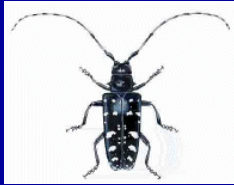




# Biological Invasions

Kathy Gerst

Dept. of Ecology and Evolutionary Biology



## What is an Invasive Species?

- Plants, animals, & microbes not native to a region
- Introduced accidentally or intentionally
- Out-compete native species for available resources, reproduce prolifically, and dominate regions and ecosystems.
- Difficult to control w/o native predators
- *Remember: not all invasive species are exotic, and not all exotic species are invasive!*



## Historical Context in North America

- Originally viewed as welcome additions to landscape!
- Domestic plants and animals
- Ornamental plants and animals to remind settlers of home

## Current State of Invasives

- Estimate there more than 6,500 species of established, self-sustaining populations of nonindigenous animals, plants, and microbes in the United States
- result from the increased movements of people, their transportation of products, and the reduced travel time between destinations



## How serious of a problem?

- Estimate of costs due to invasive spp. in U.S. is \$125-140 billion / year.
- Estimate 25% of US agriculture GNP lost to foreign pests
- Nearly 1/2 of the species listed as threatened or endangered under the E.S.A. are at risk due to competition with or predation by non-native species
- Considered by biologists to be the second greatest threat to biodiversity!!

## Ecological Impacts of Invasive Species

1. Direct interactions with native spp:
  - Competition
  - Predation
2. Impact ecosystem function
3. Spread of disease
4. Hybridization with natives

## Ecological Impacts

### 1. Direct interactions with native species:

#### Competition and Predation

- Compete for light, space, nutrients, pollinators, etc.
- Community has evolved without defense mechanisms to non-native predators

## Purple Loosestrife

- Aggressive wetland invader
- Produce up to 2.7 million seeds per plant yearly
- Spreads across approximately 480,000 additional hectares of wetlands each year
- Local fauna do NOT eat plant
- Did not become invasive for first 100 years in U.S.



## Kudzu Vine

- introduced as a fast-growing vine to help prevent soil erosion
- major pest in the southern US.
- Grows up to 1 foot/day
- Costs \$50 million/year in lost farm and timber production



## Brown Tree Snake

- originating in the South Pacific and Australia
- extirpated 10 of 13 native bird species, 6 of 12 native lizard species, and 2 of 3 bat species on the island of Guam
- Now found on Hawaii



## Domestic Cats

- Originated from wild animals in the middle east
- Hunt and kill birds, lizards, small mammals
- Carry infectious diseases that can be transferred to native animals, domestic livestock, and humans
- VERY significant impact on islands where native birds have not evolved to fear predators



## Insect Invasion!

- Argentine Ants
- Fire Ants
- Africanized Honey bees
- Asian long-horned beetle



## Ecological Impacts

### 2. Change to ecosystem function

- Biogeochemistry (ex: change in soil type)
- Biophysical processes (water uptake and transpiration)
- Trophic structure (food webs)
- Disturbance regime (ex: fire)

## Grasses in the Sonoran Desert

- Buffel grass from Africa is the most rapidly spreading invasive plant in Arizona
- Promotes fire and re-sprout easily
- Decreases water filtration into the soil
- Fire is NOT a natural part of the saguaro-palo verde plant communities
- (Kills tortoises too ☹ )
- Invasion facilitated by open space in desert: entire structure of communities changes





## Myrica faya in Hawaii

- Atmospheric nitrogen fixer
- Soils low in nitrogen (vulcanism)
- No native N-fixers in system
- Alters primary succession by increasing N availability
- By 1977 covered 600 ha, in 1985 24,200 ha
- Dispersed by a non-native bird



## Ecological Impacts

**3. Disease:** invasive species may carry diseases to which native species are not adapted.

- Avian malaria
- Chestnut blight
- Dutch Elm disease
- Small pox... ?





## Chestnut Blight

- Deciduous forests of eastern NA from Georgia and Illinois up to Maine
- Made up to 40% of overstory trees
- Early 20<sup>th</sup> century fungal disease noticed
- Fungus originated in nursery stock from Asia where it is native
- Many animal species depend on chestnuts; 7 spp. of moths and butterflies now extinct

## Ecological Impacts

### **4. Hybridization**

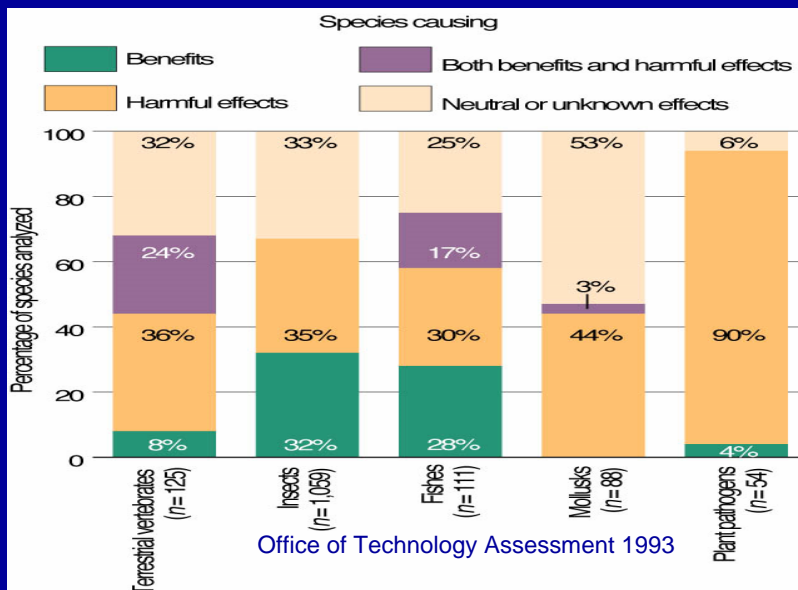
- introduced species may not be genetically separated from a native species, and can proceed to hybridize. Ex: introduced trout.
- This process may mean the end of a genetically unique local population.



## What types of species invade U.S.?

- **Plants:** ~5000 plant species (17,000 native species); ~73% of weed species exotic
- **Mammals:** ~20 species (dogs, cats, horses, burros, cattle, sheep, pigs, goats, deer, European rat, Asiatic rat, house mouse, European rabbit, Indian mongoose)
- **Birds:** ~ 97 of ~1,000 species; chickens, pigeon; starling, sparrow
- **Amphibians and Reptiles:** ~53 species
- **Fish:** ~ 138 fish (warm states); (sport fishing)
- **Arthropoda:** ~4,500 land arthropod species (2,582 in Hawaii; >2,000 in continental US; ~500 insect pests)
- **Earthworms:** 11 species
- **Mollusca:** ~ 88 species (zebra mussel, ship worm, etc)
- ~100 aquatic arthropods and worms (>95% accidental)
- **Parasites:** fungal pests; pathogens

## Potential for Harm by Organisms Type



## Not all Introduced Species Are Successful

The “Tens Rule”:

- 10% of non-native species become established
- 10% of those become ecological problems (invasives!!)

## Characteristics of Invasive Species

- Widespread distribution ( AND abundance)
- Great dispersal ability or migratory tendencies
- Great reproductive capability; being r-selected
- Early maturation; short generation time
- Small body size
- Edge species
- Affinity with humans (anthropophilic)
- Capacity for clonal/asexual reproduction

## Characteristics of Invaded Habitats

- Disturbance
- Low diversity
- Absence of predators of invading species
- Absence of native species morphologically or ecologically similar to invader
- Absence of predators or grazers in evolutionary history (naive prey)

## Accidental Introductions

- Seeds on livestock
- Disease on agricultural and forestry plants
- Aquatic organisms in ship ballast waters from international shipping
- Canals that connect formerly disconnected oceans, seas, and lakes



## Zebra Mussels

- fresh water mussels native to Black Sea
- transported to Great Lakes via ballast water from a trans-oceanic vessel.
- Mussel discovered near Detroit in 1988.
- down to Gulf of Mexico and into Connecticut
- cover large areas of lakes & rivers, prevent establishment of native species, clog pipes.



## Escaped Introductions

- Agricultural species
- Ornamental species

aquarium fish,  
residential trees,  
European birds

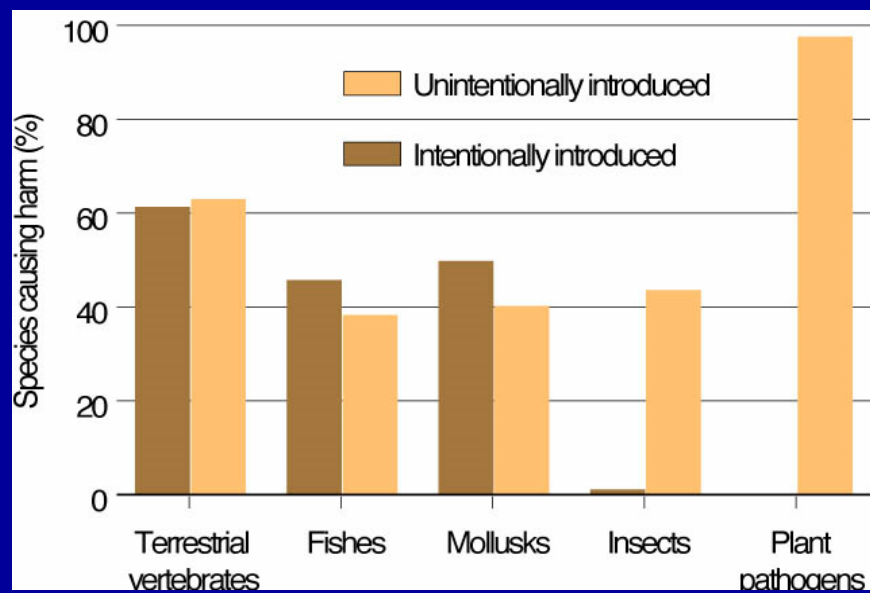


# Intentional Introductions

- Planted for erosion control, forage, forestry
- Introduced for hunting, fishing



*Arundo donax*: Giant Reed



Office of Technology Assessment 1993

## Invasives on Islands

### Example: Hawaii

- In Hawaii 50% of flora is invasive. Prior to human colonization over 90% of the flora was **endemic**
- **All** reptiles and amphibians in Hawaii are introduced.
- **Over 100** species of birds introduced.
- Mass **extinctions** of native flora and fauna are in progress due to destruction of habitat and invasion of new species.

## Federal Regulations

- **1900 Lacey Act**: U.S.F.W. ordered to restrict entry of fish or wildlife that threaten humans, agriculture, horticulture, forestry, or wildlife
- **1974 Federal Noxious Weed Act and the 1939 Federal Seed Act** : govt has authority to prohibit entry of exotic plants
- **1990 The Non-Indigenous Aquatic Nuisance Prevention and Control Act**
- **1990 Toxic Substances Control Act**: EPA can regulate non-indigenous microbes



## Federal Regulation: Effective?

- Not really
- fragmented, reductionist, and lacks policy philosophy
- Research is needed in developing effective policy and directing enforcement
- Need to incorporate economic understanding of costs
- Excellent case where science, economics, and policy need to collaborate!

## Control and Management: Options

- **Inspection/restrictions** on travel and trade
- **Genetic breeding**: selectively breed hosts for resistance against exotic diseases OR changes in genome of pests so that they are sterile or less vigorous
- **Eradication**: physically remove plants
- **Herbicides**: chemically kill plants
- **Exotic pests**: bring in biological control agent

## Salt Cedar (Tamarisk)

- Introduced as an ornamental and for windbreaks
- Invades riparian areas
- Accumulates salts in tissues which alters soil composition
- Uses lots of water!
- Provides poor wildlife habitat
- Forms monocultures
- decreases biodiversity



## Management of Salt Cedar

- **Manual removal**
  - Costly and takes a LONG time
- **Chemical/herbicide**
  - Usually used in conjunction with manual removal; expensive, risk of harming other species
- **Restore flood regime**
- **Biological control**
  - Possible more effective and less costly solution???



## Biological Control (biocontrol)

- Definition: the use of natural enemies to reduce damage caused by pest population.
- Based on principles of population dynamics- animals are adapted to interact with other species, which keep each other 'in check'

## Biological Control

- Biological Control has been used successfully in the U.S. since 1889
- Around the world, about 420 invasive spp. have been controlled successfully with biocontrol
- Benefit/cost ratio can be very high: the derived benefit of controlling a pest divided by the total cost of the biological control project.

## Biological Control

- **Agents:**
  - Predators
  - Parasites
  - pathogens
- **Objectives:**
  - Reduction
  - Prevention
  - Delay



## Why introduce insect herbivores?

- Salt cedar has little/no natural enemies in new habitat
- This gives it a competitive advantage over native species
- Introduction of one of its herbivores from its native habitat will help control it, slow reproduction, and integrate plant into the environment
- Best case scenario- will kill entire stands of individuals

## *Diorhabda elongata*

- Beetle co-evolved with salt cedar in China.
- Salt cedar is only plant insect feeds or reproduces on
- Has special adaptations to be a specialist on salt cedar



## Salt Cedar defoliation: NV



## The Big Question: What if the biocontrol agent itself becomes invasive??

- Beetle was tested for 13 years in quarantine before release to be sure it was not going to feed on native plants
- Biologists feel any risks of beetle changing hosts are outweighed by potential benefits
- Tamarisk has no close relatives in N.A.



## Biocontrol Success Stories

- Prickly Pear Cactus and moth borer in Australia (1926)
- Vedalia Beetle in California; saved citrus industry from scales: 1890s
- Cassava mealybug in Africa with a wasp from South America (1980s)



## Benefits

- Roughly one in five of all recent biological control projects have led to economically significant control of the target
- Virtually no continuing expenses
- Yearly benefits from biological control programs in the U.S. are estimated to exceed \$180 million



## Biocontrol Horror Stories

- Cane Toads in Australia: introduced to control Cane grub

*Cane Toads: An Unnatural History 1987*

- Rosy Wolfsnail in Hawaii: introduced to control Giant African Snail. Prefers small native spp. (15-20 native snails extinct)
- Indian Mongoose





## Conclusion

- Invasives are a threat to human health, biodiversity and ecosystem functions
- Need to put an **ECONOMIC** value on loss of species, habitats, and ecosystem functions as a result of invasive species
- Most important solution is early detection and **PREVENTION!**
- Education!

## Biocontrol and catastrophic mistakes

- Take home message:
  - Control agent must be a specialist on target!
  - Generalist vertebrates = bad biocontrol
- Some of worst invaders today were originally introduced for control of other invasive species
- What works in one site, won't work in others

