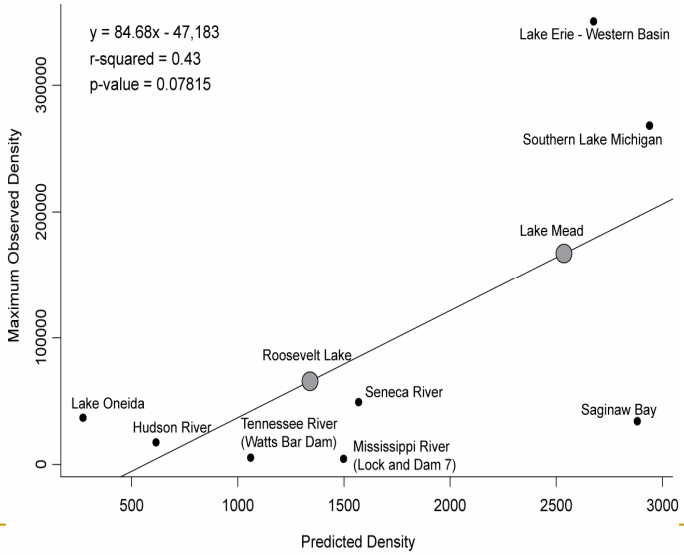


Drake and Bossenbroek, 2004



Whittier et al. 2008. Frontiers of Ecology and the Environment

Risk a function of abundance, not presence.



Bossenbroek et al. 2007

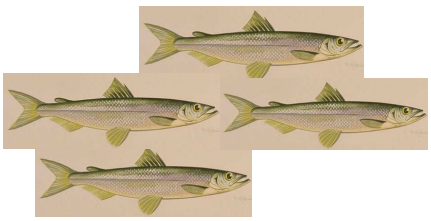
How can the potential impact of imported species be predicted?

- General Trait-based Assessment
- What species characteristics can be used to predict whether it will become invasive (i.e. have a large impact)?

- Two Examples:
  - Fishes introductions in the Great Lakes.
  - Molluscs in the Great Lakes.

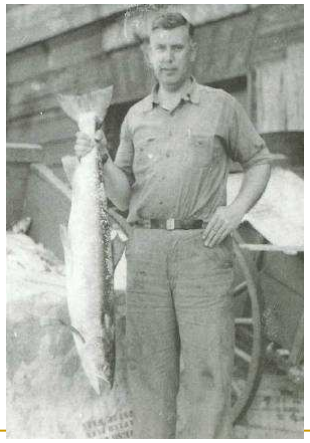
Fishes Example: How is risk related to species traits?

Successful (24 species)



***e.g.*, rainbow smelt**

Failed (21 species)



***e.g.*, Atlantic salmon**

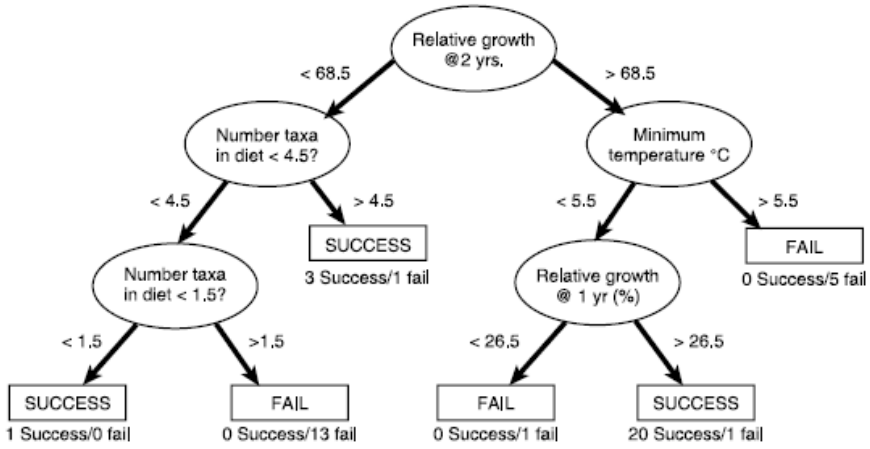
Kolar & Lodge 2002 *Science*

Characteristics compared between successful and failed fishes.

- Habitat & environmental tolerances
  - 7 parameters, e.g., temperature tolerances
- Life history characteristics
  - 14 parameters, e.g., age at maturity
- History of invasiveness
  - 2 parameters, e.g., invasive elsewhere

Kolar & Lodge 2002 *Science*

Decision tree of successful and failed introduced fishes in the Great Lakes.



~90% accuracy

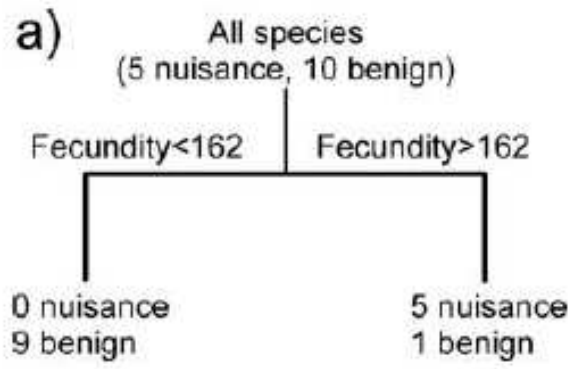
Kolar & Lodge 2002 *Science*

Mollusc Example: How is risk related to species traits?

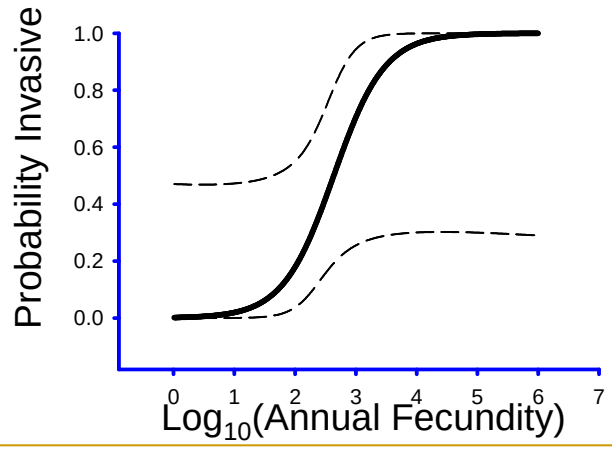
Character	Levels
Type of Reproduction	Separate sexes Sequential hermaphrodite Simultaneous hermaphrodite Self-fertilizing hermaphrodite
Egg Brooding	Ovoviviparous or viviparous
Maximum Size	mm
Fecundity/female/year	Log_{10}(propagules released)
Longevity	Years
Non-native Elsewhere	Yes or No
Latitude Range	Highest - Lowest
Larval Stage	Yes or No
Time Established	2005 - date first found

Keller et al., 2007 *Conservation Biology*

Decision tree of nuisance and benign molluscs in the Great Lakes.

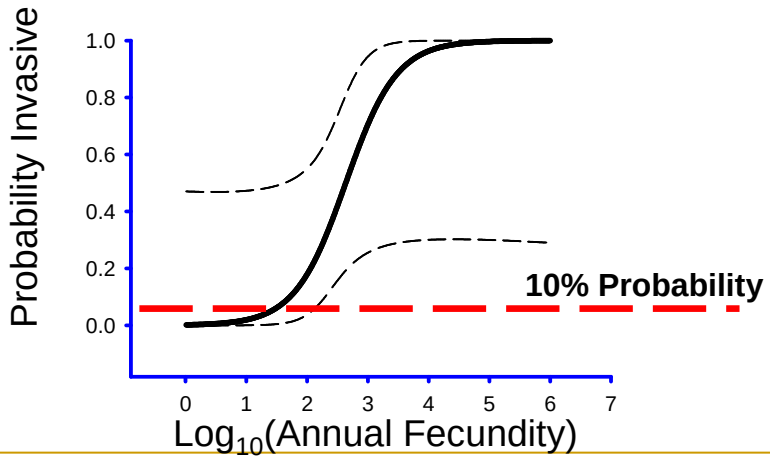


Fecundity Predicts Risk



Keller et al., 2007 *Conservation Biology*

Management Tool



Accuracy of Trait Based Screening Tools for Various Taxonomic groups

- Terrestrial plants
  - Australia (Pheloung 1995, 1999) ~90%
  - Cont. US (Reichard & Hamilton 1997) 86%
  - Hawaii (Daehler et al. 2004) 85-95%
  - Pines (Rejmanek & Richardson 1996) ~90%
- Birds (Sol et al. 2005 and others) high
- NA Gr. Lakes fishes (Kolar & Lodge 2002) 91%
- US freshw. molluscs (Keller et al. 2007) 80%

Trait-based assessments are quite accurate.

- However….
- Require lots of basic natural history data.
  - The knowledge of successful/unsuccessful or invasive/benign species that can be compared.
  - Data must also exist for the species that is going to be imported.

Conclusions about spread and impact to inform pre-import decisions.

- Spread:
  - Developing models of human-mediated dispersal pathways should be a higher priority than natural dispersal.
  - What pathways will be available to species of interest?
- Impact:
  - Impact can be hard to define: ecological vs. environmental, types of impacts (i.e. population, community level, etc.)
  - What are the characteristics of the species that are invasive in a particular taxonomic group?

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