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

- More than 6,500 species of established, self-sustaining populations of non-native animals, plants, and microbes in the U.S.
- result from: increased movements of people, transportation of products, and reduced travel time between destinations
How serious of a problem?

• Costs due to invasive spp. in U.S. is $125-140 billion / year.
• 25% of US agriculture GNP lost to foreign pests
• Nearly 1/2 of 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**

- fast-growing vine introduced to prevent soil erosion
- major pest in the southern US.
- Grows up to 1 foot/day
- Costs $50 million/year in lost farm & 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 cats in the middle east

• Hunt native 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 Invasions

• 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
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
- Made up to 40% of overstory trees
- In early 1900s 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.
   → may mean the end of a genetically unique local population.

Invasives on Islands
   Example: Hawaii
   • 50% of flora considered invasive. Prior to human colonization over 90% of flora was endemic
   • All reptiles and amphibians 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.
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

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 (anthrophilic)
• 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.
- 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
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/animals

• **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’

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**Biological Control**

- **Used successfully in the U.S. since 1889**

- **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.
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
- Very small risks of beetle changing hosts are outweighed by 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 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

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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
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