Biological invasion

- **Biological invasion** :The process by which an organism is introduced to, and establishes a sustainable population in, a region beyond its native range.
- **Eradication :**The managed extirpation of an entire nonnative population.
- **Impact:** The effect of a nonnative species on its environment.
- **Invasibility:** The vulnerability of a habitat, community, or ecosystem to invasion.
- **Invasion ecology :** A multidisciplinary field that examines the causes and consequences of biological invasions.

- **Invasional meltdown :**The phenomenon in which multiple nonnative species facilitate one another's invasion success and impact.
- **Invasive species:** Nonnative species with conspicuously high colonization rates. Such species have the potential to spread over long distances. The term invasive is also used (often by policy makers) to describe colonizing species that cause undesirable ecological or economic impacts.

- **Biological invasion** is the process by which a species is introduced, deliberately or inadvertently, into a new geographic region where it proliferates and persists.

- The process of invasion comprises a sequence of events involving the transport, introduction, establishment, and spread of organisms into a new region.

- Lonsdale presented an instructive model to describe the number of nonnative species in a region, E:

$$E = I \times S$$

- where I is the number of species introduced (colonization pressure) and S is the product of the survival rate of each species.
- S is a function of both the biological traits of the nonnative species and the environmental conditions of the target habitat

- There is a variable time lag between initial introduction and establishment, followed by an exponential increase in abundance until the population reaches limits imposed by local abiotic and biotic conditions, at which point population growth diminishes.
- The range expansion of the species (increase in area occupied per unit time) is correlated with its population growth.

- The range expansion of an introduced species is characterized by
- an establishment lag phase,
- an expansion phase,
- and, when a geographic limit to suitable habitat is realized, a saturation phase

lag phase

- Non-mutually exclusive factors contributing to lag phases include:
- (1) density-dependent effects, in which the organism's birth rate is correlated with its population density
- (2) adaptation and selection of new genotypes

- (3) a change in the composition of the recipient community (e.g., the introduction of a pollinator or seed disperser or the extinction of a dominant resident predator) that triggers the explosive growth of a previously subdued nonnative species
- (4) changing abiotic conditions (e.g., climate change) that release the nonnative species from physiological constraints.

- The species expands its range linearly through time; this pattern is the result of random short-distance dispersal outward in all directions through a homogeneous environment eg;muskrats.
- The expanding range is modeled as a circle whose radius increases at a constant rate.
- The probability of invasion at a given site is inversely proportional to the distance from the edge of the expanding colony and directly proportional to time.

- A second pattern is defined by a slow initial rate of linear spread followed by an abrupt shift to a higher linear rate.
- This biphasic pattern, which has been observed in
- invasive birds such as the European starling (Sturnus vulgaris), occurs when long distance migrants generate new satellite colonies not far from the primary colony;
- the coalescence of satellites into the expanding primary colony generates a higher linear rate of expansion.

- A third pattern occurs when long-distance dispersers create numerous remote satellite colonies that begin to expand their range independent of each other
- their continuous coalescence generates an exponential expansion phase,
- Eg: European cheatgrass (Bromus tectorum) in North America and tiger pear cactus (Opuntia aurantiaca) in South Africa

N Pools

- The invasion of woody N-fixing species into habitats that previously lacked woody N fixers, such as Myrica faya in Hawaii and Acacia spp. in South Africa has been shown to result in substantial increases in soil N pools.
- Because of its association with N-fixing microbes, Myrica is able to fix 18.5 kg N ha/yr as compared with 0.17 kg N ha/ yr fixed by other known biological sources

- As a result, litter from Myrica had significantly higher N content than litter from the dominant native tree, *Metrosideros polymorpha* (1.33 vs. 0.56%), and significantly lower lignin- N ratio in litter (25.3 vs. 37.5). Examination of the total N in the forest floor plus soil under forests with and without Myrica revealed that the invaded sites had 631 + 305 g more N than uninvaded sites.

- the invasion of Acacia spp. into South African habitats previously lacking N fixers found that soil N content was 1.7 and 2.7 times higher in invaded strandfeld and fynbos habitats as compared with uninvaded sites.

- Species that are capable of altering soil N pools, whether by augmenting ecosystem N through fixation of atmospheric N or by increasing rates of N losses, have the greatest capacity to interfere with restoration efforts. In contrast, exotic species that influence soil N fluxes through such mechanisms as differences in tissue quality or quantity, without altering soil N pools may not exhibit a legacy long after removal of the exotic species

Biocontrol

- The most successful method of controlling invasive weeds and pests is biological control, or “biocontrol”, using their own enemies against them.
- These “biocontrol agents” can be bacteria, fungi, viruses, or parasitic or predatory organisms, such as insects.

- Biocontrol agents are highly specific and usually found in the native home range of the invasive species. Candidate biocontrol agents undergo extensive safety testing to assess unacceptable risks to domestic, agricultural, and native species

- Biocontrol is the most cost effective and environmentally benign solution to managing IAS because when it works it does not require reapplication like chemicals or poisons.
- Most biocontrol agents for weeds and insects, once established, are self-sustaining and don’t have to be reapplied.

- Biological control can be viewed as proactive attempts to manipulate food webs to restructure a biotic community in ways that enhance ecosystem services, including conservation goals and human welfare

Knapweed (Centaurea spp.) invasions in North America

- several species of Centaurea (Asteraceae) caused widespread economic and ecological damage.
- spotted knapweed (Centaurea stoebe) and diffuse knapweed (Centaurea diffusa).
- In the two Centaurea species, the production of strong putative allelopathic substances was reported, that is, the exudation of chemicals from root tissues to harm adjacent, competing plant species, which potentially could be amplified by biological control agents