



Biological Invasions

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Historical context in North America

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

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What is an invasive species?

- a species of plant, animal, or other organism that was introduced (usually by man; occasionally invasives are natives) to a non-native ecosystem, where it became harmful to the natural environment or to human health.

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Current state

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



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What is an invasive species?

TYPICALLY: organism 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!



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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!

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Not all introduced species are successful

The "Tens Rule":

10% of non-native species become established

10% of those become ecological problems (invasives!!)

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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



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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

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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.



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)

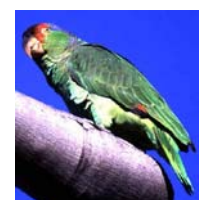
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Escaped Introductions

Agricultural species

Ornamental species

aquarium fish,
residential trees,
European birds



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Intentional Introductions

Planted for erosion control,
forage, forestry

Introduced for hunting,
fishing



Arundo donax: Giant Reed

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.



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Ecological impacts of invasive species

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

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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



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Ecological impacts

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

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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 (islands and invasives)

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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



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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... ?



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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)

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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

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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



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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.



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Control and management options

Inspection/restrictions on travel and trade

Genetic breeding

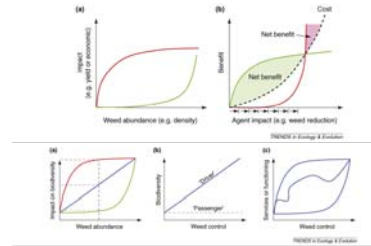
Eradication: physically remove plants/animals

Herbicides: chemically kill (plants)

Exotic pests: bring in biological control agent

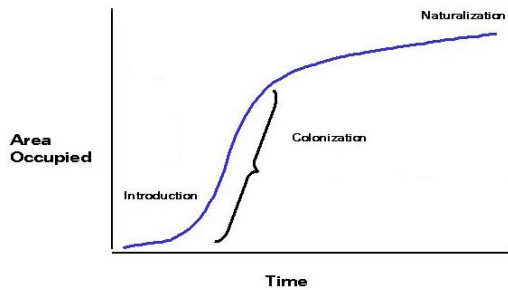
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But... may have different patterns of impact

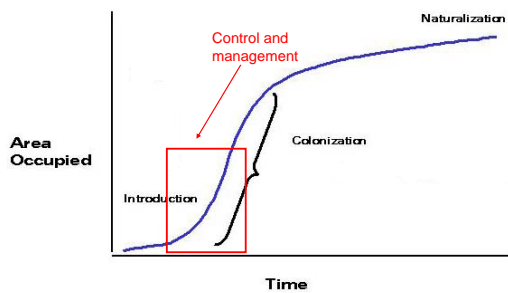


Control may have different levels of benefits for biodiversity depending on the nature of the invasive spp and the circumstances of invasion.²⁸

Thomas and Reid, 2007. *TREE*.



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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

Restore flood regime

Biological control

use of natural enemies to reduce damage caused by pest population

Possible more effective and less costly solution???

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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.

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Salt Cedar defoliation: NV



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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 herbivores from native habitat will help control it and slow reproduction

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Moab, Utah

-increased bird, spider diversity with beetle introduction



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



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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
- The very small risk of beetle changing hosts are outweighed by benefits
- Tamarisk has no close relatives in N.A.



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Biocontrol Success Stories

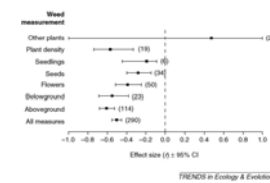
- Prickly Pear Cactus and moth borer in Australia (1926)
- Vedalia Beetle in California; saved citrus industry from scales: 1890s
- Cassava mealybug in Africa with a wasp from South America (1980s)



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Additional issues with biocontrol

- Not enough quantitative evaluation of success
- Studies focus on affects of biocontrol agent on individual plants but not necessarily the whole population, community and ecosystem



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Thomas and Reid, 2007. *TREE*.

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)



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Conclusion

- Invasive species 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 impact
- Most important solution is early detection and **PREVENTION**

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Biocontrol 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

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