

# PoE lecture 2: Species distributions

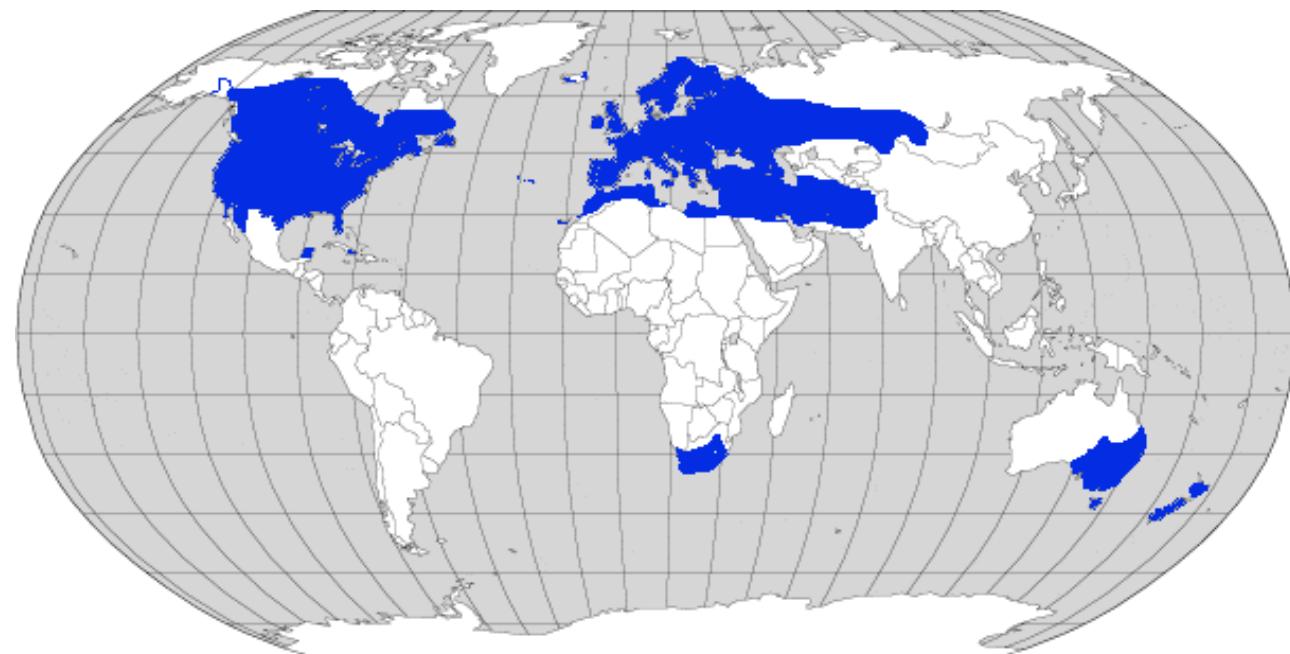
Isla Myers-Smith  
Crew Building, School of GeoSciences

What is a species distribution?



# Species Distributions

A species distribution is the manner in which biological taxa are spatially arranged.



# Range Limits

A geographic range limit is the geographic boundary beyond which a species does not occur, the limit or limits of the range of a species.

"Core populations" are populations of individuals occurring within the center of the range.

"Peripheral" or "edge populations" are groups of individuals near the boundary of the range.



# Range Expansion/Contraction

Species ranges can expand or contract in relation to the following factors:

1. Abiotic factors
2. Biotic factors
3. Anthropogenic factors
4. Genetic factors
5. A combination of these factors

[http://en.wikipedia.org/wiki/Geographic\\_range\\_limit](http://en.wikipedia.org/wiki/Geographic_range_limit)

# Range Expansion/Contraction

Treelines are advancing at the treeline ecotone



Harsch et al. Ecol Lett 2009

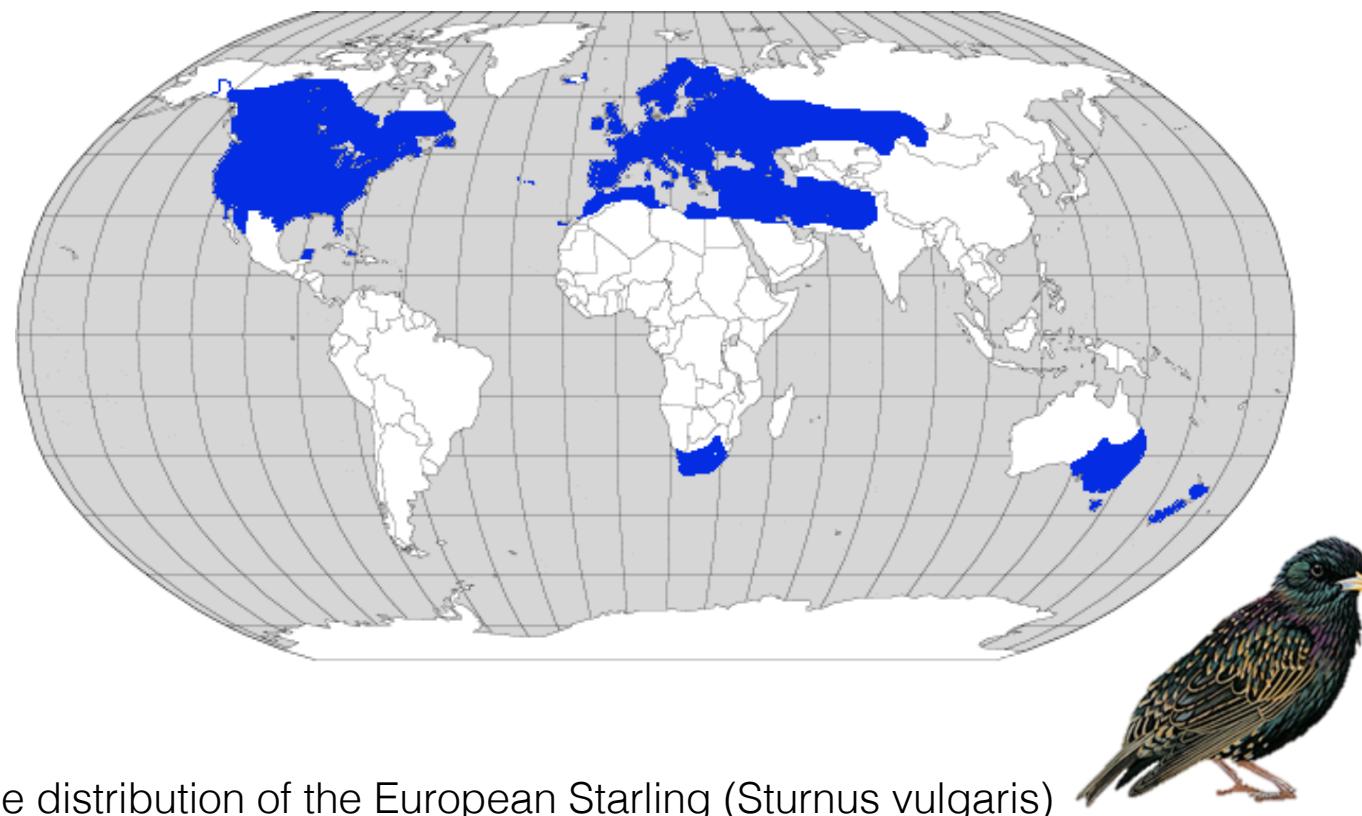
Can you name some widely distributed species?



# European Starling



# European Starling



The distribution of the European Starling (*Sturnus vulgaris*)

# Scotch Broom



The distribution of Scotch Broom (*Cytisus Linnaeus*)

# GBIF

The screenshot shows the GBIF homepage with a green world map background. The map is dotted with white circles representing data records. Overlaid on the map is the GBIF logo (a stylized flower) and the text "Global Biodiversity Information Facility" followed by "Free and Open Access to Biodiversity Data". Below this, key statistics are displayed: 516,071,884 occurrences, 1,454,694 species, 13,810 datasets, and 639 data publishers. A navigation bar at the top right includes links for Data, News, Community, and About. At the bottom, there are three main sections: "Sharing biodiversity data for re-use", "Providing evidence for research and decisions", and "Collaborating as a global community", each with associated links.

GBIF

Global Biodiversity Information Facility

Free and Open Access to Biodiversity Data

516,071,884 OCCURRENCES

1,454,694 SPECIES

13,810 DATASETS

639 DATA PUBLISHERS

Sharing biodiversity data for re-use

Learn about GBIF

Publish your data through GBIF

Technical infrastructure

Providing evidence for research and decisions

Using data through GBIF

Enabling biodiversity science

Supporting global targets

Collaborating as a global community

Current Participants

How GBIF is funded

Enhancing capacity

gbif.org

Search news items and information pages...

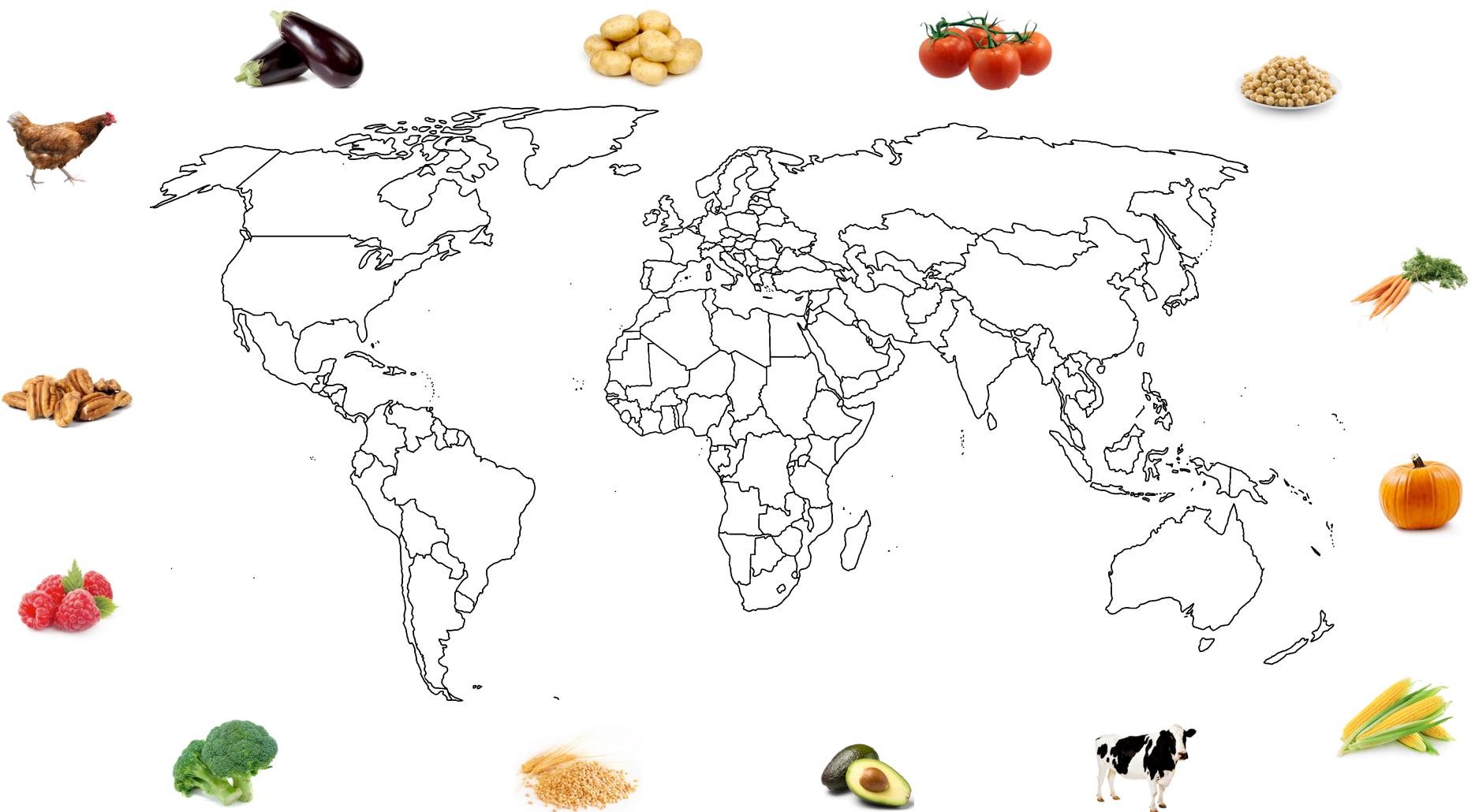
<http://www.gbif.org/>

How are species distributions changing?



# Agricultural Crops

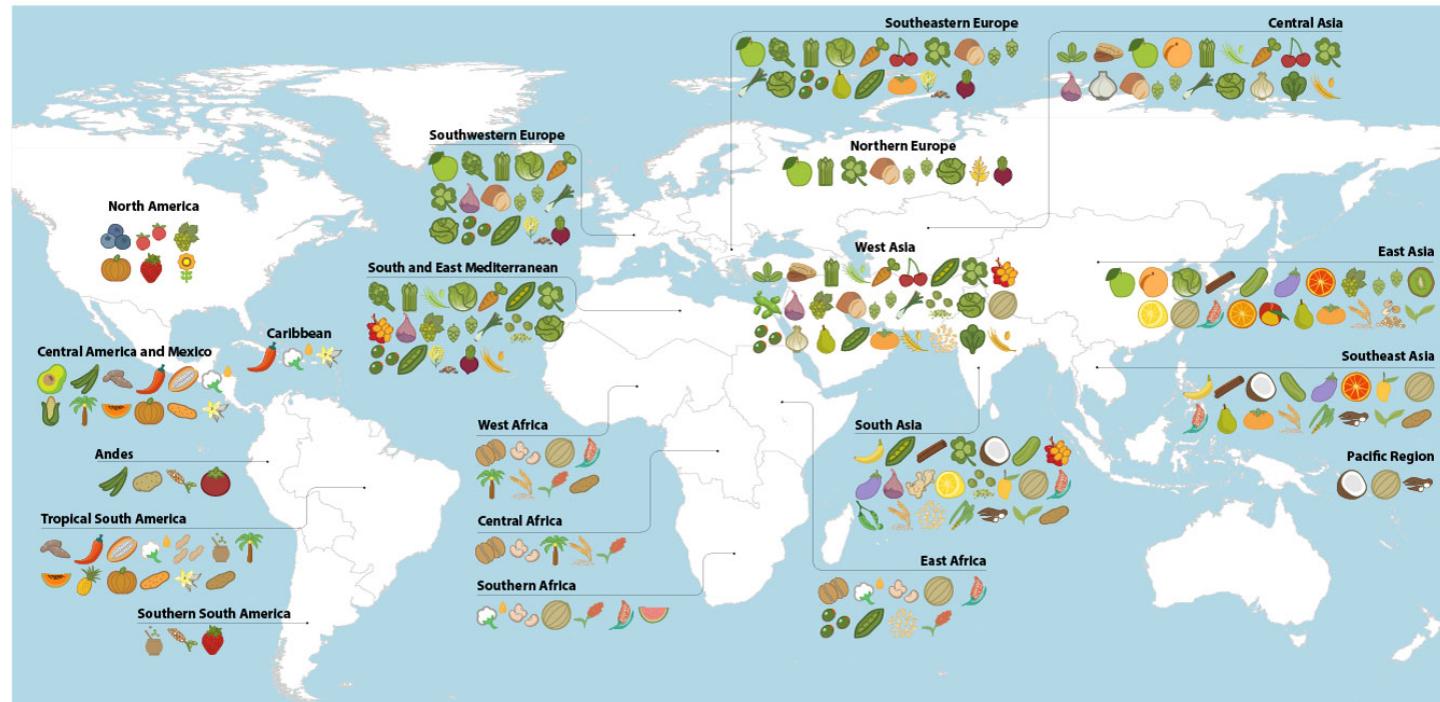




# Agricultural Crops

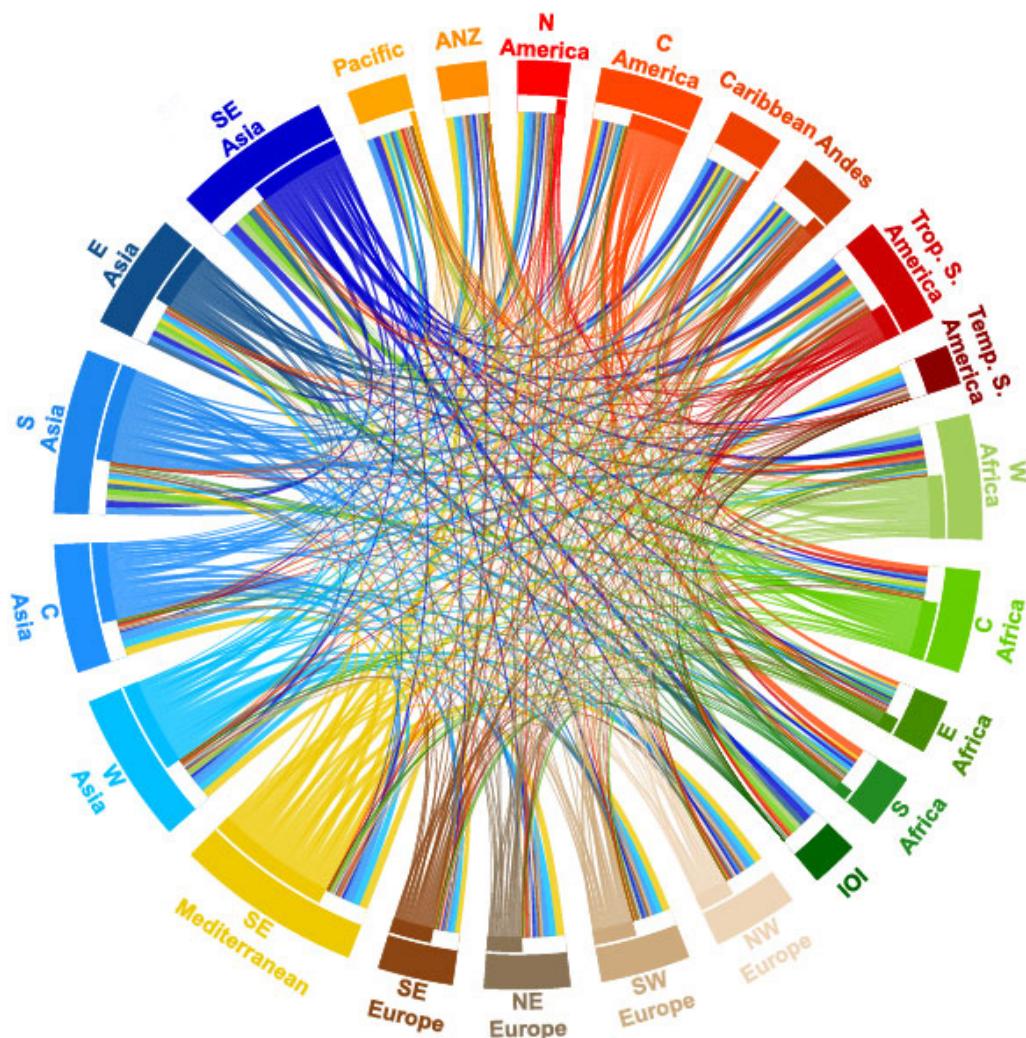


## WHERE OUR FOOD CROPS COME FROM *Global interdependence on plant genetic resources*



Alfalfa	Beans	Clover	Eggplants	Hops	Melons	Pears	Rice	Sunflower
Almonds	Blueberries	Cocoa beans	Faba beans	Kiwi	Millets	Peas	Rye	Sweet potatoes
Apples	Cabbages	Coconuts	Figs	Leeks	Oats	Pigeonpeas	Sesame	Taro
Apricots	Carrots	Coffee	Garlic	Ginger	Olives	Pineapples	Sorghum	Tea
Artichokes	Cassava	Cottonseed oil	Cowpeas	Grapefruit	Lentils	Onions	Soybean	Tomatoes
Asparagus	Cherries	Cranberries	Cucumbers	Grapes	Lettuce	Oranges	Spinach	Vanilla
Avocados	Chillies & peppers	Chickpeas	Dates	Groundnut	Maize	Palm oil	Pumpkins	Watermelons
Bananas & plantains				Hazelnuts	Mangoes	Papayas	Quinoa	Wheat
Barley				Mate	Peaches & nectarines	Peppers & mustard seed	Rape & mustard seed	Yams

[http://www.planttreaty.org/sites/default/files/files/ITPGRA\\_Interdependence\\_text\\_2015\\_9\\_18\\_0\\_Main%20text.pdf](http://www.planttreaty.org/sites/default/files/files/ITPGRA_Interdependence_text_2015_9_18_0_Main%20text.pdf)



[http://www.planttreaty.org/sites/default/files/files/ITPGRFA\\_Interdependence\\_text\\_2015\\_9\\_18\\_0\\_Main%20text.pdf](http://www.planttreaty.org/sites/default/files/files/ITPGRFA_Interdependence_text_2015_9_18_0_Main%20text.pdf)

Are these species invasive species?

What is an invasive species?

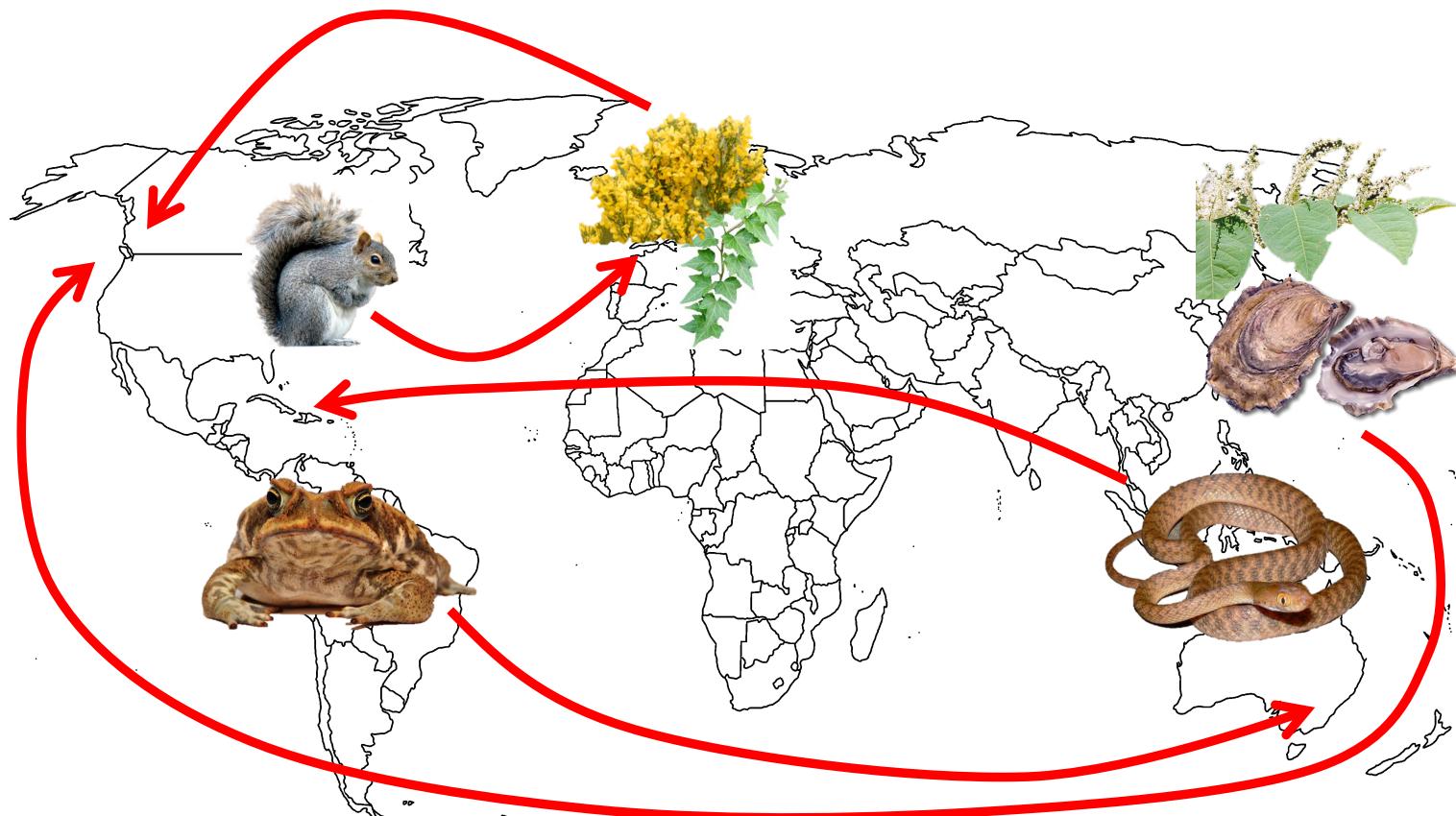


# Invasive Species

An invasive species is a plant, animal or other organism that is not native to a specific location (an Introduced species); and has a tendency to spread (invade), and causes damage to the environment, economy and/or human health.



# Invasive Species



[http://en.wikipedia.org/wiki/List\\_of\\_globally\\_invasive\\_species](http://en.wikipedia.org/wiki/List_of_globally_invasive_species)

# Invasive Species

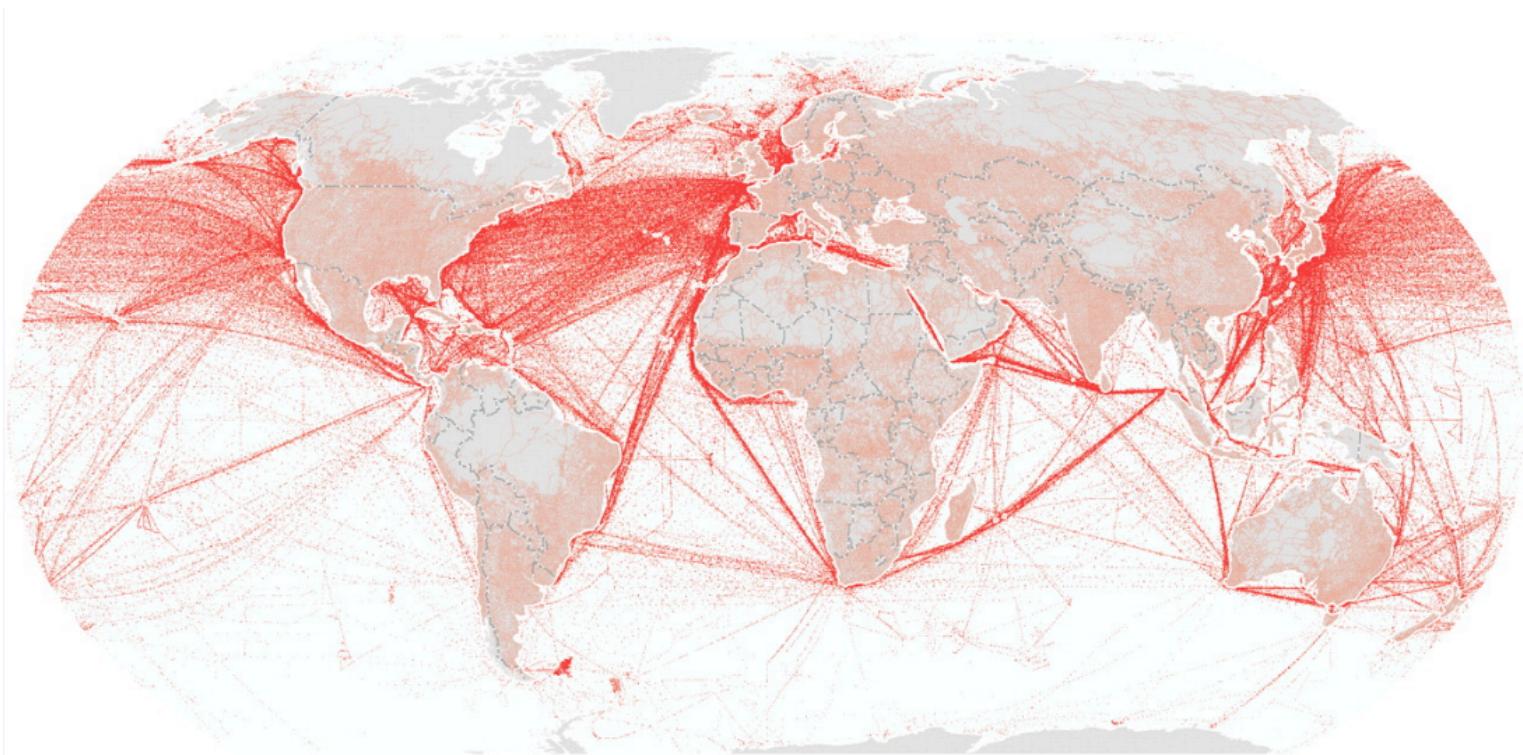


- The invasion process
- Ecological and economic impacts
- Pathways of introduction
- Predictors of invasive “success”
- Methods of prevention and control

How do invasive species get around?

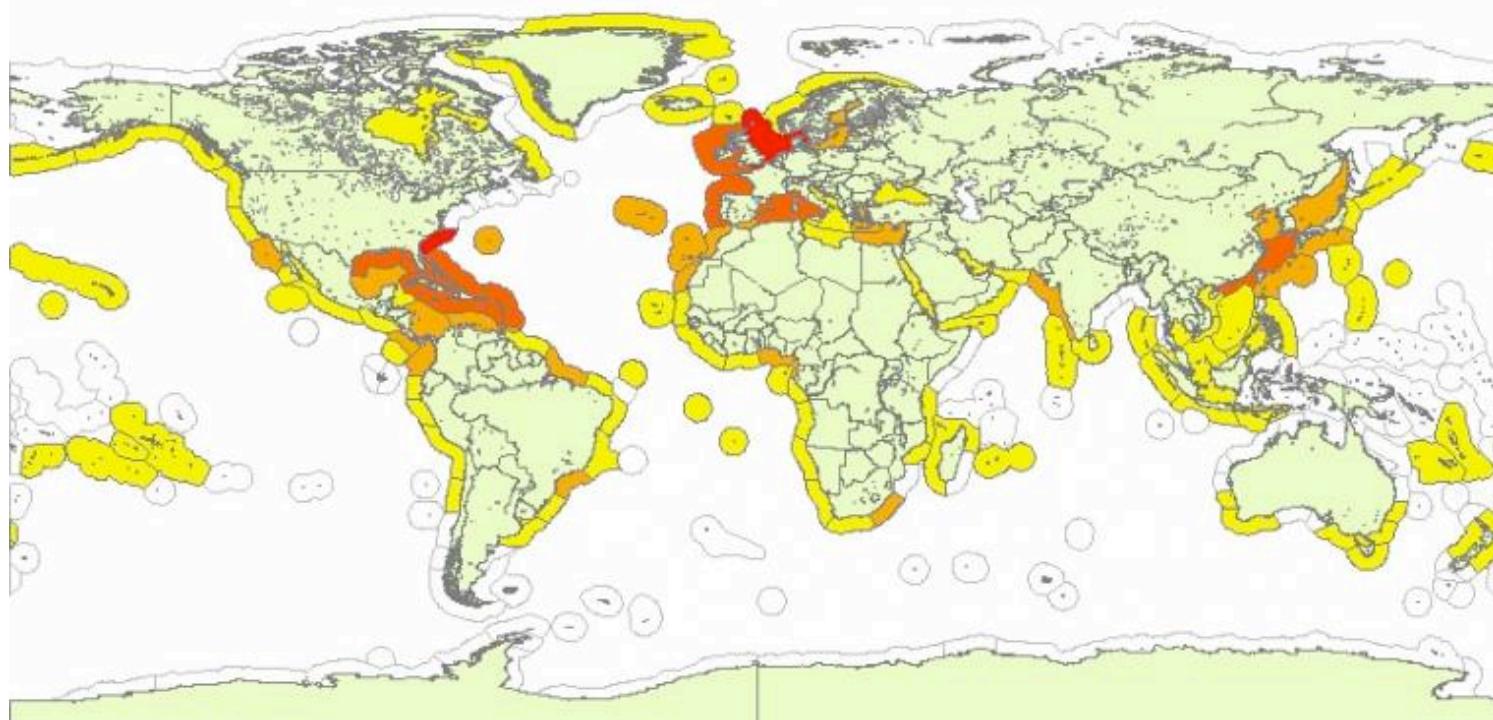


# Shipping Routes



The world's roads and shipping routes

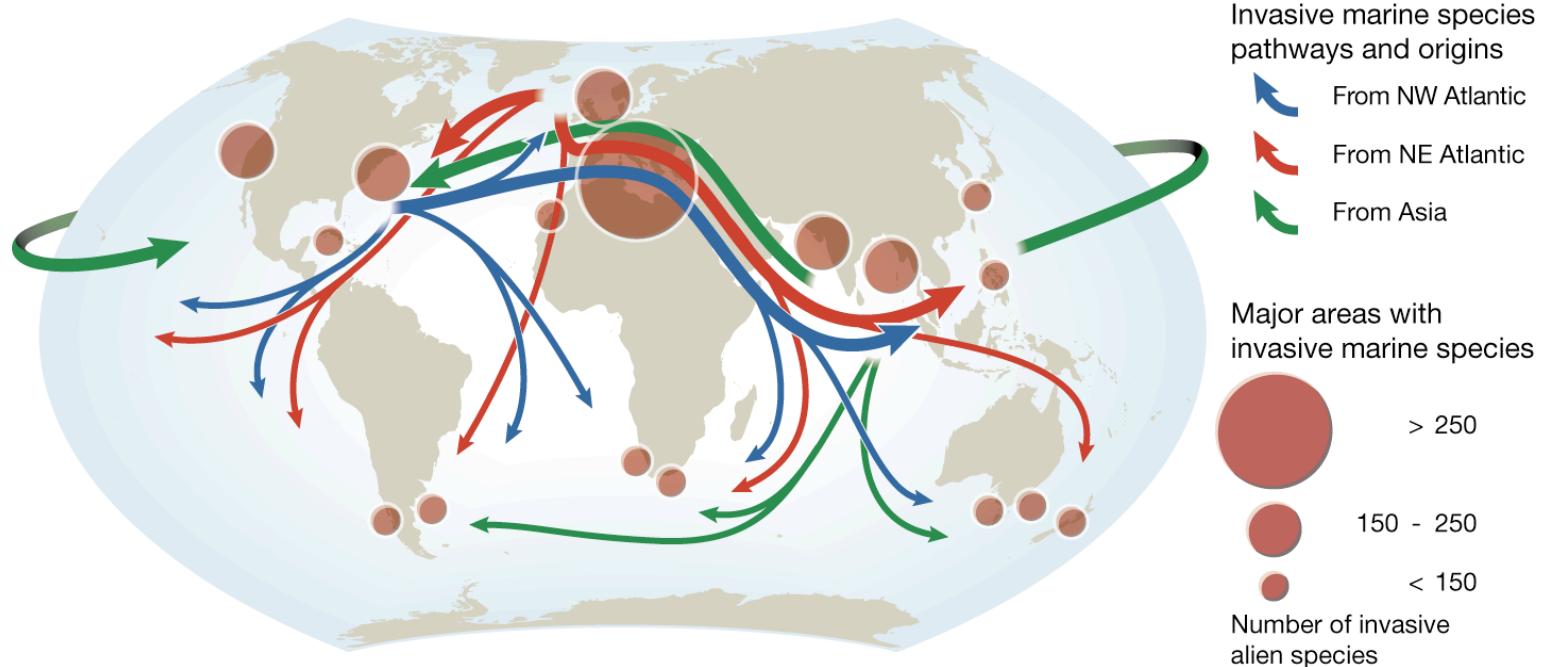
# Where is range expansion occurring?



Threat of invasive species from shipping ballast water

<http://newsoffice.mit.edu/2011/marine-species-0819>

# Pathways of Species Invasions



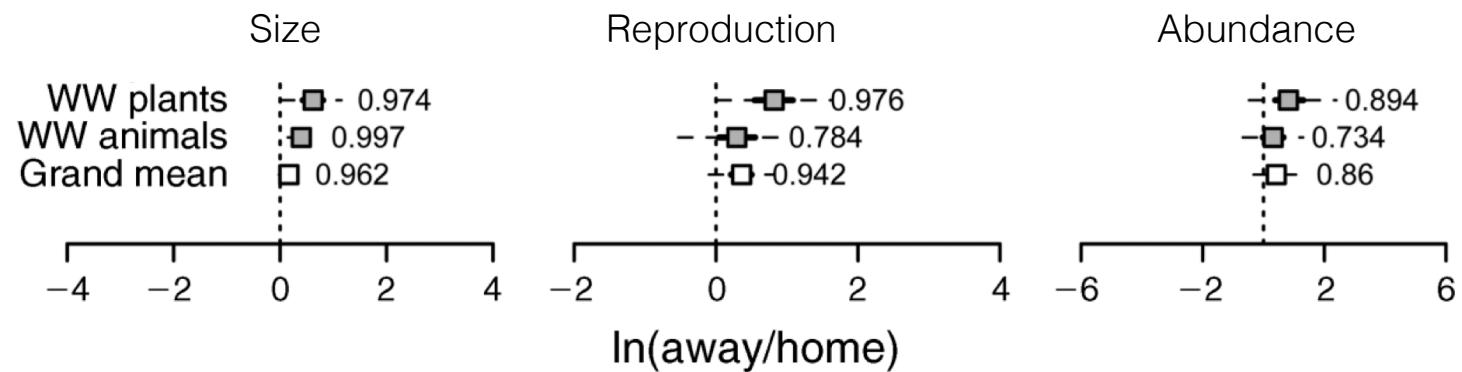
Pathways of marine invasive species

# Do invasive species perform better in their new ranges?

Broom in Scotland



Broom in British Columbia



Parker et al. Ecology 2013

What is the process of invasion?



# The Invasion Process

Uptake from native range



Transfer via vector



Release in new region



Establishment



Population increase  
& range expansion

What fraction of plant species introduced to a new continent ultimately become “invasive”?

- a) 1/2
- b) 1/5
- c) 1/10
- d) 1/100
- e) 1/1000

# The Invasion Process

The “tens rule”:

- 1/10 species that arrive will survive
- 1/10 species that survive will establish
- 1/10 species that establish will become “invasive”

The tens rule is not to be taken literally, but it captures the result that only a small proportion of introduced species ever actually becomes a concern to people.

What are the ecological impacts of invasive species?



# Ecological Impacts of Invasion

1. “Dilution” of native biodiversity
2. Direct impact on native species populations via competition, predation, disease
3. Ecosystem level change

## Dilution and competition

Even if no (little) regional extinction – effects on abundance and local diversity  
e.g., Purple loosestrife in temperate NA wetlands



## Population Declines/Extinction

Introduced predators can cause great damage (including extinction), particularly on islands with “naïve” prey e.g., brown tree snakes and feral cats on islands



Brown tree snakes



Feral cats

# Altered Ecosystem Processes

Introduced species can alter ecosystem processes  
e.g. nutrient cycling and succession in Hawaii

C4 grasses increase fire frequency, alter ecosystem properties and vegetation change in grasslands

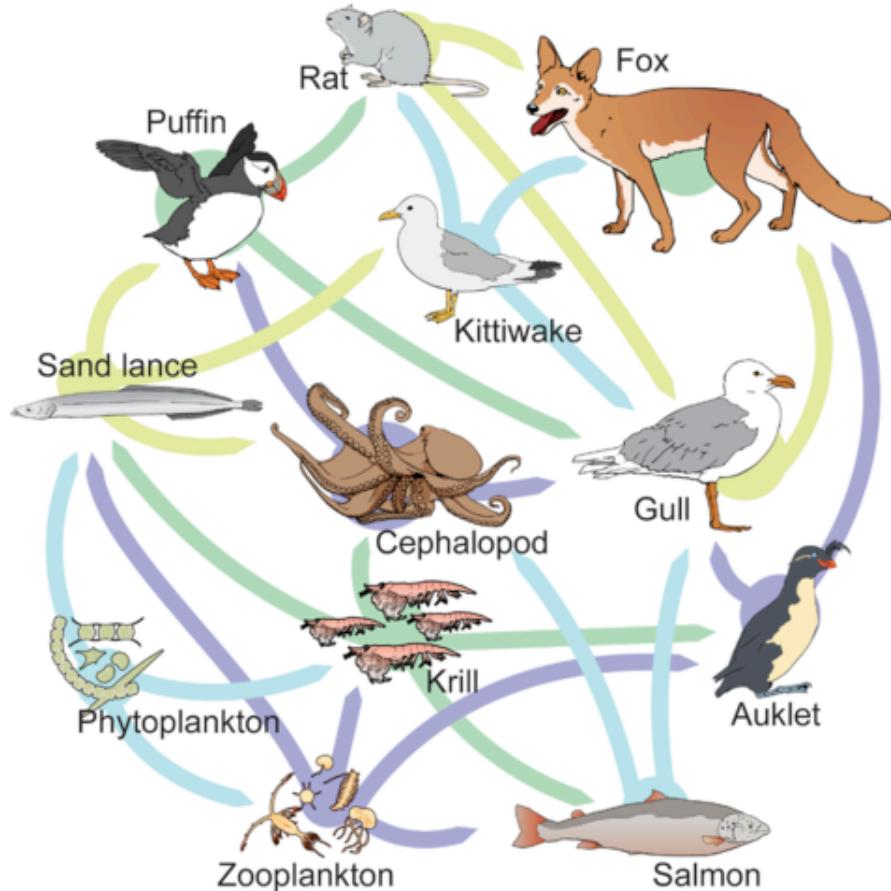


Exotic nitrogen fixer (*Myrica faya*) colonizes volcanic sites, altering nutrient cycling and succession

Hawaii Volcanoes National Park



Vitousek et al. Science 1987  
Mack & D'Antonio Ecol Appl 2001



## Ecology 101:

If we monkey around with a food web, major changes can happen (abundances of other species, fluxes of nutrients, energy, etc.).

BUT, not necessarily...

What are the economic impacts of invasive species?



## Economic impacts

- Reduce agricultural productivity (weeds)
- Forest damage (insect pests)
- Clog water intakes (zebra mussels)
- Choke waterways (aquatic plants)
- Health costs (introduced diseases)

Estimate: ~50,000 non-native species costs  
the U.S. economy >\$130 billion per year

Why do humans move species around?



# Pathways of introduction

## Intentional introduction:

- Early European settlers wanting to feel “at home”  
Horticulture and the pet trade
- Food/forage organisms: fish, pasture grasses etc.
- Biocontrol agents

## Unintentional introduction:

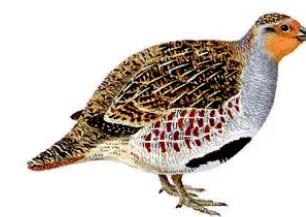
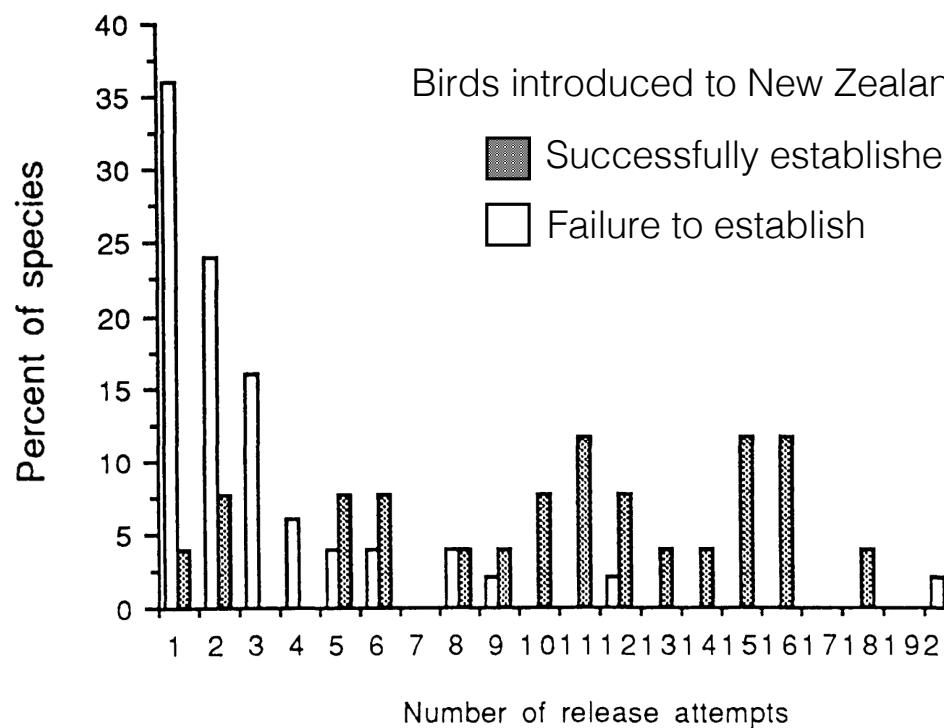
- Ship ballast water (e.g., marine invasive)
- Grain shipments (e.g., rats)
- “Stowaways” (e.g., brown tree snake)

For species that have been introduced to a new continent, the most consistent predictor of which ones will become invasive is:

- a) Reproductive rate
- b) Body size
- c) Number of individuals introduced
- d) Habitat/diet specialization

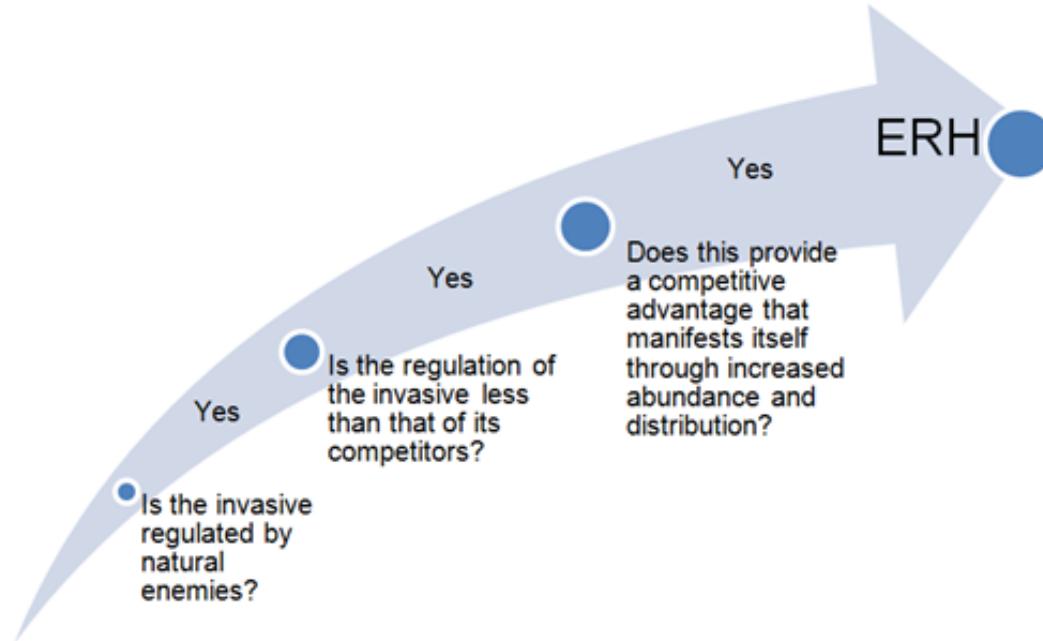
## Determinants of establishment:

The most consistent predictor of success is “propagule pressure” –  
How many individuals introduced and how often



Veltman et al. American Naturalist 1996

Determinants of invasion: The enemy-release hypothesis:  
Degree of “enemy release” predicts invasiveness of plant species in the U.S.



In pathogenic fungi & viruses in introduced range vs. native range

Mitchell & Power Nature 2003

What makes an ecosystem more or less invasible?



Determinants of invasion:

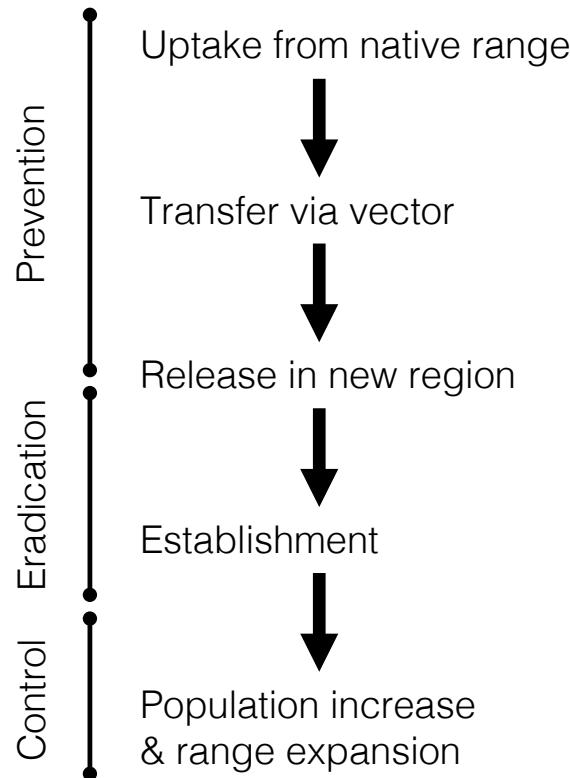
What makes a habitat more or less invasible?

- Climatic match to tolerances of invaders
- Empty niches (islands)
- Lack of enemies of invaders
- Resource availability
- Disturbance
- Anthropogenic habitats (human commensals)
- Naïve prey (islands)

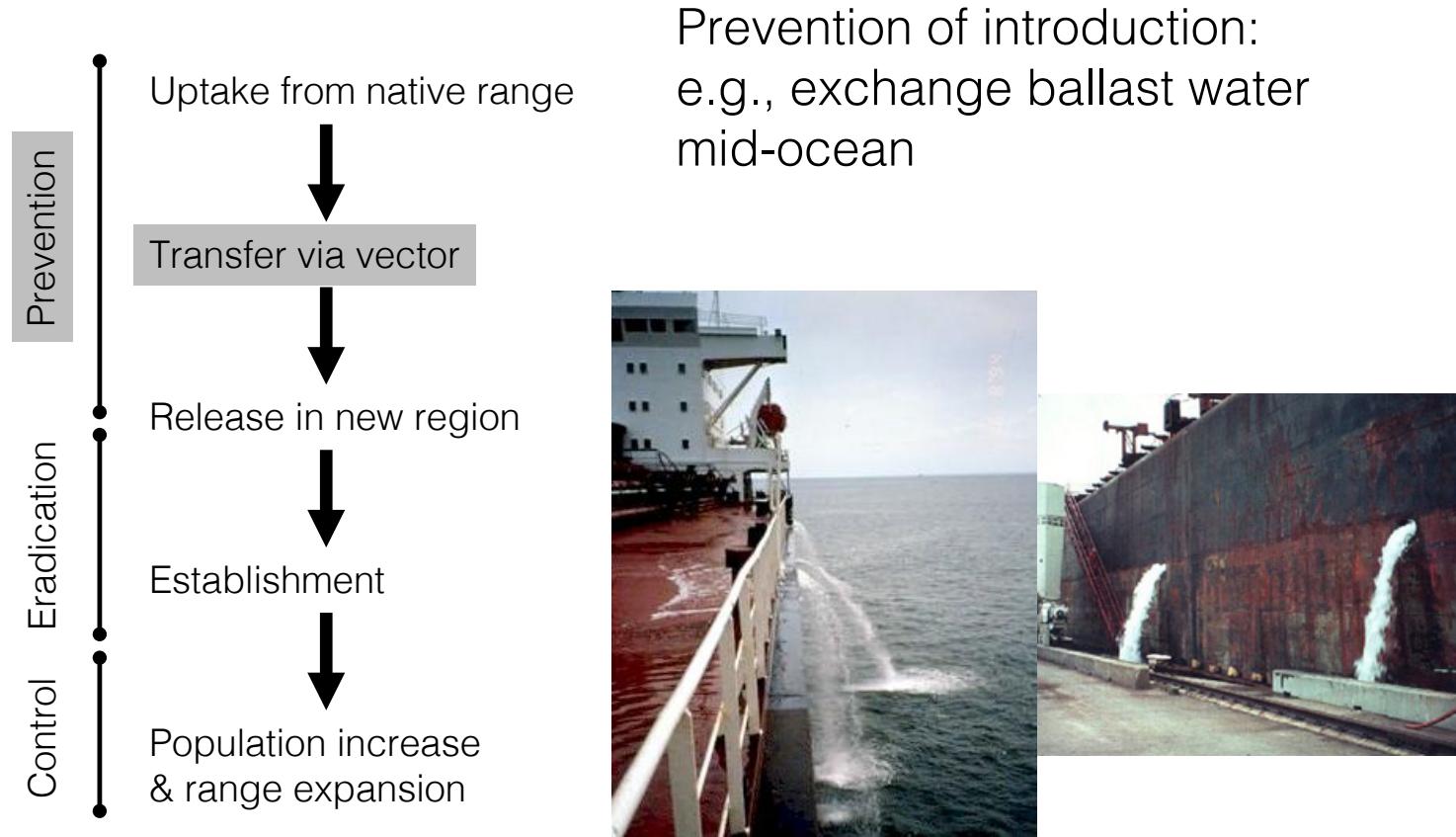
How can we limit species invasions?



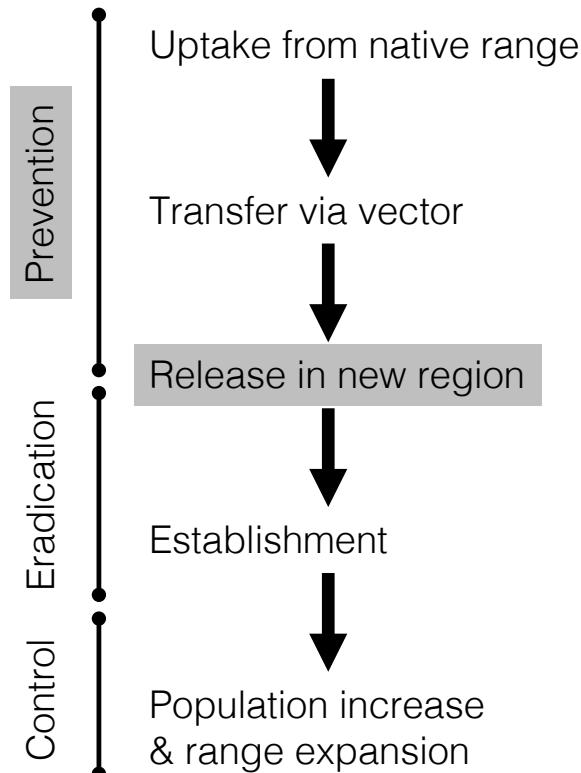
# Prevention, eradication & control of exotic species



# Prevention, eradication & control of exotic species

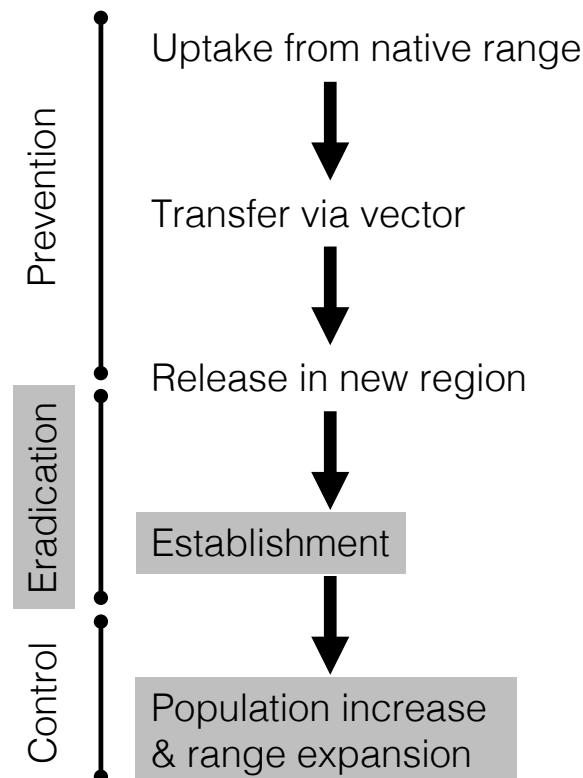


# Prevention, eradication & control of exotic species



<p><b>(-A-)</b> Customs Form C No.5360-B <b>CUSTOMS DECLARATION</b></p> <p>Declaration of Personal Effects and Unaccompanied Articles</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Flight No./Name of vessel</td> <td style="width: 50%;">(Point of embarkation)</td> </tr> <tr> <td>Date of Arrival in Japan</td> <td>Year      Month      Day</td> </tr> <tr> <td>Last name (or Surname)</td> <td>First &amp; middle name</td> </tr> <tr> <td>Name</td> <td></td> </tr> <tr> <td colspan="2">Address in Japan</td> </tr> </table>	Flight No./Name of vessel	(Point of embarkation)	Date of Arrival in Japan	Year      Month      Day	Last name (or Surname)	First & middle name	Name		Address in Japan		<p><b>(-B-)</b> Please fill out from side A. (If you have any question, please ask Customs Officer.)</p> <p><b>※ Description of Personal Effects</b></p> <p>If the total market value of each personal items dose not exceed ¥10,000, you need not write it to this Declaration Form.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td>Alcoholic Beverages</td> <td>Bottles</td> <td>* Customs use only</td> </tr> <tr> <td>Cigarettes</td> <td>Pieces</td> <td></td> </tr> <tr> <td>Tobacco Products</td> <td>Cigars</td> <td>Pieces</td> </tr> </table>	Alcoholic Beverages	Bottles	* Customs use only	Cigarettes	Pieces		Tobacco Products	Cigars	Pieces
Flight No./Name of vessel	(Point of embarkation)																			
Date of Arrival in Japan	Year      Month      Day																			
Last name (or Surname)	First & middle name																			
Name																				
Address in Japan																				
Alcoholic Beverages	Bottles	* Customs use only																		
Cigarettes	Pieces																			
Tobacco Products	Cigars	Pieces																		
<p><b>② RESTRICTED ARTICLES</b></p> <ul style="list-style-type: none"> <li>① Hunting guns, air guns, swords, etc.</li> <li>② Internationally protected endangered animals, plants, or their products. (crocodiles, cobras, turtles, ivory, musk, cactus, etc.)</li> <li>③ Live animals and plants, meat products (including sausage etc), vegetables, fruits, rice etc. (Quarantine inspection is required prior to Customs inspection.)</li> </ul> <p><b>④ Duty-Free Allowance (excluding crew member)</b></p> <p>Use to bring into Japan * If your answer to any of the questions above is "Yes", please write your belongings in "Description of Personal Effects" of side B.</p> <p>2. Cash, Checks(including T/C), Promissory Notes, Securities which exceed the amount of ¥1,000,000 or its equivalent. * If you choose "Yes", you are required to submit "REPORT OF CARRYING OF MEANS OF PAYMENT, ETC" to Customs.</p> <p>3. Do you have Unaccompanied Articles? <input checked="" type="checkbox"/> Yes <input type="checkbox"/> No * If you have unaccompanied articles, please submit this Declaration Form in duplicate. Unaccompanied articles shall be imported within 6 months from the date of your arrival. The sealed declaration must be presented at the time of clearance of the unaccompanied articles.</p> <p><b>(NOTICE)</b> Declare all the articles that you have acquired abroad and are bringing into Japan. Please cooperate with Customs Inspection. Any false declaration may be subject to punishment in accordance with the laws and regulations concerned. Thank You, and Welcome to Japan.</p>																				

# Prevention, eradication & control of exotic species



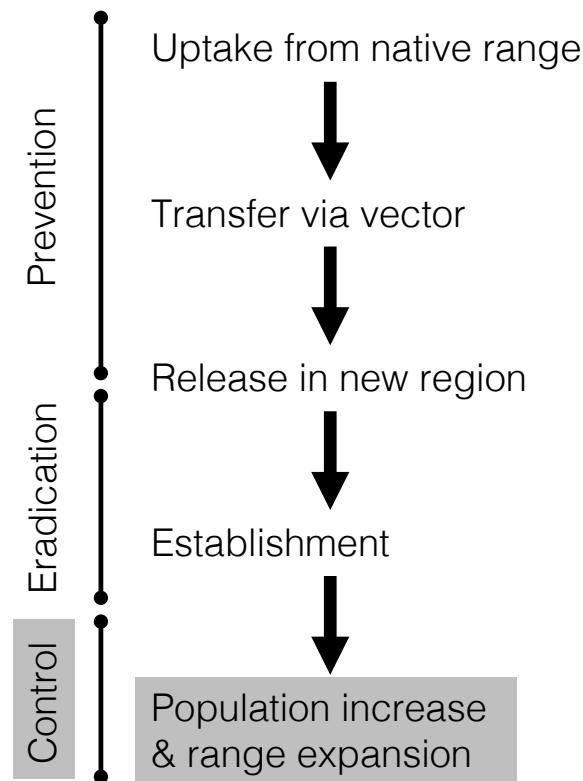
Eradication of mammals on islands:  
Feral pigs on Santiago Island, Galapagos ~19,000  
animals killed by hunting & poison over 30 years



Would be extremely difficult on a mainland

Cruz et al. Biological Conservation 2005

# Prevention, eradication & control of exotic species



Biological control:  
Introducing natural enemies to control  
invasive species



Myers et al. Biological Control 2009

Could exotic species actually lead to the creation of new biodiversity?



# Native apple maggot flies: Evolution of a novel host race – from native hawthorns to introduced apples



Filchak et al. Nature 2000

## Hybridization of closely-related natives and exotics: Polyploid speciation



Ashton & Abbott Heredity 1992

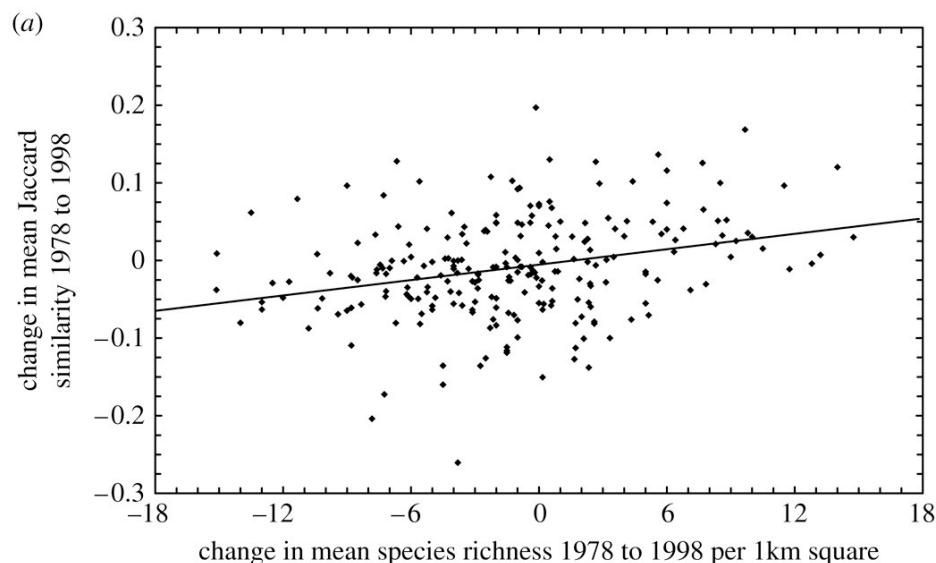
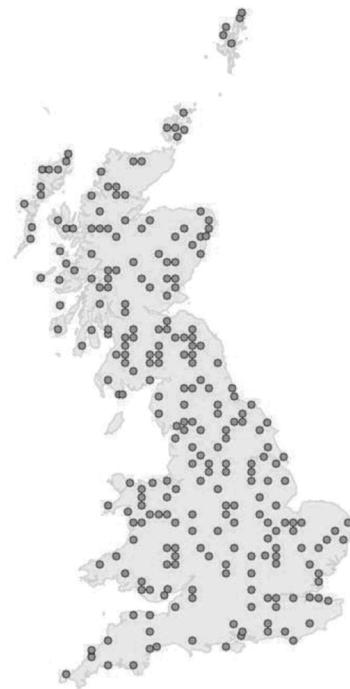
How do species range expansions influence biodiversity?



# Biotic Homogenization



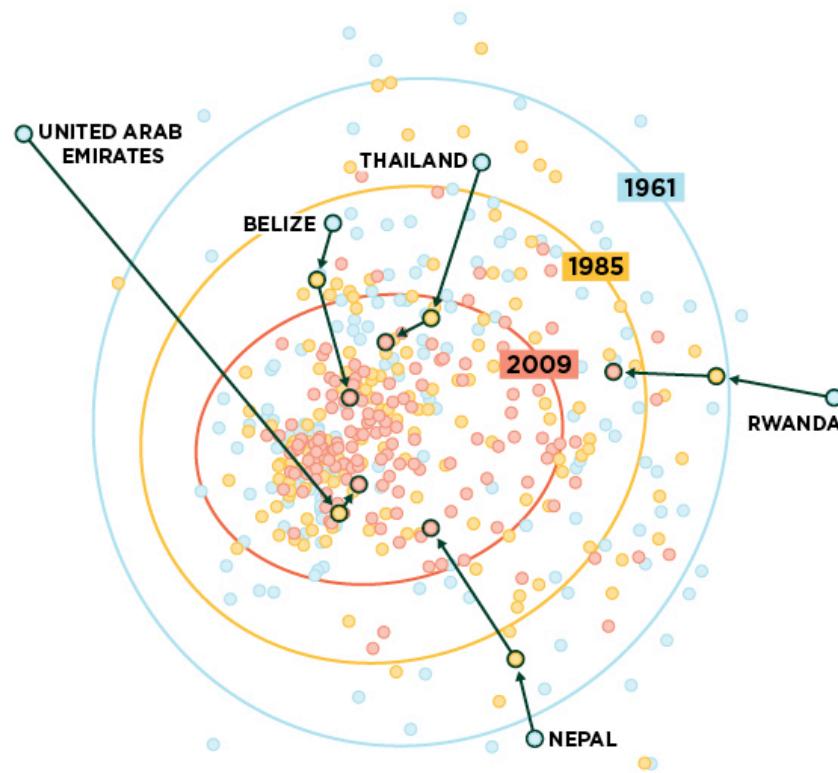
# Biotic Homogenization in the UK



Increasing similarity in plant community  
composition across the UK

Smart et al. PRSB 2006

# Biotic Homogenization in Crops



Increasing similarity in food crops  
in countries around the world

Khoury et al. PNAS 2014

What does this all mean for  
biodiversity change over time?



# Extra Reading

Williamson, Mark, and Alastair Fitter. 1996. The varying success of invaders. *Ecology*: 1661-1666.

Parker, John D., et al. 2013. Do invasive species perform better in their new ranges?. *Ecology* 94.5: 985-994.

Pimentel, David, et al. 2000. Environmental and economic costs of nonindigenous species in the United States. *BioScience* 50.1: 53-65.

Smart, Simon M., et al. 2006. Biotic homogenization and changes in species diversity across human-modified ecosystems. *Proceedings of the Royal Society B: Biological Sciences* 273.1601: 2659-2665.

Khoury, Colin K., et al. 2014. Increasing homogeneity in global food supplies and the implications for food security. *Proceedings of the National Academy of Sciences* 111.11: 4001-4006.