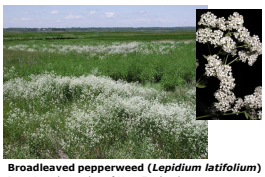
Landscape Level Effects Biological Invasive Species



Broadleaved pepperweed (*Lepidium latifolium*)
Invasive plant atlas of New England

Spotted knapweed (*Centaurea biebersteinii*)
Weedwatchers.org

Eucalyptus (*Eucalyptus grandis x urophylla*)
Forestryimages.org

Definition of "biological invasive species":

- ✓ A species whose introduction and subsequent in an ecosystem alters how that ecosystem functions. The changes caused may be related to: competition for resources, species recruitment, nutrient cycling, probability of disturbance or many other ecosystem processes.
- ✓ The presence of the biological invasive species results in the partial or complete replacement of the native community.
- ✓ Most ecologists reserve this term for non-native species, but it has also been applied to native species in some instances.

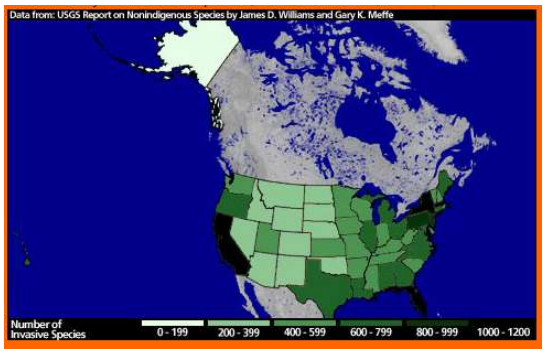
Related terms that are often confused with Biological Invasive Species

Exotic species- exotic species are those that were intentionally or otherwise introduced to an area

Weed- an undesirable species, these may include both native and non-native species, desirability is relative to the current land use

Noxious weed- these are species that have been designated as undesirable and **must** be controlled by the land manager, this designation is done usually at the state level but occasionally at the county level as well

Number of Invasive Species



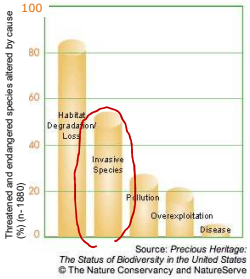
Source: Science Online

Importance of Biological Invasions

Biological invasions by non-native species may be one of the most serious conservation problems that we face in the future.

The invasions are occurring on a global scale on most types of vegetation.

It has been stated that it is the second most important cause of loss of global diversity on all vegetation types, following direct loss of habitat (Vitousek et al. 1997).



Source: The Nature Conservancy

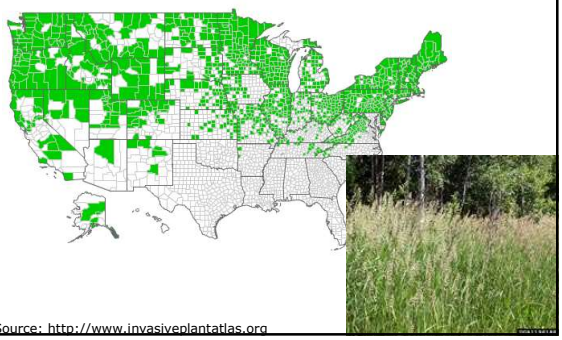
Exotic Flora in Biomes of the World

The percentage of the flora that is exotic of different biomes around the world

Biome	Mean (%)	n
Temperate agriculture/urban	31±9	24
Temperate forest	22±16	13
Multiple habitats	19±11	26
Mediterranean shrubland	17±13	43
Alpine	11±8	26
Savanna	8±6	33
Wet tropics	6	1
Desert	6±3	18

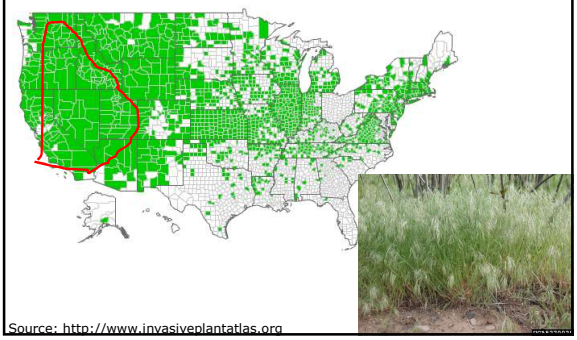
Adapted from Lonsdale 1999, Table 6

US Counties where reed canarygrass (*Phalaris arundinacea*) has been reported invasive



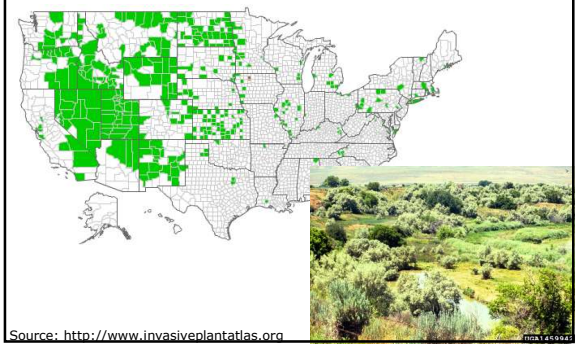
Source: http://www.invasiveplantatlas.org

US Counties where cheatgrass (*Bromus tectorum*) has been reported invasive



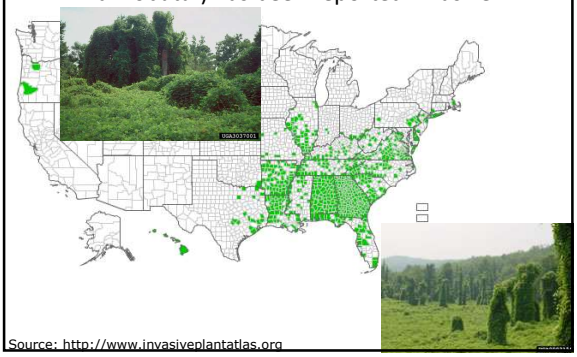
Source: http://www.invasiveplantatlas.org

US Counties where Russian-olive (*Elaeagnus angustifolia*) has been reported invasive



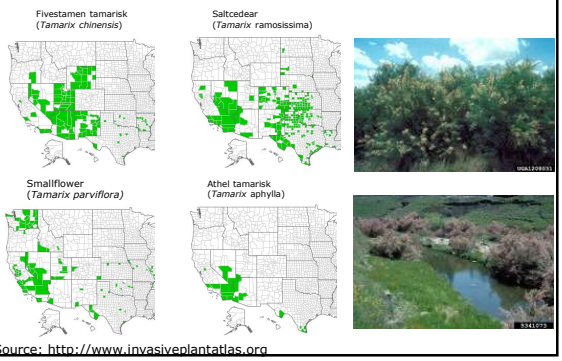
Source: http://www.invasiveplantatlas.org

US Counties where kudzu (*Pueraria montana* var. *lobata*) has been reported invasive



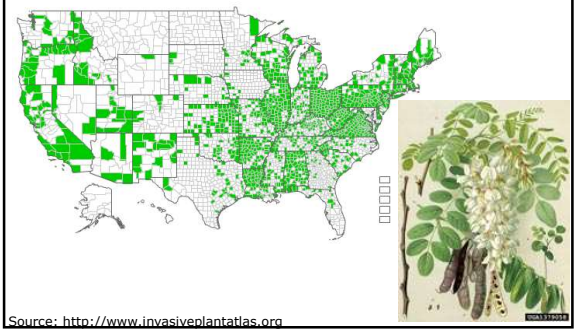
Source: http://www.invasiveplantatlas.org

US Counties where saltcedar (aka Tamarisk) (*Tamarix spp.*) has been reported invasive



Source: http://www.invasiveplantatlas.org

US Counties where black locust (*Robinia pseudoacacia*) has been reported invasive



Source: http://www.invasiveplantatlas.org

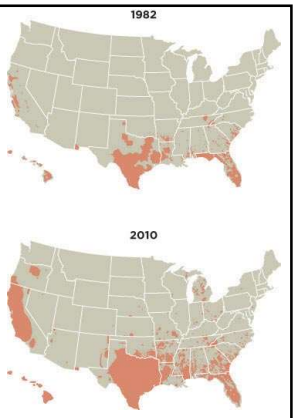
Feral pigs occur in 39 states and 4 Canadian provinces

Source: Smithsonian web site: http: smith.hy.pr/invasive

Increase in the range of feral pigs in the United States (1982-2010)

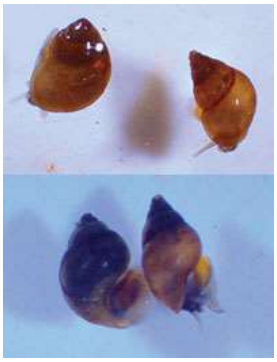
Estimated population: 2-6 million animals, 50% in Texas

Feral pig damage to field in eastern Texas



Source: Smithsonian web site: http: smith.hy.pr/invasive

Invasive invertebrates



The endemic Jackson Lake spring snail (*Pyrgulopsis robusta*; top) and the invasive New Zealand mudsnail (*Potamopyrgus antipodarum*; bottom) can be difficult to distinguish in the field; however, the Jackson Lake spring snail is wider for its length.

The distribution of the New Zealand mudsnail is widespread and completely overlaps the remaining narrow range of the Jackson Lake spring snail. Study results in 2006 show that the mudsnail population exists in there at extremely high densities (>500,000 snails/m^2). The superior competitive ability of the mudsnail is threatening coexistence of the spring snail.

Source: US National Park Service

Native Invasive Species

Native species may also increase in abundance or expand their local range responding to changes in disturbance regimes or other factors. These species may also dramatically change the composition and ecological function of a site. However, the term "**biological invader**" is typically reserved for non-native species.

Curly-cup gumweed
U of I Range Dept photo

Green rabbitbrush
U of I Range Dept photo

Plains pricklypear cactus
forestryimages.org photo

100 OF THE WORLD'S WORST INVASIVE ALIEN SPECIES

MICRO-ORGANISM

avian malaria (*Plasmodium relictum*)
banana bunchy top virus (*Banana bunchy top virus*)
rinderpest virus (*Rinderpest virus*)

MACRO-FUNGI

chestnut blight (*Cryphonectria parasitica*)
crayfish plague (*Aphanomyces astaci*)
Dutch elm disease (*Ophiostoma ulmi*)
frog chytrid fungus (*Batrachochytrium dendrobatidis*)
phytophthora root rot (*Phytophthora cinnamomi*)

AQUATIC PLANT

caulerpa seaweed (*Caulerpa taxifolia*)
common cord-grass (*Spartina anglica*)
wakame seaweed (*Undaria pinnatifida*)
water hyacinth (*Eichhornia crassipes*)

LAND PLANT

African tulip tree (*Spathodea campanulata*)
black wattle (*Acacia mearnsii*)
Brazilian pepper tree (*Schinus terebinthifolius*)
cogon grass (*Imperata cylindrica*)
cluster pine (*Pinus pinaster*)
erect prickly pear (*Opuntia stricta*)
fire tree (*Myrica faya*)
giant reed (*Arundo donax*)
gorse (*Ulex europaeus*)
hiptage (*Hiptage benghalensis*)
Japanese knotweed (*Fallopia japonica*)
Kahili ginger (*Hedychium gardnerianum*)
Kostor's curse (*Clidemia hirta*)
leadtree (*Pueraria montana* var. *lobata*)
lantana (*Lantana camara*)
leafy spurge (*Euphorbia esula*)
leucaena (*Leucaena leucocephala*)
melaleuca (*Melaleuca quinquenervia*)
mesquite (*Prosopis glandulosa*)
miconia (*Miconia calvescens*)
mile-a-minute weed (*Mikania micrantha*)
mimosa (*Mimosa pigra*)
privet (*Ligustrum robustum*)
pampasweed (*Cortaderia jubata*)
purple loosestrife (*Lythrum salicaria*)
quinine tree (*Cinchona pubescens*)
shoebutton ardisia (*Ardisia elliptica*)

LAND PLANT (CONTINUED)

Sam weed (*Ulex europaeus*)
strawberry guava (*Pistia stratiotes*)
tamarisk (*Tamarix ramosissima*)
wedelia (*Sphagneticola trilobata*)
yellow Himalayan raspberry (*Rubus ellipticus*)

AQUATIC INVERTEBRATE

Chinese mitten crab (*Eriocheir sinensis*)
comb jelly (*Mnemiopsis leidyi*)
fish hook flea (*Cercopagis pengoi*)
golden apple snail (*Pomacea canaliculata*)
green crab (*Carcinus maenas*)
marine clam (*Potamocorbula amurensis*)
Mediterranean mussel (*Mytilus galloprovincialis*)
Northern Pacific seastar (*Asterias amurensis*)
zebra mussel (*Dreissena polymorpha*)

LAND INVERTEBRATE

Argentine ant (*Linepithema humile*)
Asian longhorned beetle (*Anoplophora glabripennis*)
Asian tiger mosquito (*Aedes albopictus*)
big-headed ant (*Pheidole megacephala*)
common malaria mosquito (*Anopheles quadrimaculatus*)
common wasp (*Vespula vulgaris*)
crazy ant (*Anoplolepis gracilipes*)
cypress aphid (*Cinara cupressi*)
flatworm (*Platydemus manokwari*)
Formosan subterranean termite (*Coptotermes formosanus shiraki*)
giant African snail (*Achatina fulica*)
gypsy moth (*Lymantria dispar*)
Khapra beetle (*Trogoderma granarium*)
little fire ant (*Wasmannia auropunctata*)
red imported fire ant (*Solenopsis invicta*)
rosy wolf snail (*Euglandina rosea*)
sweet potato whitefly (*Bemisia tabaci*)

AMPHIBIAN

bullfrog (*Rana catesbeiana*)
cane toad (*Bufo marinus*)
Caribbean tree frog (*Eleutherodactylus coqui*)

FISH

brown trout (*Salmo trutta*)
carp (*Cyprinus carpio*)
large-mouth bass (*Micropterus salmoides*)

FISH (CONTINUED)

Mozambique tilapia (*Oreochromis mossambicus*)
Nile perch (*Lates niloticus*)
rainbow trout (*Oncorhynchus mykiss*)
walking catfish (*Clarias batrachus*)
Western mosquito fish (*Gambusia affinis*)

BIRD

Indian myna bird (*Acridotheres tristis*)
red-vented bulbul (*Pycnonotus cafer*)
starling (*Sturnus vulgaris*)

REPTILE

brown tree snake (*Boiga irregularis*)
red-eared slider (*Trachemys scripta*)

MAMMAL

brushtail possum (*Trichosurus vulpecula*)
domestic cat (*Felis catus*)
goat (*Capra hircus*)
grey squirrel (*Sciurus carolinensis*)
mangabey monkey (*Macaca fascicularis*)
mouse (*Mus musculus*)
nutria (*Myocastor coypus*)
pig (*Sus scrofa*)
rabbit (*Oryctolagus cuniculus*)
red deer (*Cervus elaphus*)
red fox (*Vulpes vulpes*)
ship rat (*Rattus rattus*)
small Indian mongoose (*Herpestes javanicus*)
stoat (*Mustela erminea*)

Species were selected for the list using two criteria: their serious impact on biological diversity and/or human activities, and their illustration of important issues of biological invasion. To ensure a wide variety of examples, only one species from each genus was selected. **Absence from the list does not imply that a species poses a lesser threat.**

Development of the *100 of the World's Worst Invasive Alien Species* list has been made possible by the support of the Frodaland Enterprise TOTAL (1998 - 2000).

For further information on these and other invasive alien species consult: The *Global Invasive Species Database*: www.issg.org/database

The Invasive Species Specialist Group (ISSG) is a New Zealand-based specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN). It is chaired by Dr Mick Clout (University of Auckland).

Invasive Species Strategies

- **Efficient gap colonizers**- prolific seed producers and possess efficient seed transport mechanisms
  - Get there first!
- **Efficient competitors**- extremely efficient at gathering light or nutrients from a system, or may be able to gather resources at a time when the natives can not
  - Once established can spread quickly
- **Adapted to human-caused habitats**- extremely well suited to occupying habitats frequently created by human activities (roadsides, fields, animal corrals)
- **Open niche fillers**- occupies niches that are not well filled by the natural biota
- **Predator release**- suffer high predator loss in natural environment but are prolific when introduced to an area without this predator.
  - Good targets for biocontrol

Bazzaz 1986, Newsome and Noble 1986, Vitousek 1986

Conditions that Predispose Vegetation to Biological Invasion

- Communities with simple flora, composed of species with broad realized niches and poorly developed interspecific relationships.
- Non-resilient communities with severe disturbance as part of the "normal" disturbance regime.
- Communities which have experienced changes in the disturbance regime (frequency, severity, extent).
- Human-caused changes in resource availability (nutrient levels, chemical pollution, water impoundments) which are far beyond the system's natural capability to buffer.

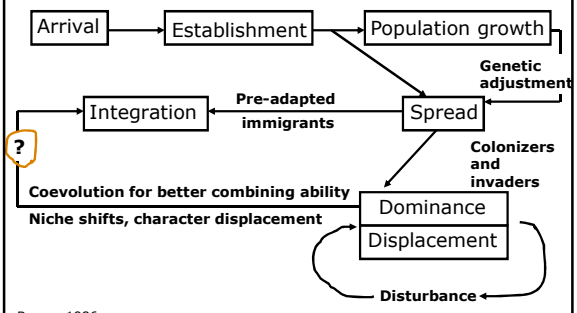
Community Invasibility

- Invasibility of the community increased as gaps (bare ground) increased (Burke and Grime 1996).
- Higgins et al. (1996) found that seed dispersal potential was the most important factor in invasive species spread in South African fynbos vegetation (a Mediterranean-type shrubland).
- Communities assembled from larger pools of species were more resistant to invasion than those from small pools (Law and Morton 1996).
- Shurin (2000) found that more diverse communities were more resistant to invasion than more simple communities (Pond zooplankton).

Community Invasibility

- Stohlgren et al. (1999) **did not** find that diversity was strongly associated with resistance to invasion in central Great Plains grasslands. Resistance was more related to how well the resources of a community were utilized.
- Symstad (2000) found that for restored Minnesota prairie vegetation that:
  - Functional group diversity **did not** make the community more resistant to invasion. Only C3 grass species presence was weakly associated with resistance to invasion.
  - The individual species response to disturbance was more highly related to resistance to invasion.

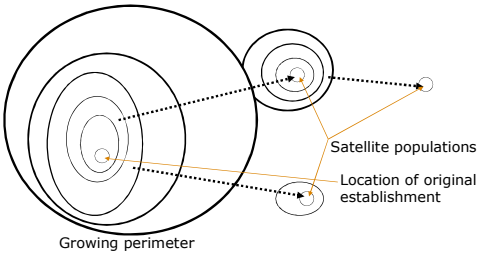
Invasion Process



Bazzaz 1986

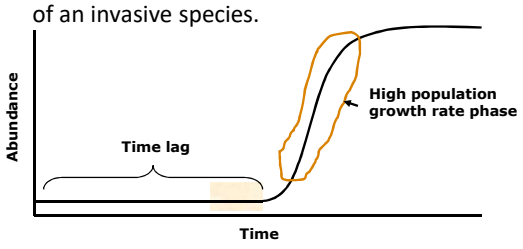
Invasion Process

The invasion process has been likened to the spread of wild fire. The area affected grows at the perimeter as well as through the establishment of new satellite populations.

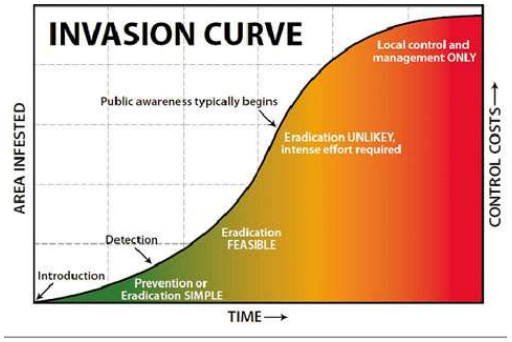


Invasion Lag Time

We frequently see the following trend in population growth following the introduction of an invasive species.



Invasion Process of Invasive Species



Source: Oregon State University

Ecological Concepts Related to Biological Invasions

Three main factors related to niche and niche opportunity contribute to an invader's population growth rate:

- Resource availability
- Natural enemies
- Biophysical environmental conditions

Shea and Chesson 2002

Ecological Concepts Related to Biological Invasions

Resource opportunities:

- Resource opportunities arise when the resources that a species needs are high in availability.
- Invaders are predicted to be successful when the invading species have a greater response (per-capita growth) than the resident.
- The invader may not be uniformly superior to all species but there is an invasive potential whenever the resident species do not keep resources below the requirements of the invading species.

Shea and Chesson 2002

Ecological Concepts Related to Biological Invasions

Interactions between the physical environment, resources, and natural enemies

- Many invasive species have broad environmental amplitudes, thus there are many opportunities for interactions between the environment, resources and natural enemies.
- A harsher environment may result in a greater demand for resources. However, the invader and the resident may respond differently to the change in resource demand.

Shea and Chesson 2002

Feedback Mechanisms

In some instances ecosystem feedback mechanisms may make the return to former conditions difficult.

Examples of bio-invasive feedback mechanisms include:

- tying up nutrients to create nutrient poor conditions (Eucalyptus)
- chemical alteration of the soil (Eucalyptus, salt cedar)
- alteration of disturbance regime (cheatgrass)
- positive interaction between introduced plants and introduced animals (a number of introduced plants and feral pigs in Hawaii)

Vitousek 1986

Effects of Biological Invasive Species

Biological invaders generally, in addition to being non-native, change the ecological function and composition of a site. In many cases, it may be impossible to return the site to the original condition.

Meadow hawkweed (Hieracium *caespitosum*)
Forestryimages.com

Yellow strathistle (Centaurea solstitialis)
Forestryimages.com

How do biological invasions alter landscape function and composition?

Processes involved include:

- Recruitment
- Mortality
- Alteration of microsites
- Resource utilization
- Nutrient cycling
- Probability of disturbance

Effects of Biological Invasions

- Altered competitive relationships and realized niches
- Displacement of some species
- Reduced community stability, at least until a new stability level is achieved
- Reduced species richness and diversity
- Altered soil biota

  Belnap and Phillips (2001) found that bio-invasive species reduced species richness of soil biota, and lowered numbers of fungi and invertebrates and increased bacteria numbers in cheatgrass dominated sites in southeastern Utah.

Effects of Biological Invasions

- Change nutrient cycling
- Dominance of annual grasses and Kentucky bluegrass has been shown to reduce the average rooting depth of plants and thereby reduce the zone of nutrient cycling upwards by plants.
- Medusahead litter contains greater amounts of silica which reduces the rate of microbial decomposition of litter.
- Invasion of exotic grasses in Hawaiian woodland did not directly affect nutrient cycling. However, they indirectly affected nutrient cycling by
  1) increasing the fire occurrence which resulted in greater N loss
  2) fire reduced native species that had a greater N uptake level
  3) created a more "leaky" ecosystem with respect to N

  (Mack et al. 2001)

Adding a life form to the ecosystem

- Add a life form that is not well represented in the community (salt cedar in the Southwest, Russian-olive in the Great Plains)

Russian olive (*Elaeagnus angustifolia*)
Forestryimages.org

Saltcedar (*Tamarix ramosissima*)
Forestryimages.org

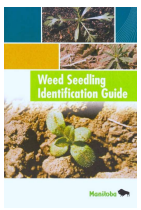
How can the problem of biological invasions be addressed?

- Prevention of organism introductions

Ornamental plants

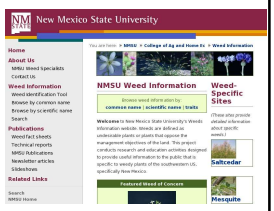
How can the problem of biological invasions be addressed?

- Prevention of organism introductions
- Better detection systems



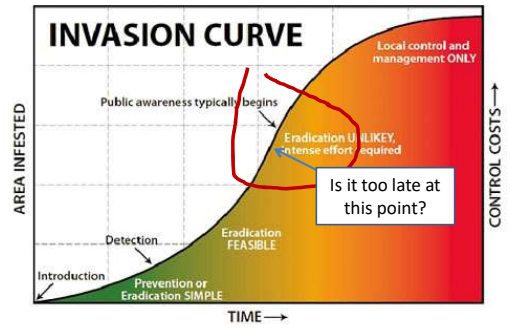
Publications

Shortcourses



Web sites

Invasion Process of Invasive Species

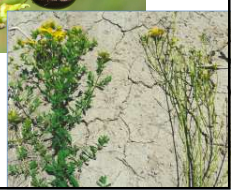


Source: Oregon State University

How can the problem of biological invasions be addressed?

- Prevention of organism introductions
- Better detection systems
- Biological control programs

Chryosolina beetle



Summary- Biological invaders generally change the ecological function and composition of a landscape.

- **Biological invasions** by non-native species may be one of the most serious conservation problems that we face in the future.
- Invasive species utilize a number of '**strategies**' to become successful in the new environment.
- **Ecological concepts** related to biological invasions include: Resource availability, Natural enemies and biophysical environmental conditions
- The problem of biological invasions can be partially addressed through: Prevention of organism introductions, Better detection systems, Biological control programs
- The long-term solution may be reduced through the management for **resilient ecosystems**.

What concepts related to landscape ecology have we discussed that could be useful when addressing invasive species?

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