ENVE203
Environmental Engineering Ecology
(Nov 05, 2012)

Elif Soyer

'Ecosystems and Living Organisms'

Principles of Population Ecology

- Population Density
- How Do Populations Change in Size?
- Maximum Population Growth
- Environmental Resistance & Carrying Capacity
- Factors That Affect Population Size
- Reproductive Strategies
- Survivorship
- Metapopulations

Principles of Population Ecology

ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY

Certain populations may exhibit exponential population growth

- Bacterial cultures, protist cultures, certain insects

Encyclopedia.com – Bacteria Growth
http://www.youtube.com/watch?feature=player_embedded&v=gEwzDydciWc

However, organisms can not reproduce indefinetely at their intrinsic rate of increase

ENVIRONMENT SETS LIMITS: ENVIRONMENTAL RESISTANCE

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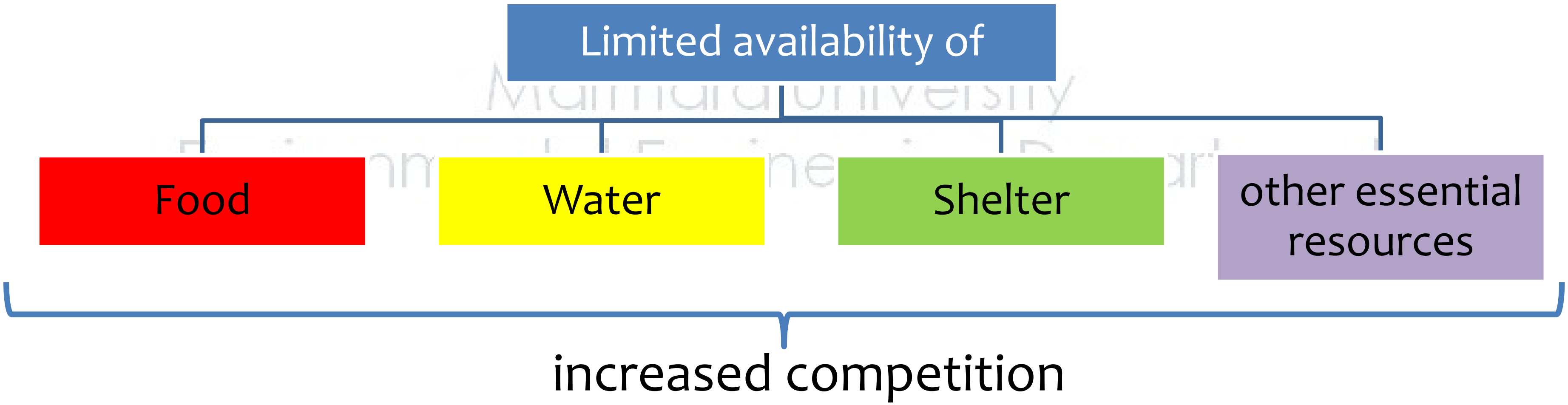
ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY

ENVIRONMENTAL RESISTANCE

- Unfavorable environmental conditions



- Limits imposed by disease and predation

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ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY

Bacteria example

- Run out of food
- Run out of living space
- Poisonous body wastes would accumulate in their surroundings

→ Would never reproduced unchecked

with crowding → more susceptible to parasites

High population densities facilitate the spread of infectious organisms, e.g. viruses, among individuals

with crowding → more susceptible to predators

High population densities increase the likelihood of a predator catching an individual

Principles of Population Ecology

ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY

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Predators

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ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY

Bacteria example

Environment deteriorates → * Birth rate decline * Death rate increase → $d > b$ → population decreases

The number of population in a population is controlled by the ability of the environment to support it.

ENVIRONMENTAL RESISTANCE is an excellent example of a NEGATIVE FEEDBACK MECHANISM

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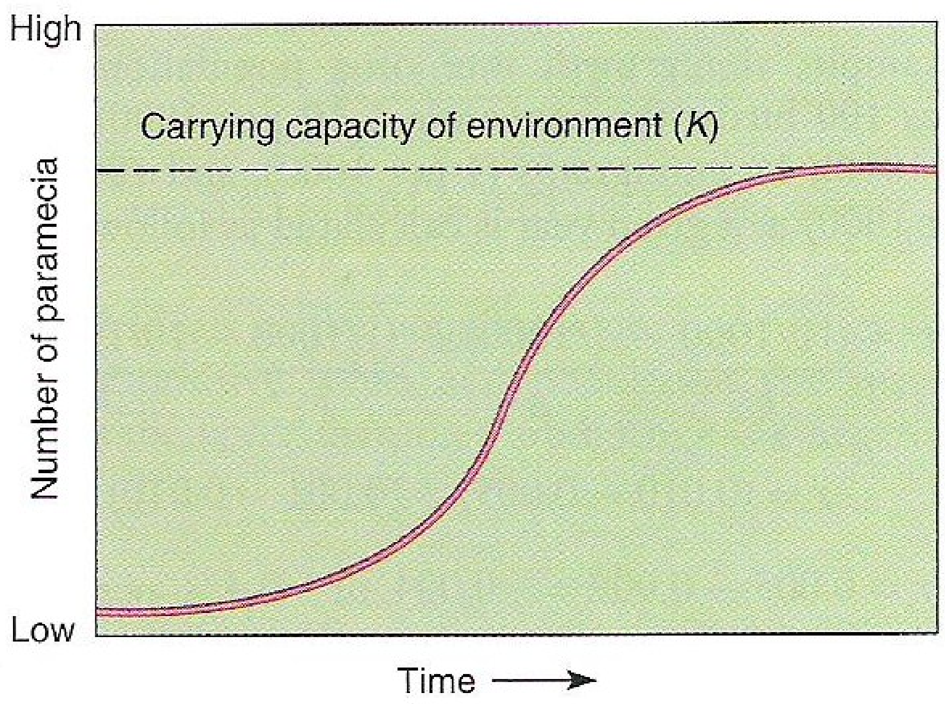
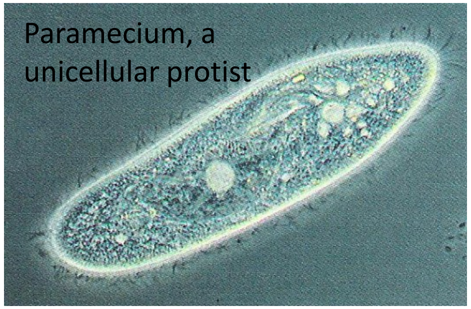
ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY



Carrying capacity (K):
The maximum number of individuals of a given species that a particular environment can support for an indefinite period, assuming there are no changes in the environment



Curve has the characteristic S shape of **Logistic Population Growth**

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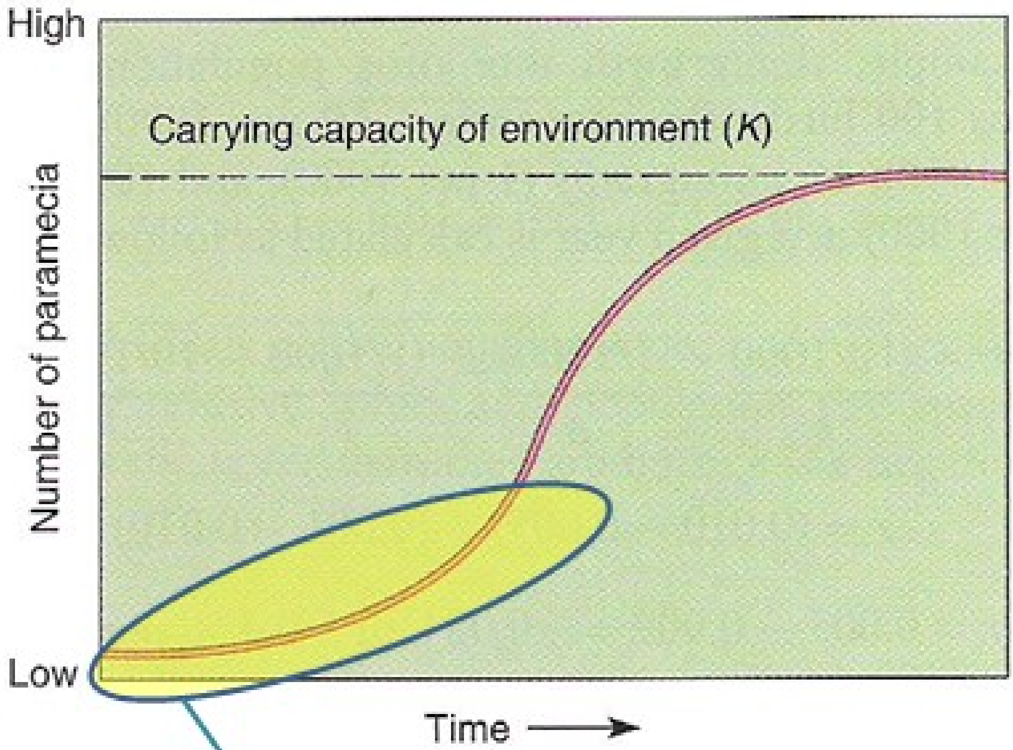
ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY



Population growth increases approximately exponentially when the population is low

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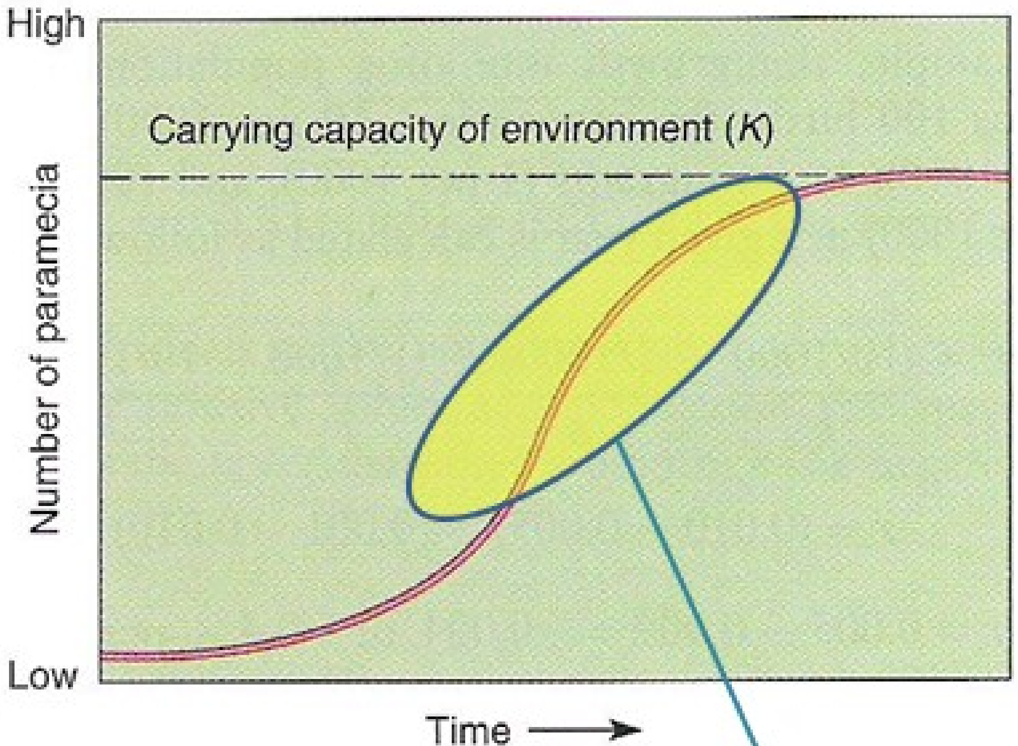
ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY



Population growth slows as the carrying capacity of the environment is approached

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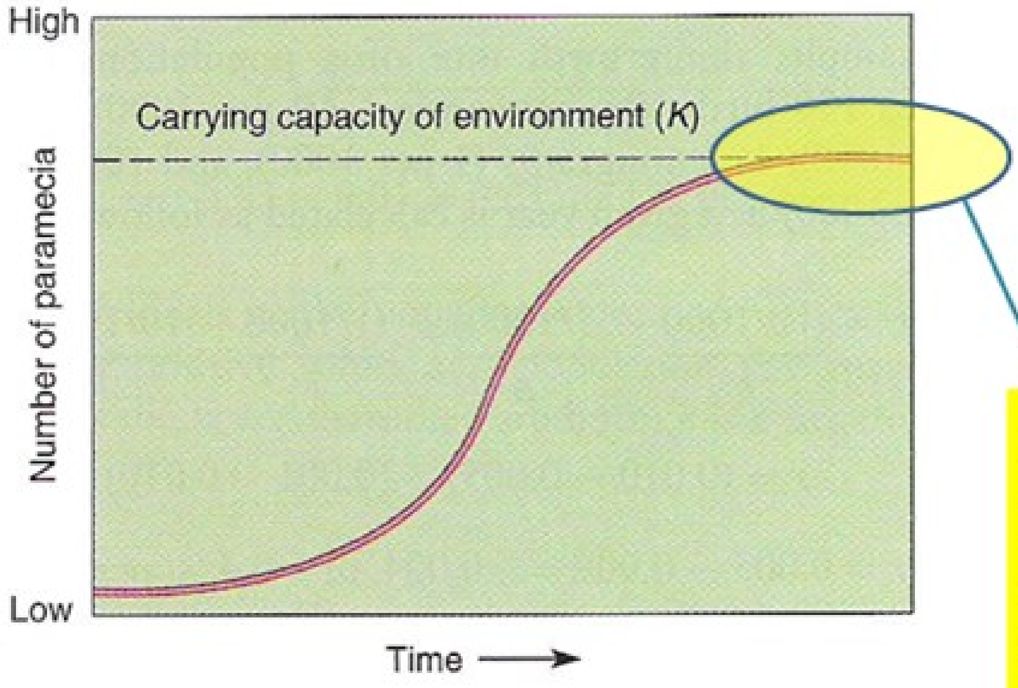
ENVIRONMENTAL RESISTANCE & CARRYING CAPACITY



Leveling out occurs at or near the **CARRYING CAPACITY (K)** 'the limit of the environment's ability to support a population'

In nature, 'Carrying capacity' is dynamic & changes in response to environmental changes

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FACTORS THAT AFFECT POPULATION SIZE

Natural mechanisms that influence population size fall into 2 categories:

1. Density-Dependent Factors
2. Density-Independent Factors

They vary in importance from one species to another

Most cases interact simultaneously to determine the size of a population

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FACTORS THAT AFFECT POPULATION SIZE

1. Density-Dependent Factors

An environmental factor whose effects on a population change as population density changes

Examples: Predation, Disease, Competition

Those factors have greater influence on population when its density is greater

Principles of Population Ecology

FACTORS THAT AFFECT POPULATION SIZE

2. Density-Independent Factors

An environmental factor that affects the size of a population but is not influenced by changes in population density

These factors are typically **abiotic**

Weather events that reduce population size (regardless of its size) serve as density-independent factors

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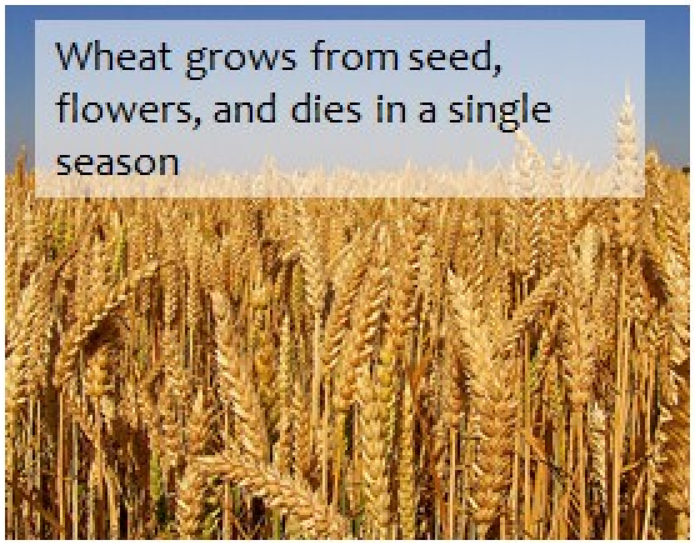
REPRODUCTIVE STRATEGIES

Each species has a lifestyle uniquely adapted to its reproductive patterns



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REPRODUCTIVE STRATEGIES

Imagine a hypothetical organism that produces the maximum number of offsipring, and all of these offspring survive to reproduce.

In nature, such an organism does not exist.

Nature requires organisms to make tradeoffs in the expenditure of energy

Energy into reproduction	Energy toward ensuring its own survival

Principles of Population Ecology
REPRODUCTIVE STRATEGIES

Two extremes with respect to reproductive strategies:

***r*-selected species**

***K*-selected species**

- these concepts are useful
- but oversimplifies most life histories
  - Many species:
    - combination of *r*- and *K*-selected traits
    - traits that are neither r-selected nor K-selected

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REPRODUCTIVE STRATEGIES

Populations described by **r selection** have traits that contribute to a high population growth rate.

- Small body size,
- Early maturity,
- Short life span
- Large broods,
- Little, or no parantel care

Examples: insects such as mosquitoes, weeds

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REPRODUCTIVE STRATEGIES

Populations described by ***K* selection**, traits maximize the chance of surviving in an environment where the number of individuals is near carrying capacity (*K*) of the environment.

- Do not produce large number of offspring.
- Have long life spans with
  - Slow development
  - Late production
  - Large body size
  - Low reproductive rate

Examples: Redwood trees, tawny owls

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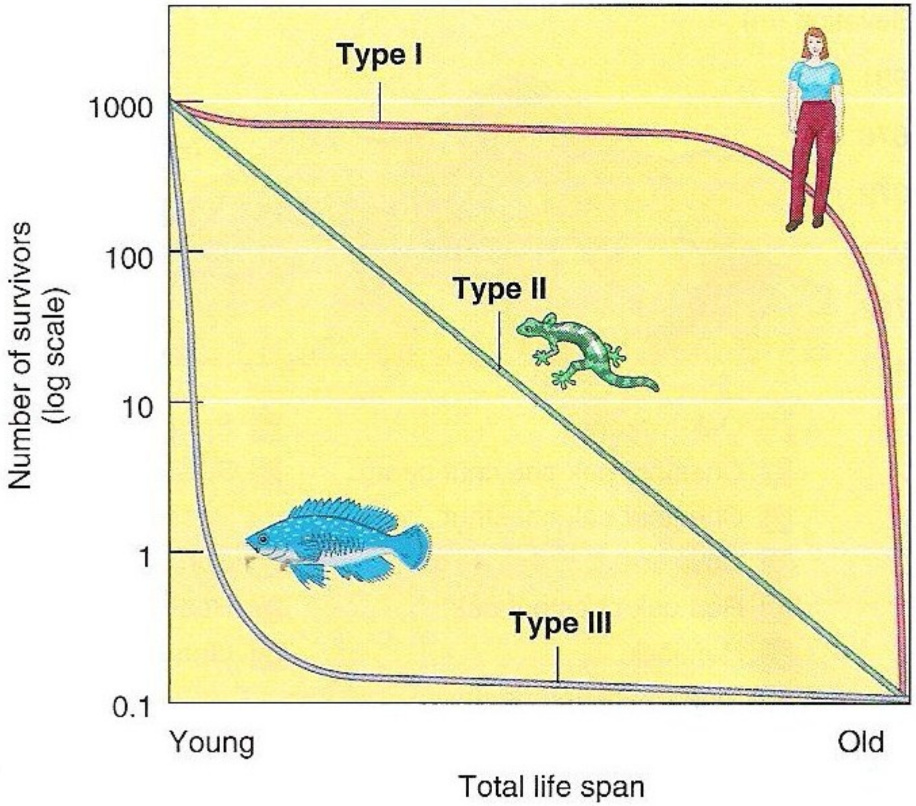
SURVIVORSHIP

The proportion of individuals surviving at each age in a given population



graph of the 3 main survivorship curves recognized by ecologists

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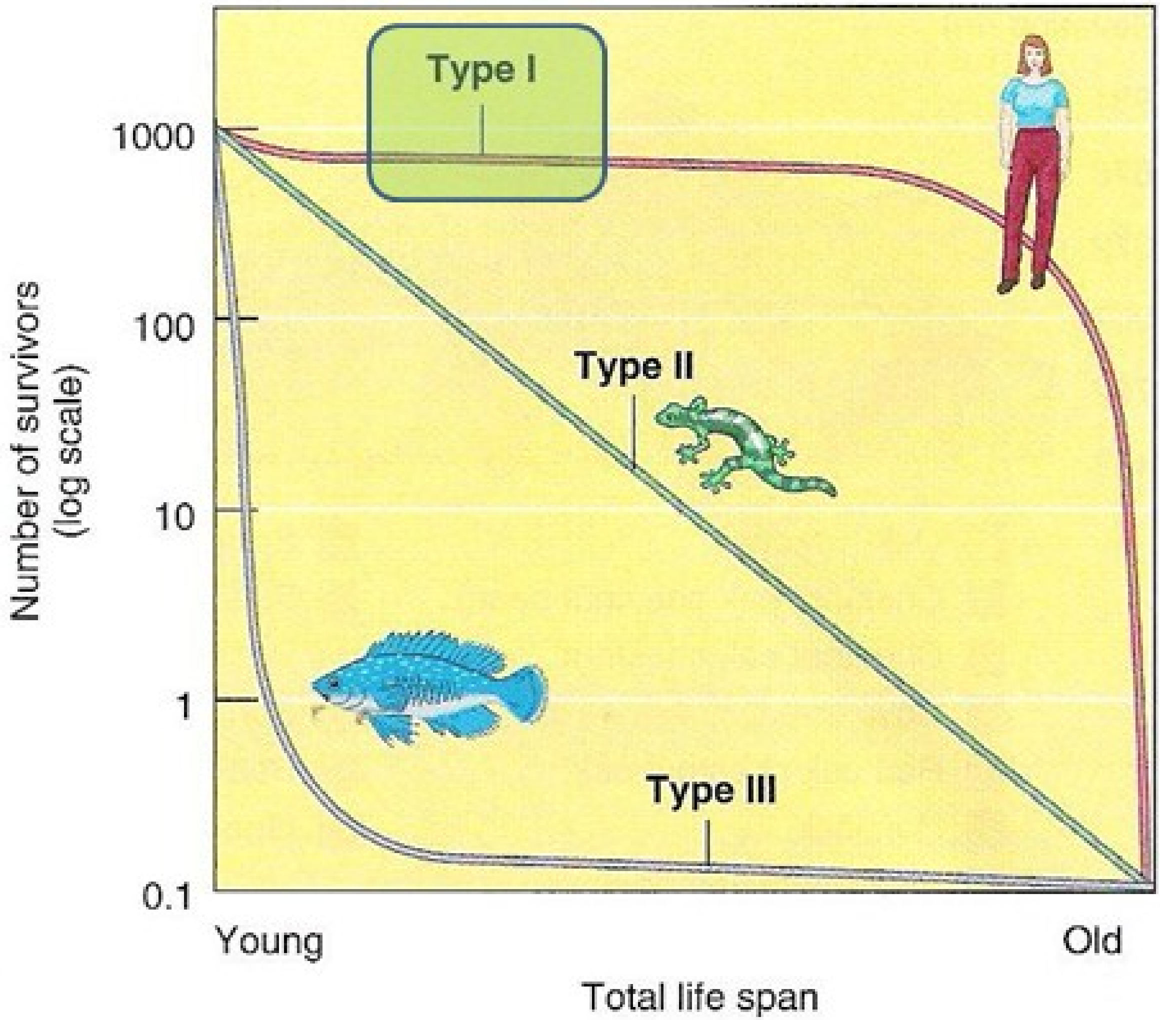
SURVIVORSHIP

Humans and elephants

Prereproductive individuals

Probability of survival decreases more rapidly with increasing age

Deaths are concentrated later in life



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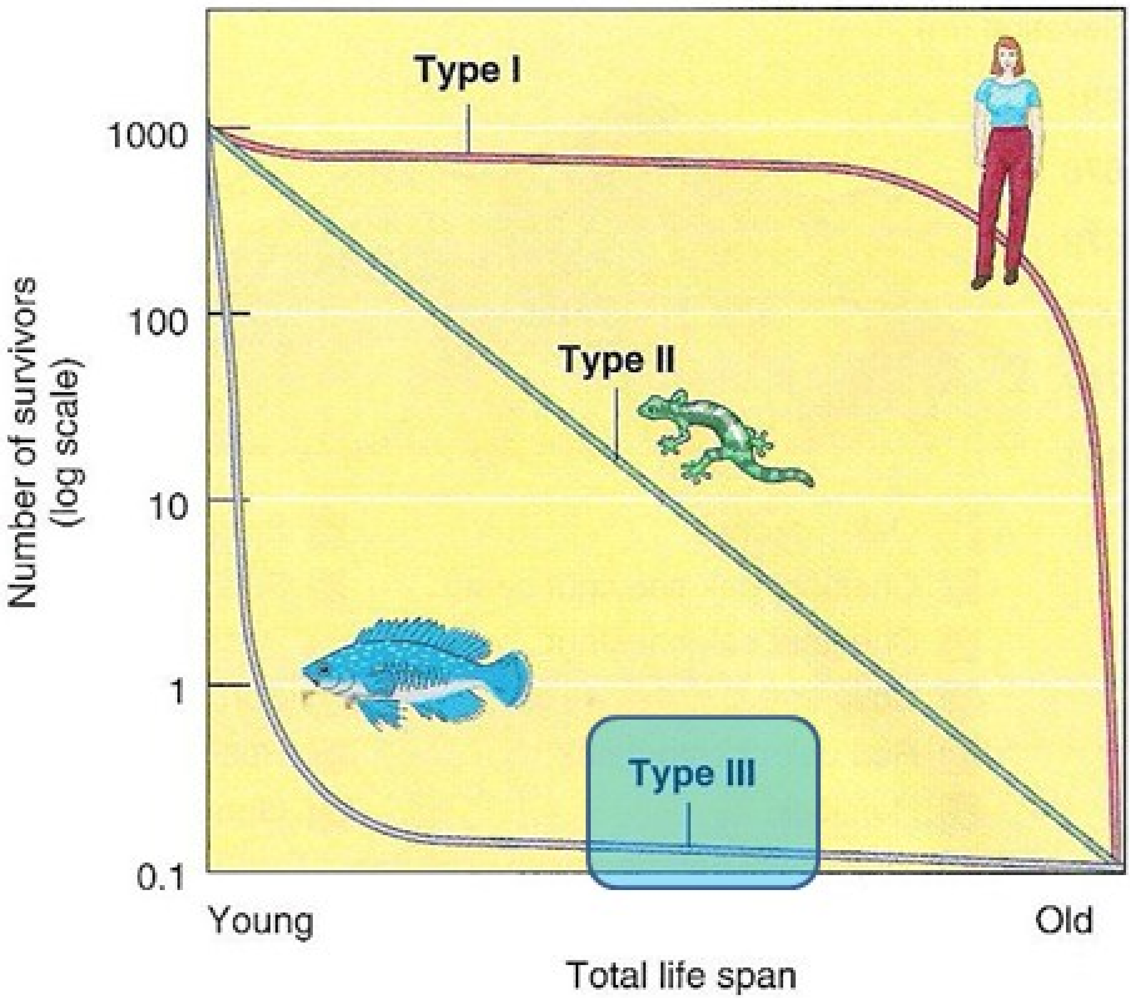
SURVIVORSHIP

Probability of death is greatest early in life

Individuals that avoid early death subsequently have a high probability of survival

Examples: Many fish species and oysters



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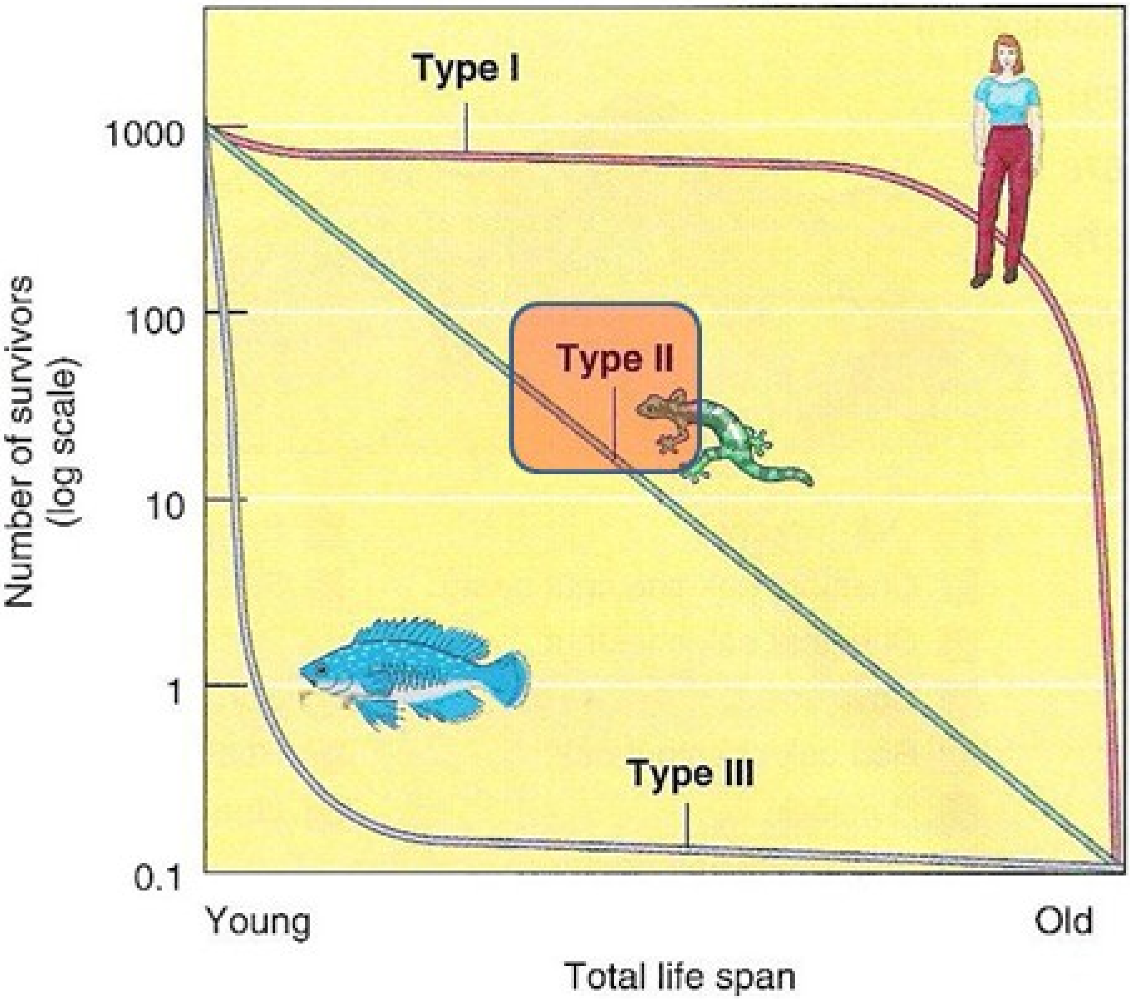
SURVIVORSHIP

Probability of survival does not change with age

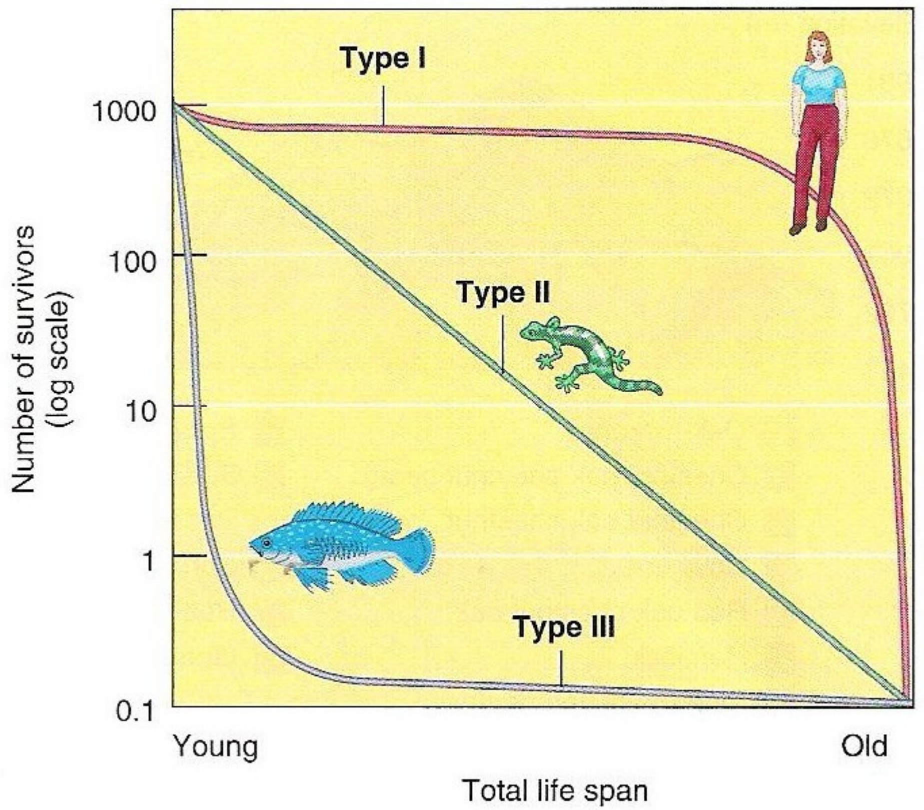
Probability of death is likely across in all age groups → a linear decline in survivorhsip

This type is relatively rare

Example: some lizards



Principles of Population Ecology
SURVIVORSHIP



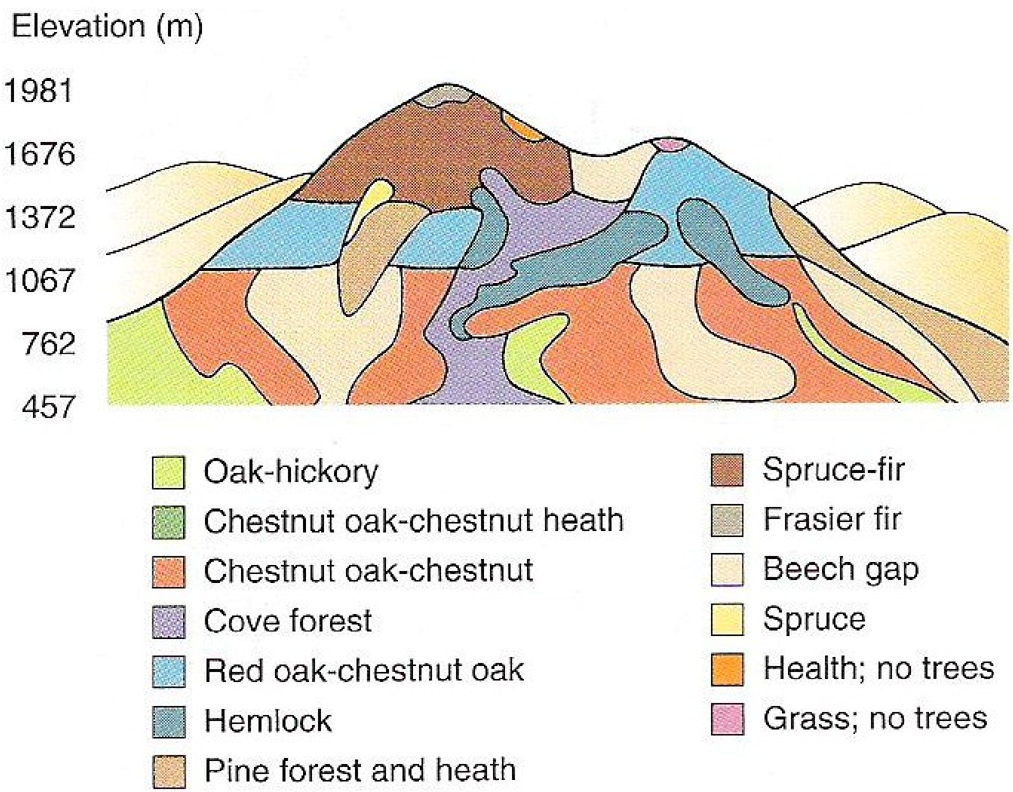
3 survivorship curves are generalizations.

Some species have one type of survivorship curve early in life and another type as adults.

Principles of Population Ecology

METAPOPULATIONS

A set of local populations among which individuals are distributed in distinct habitat patches across a landscape



Distribution of vegetation on a west-facing slope in Great Smoky Mountains National Park

Principles of Population Ecology

METAPOPULATIONS

Occurs because of local differences in

- Elevation
- Temperature
- Amount of precipitation
- Soil moisture
- Availability of soil minerals

Source Habitats:
Increase the likelihood of survival & reproductive success for the individuals living there

Sink Habitats:
Areas where the local birth rate is less than the local death rate
Low-quality habitats

Source and sink habitats are linked to one another by immigration and emigration

Biological Communities

Community is an association of different populations of organisms that live and interact in the same place at the same time.

- The organisms in a community are independent in a variety of ways.
- Species compete with one another for food, water, living space, and other resources.
- Some organisms kill and eat other organisms.
- Some species form internal associations with one another.
- Some species seem only distantly connected.

Biological Communities

THE ECOLOGICAL NICHE

Consider the way of life of a given species in its community:

(1) Whether it is a producer, consumer, or decomposer
(2) The kinds of symbiotic associations it forms
(3) Whether it is a predator and/or prey
(4) What species it competes with

Biological Communities

THE ECOLOGICAL NICHE

Every organism has its own role, or ecological niche, within the structure and function of an ecosystem.

Ecological niche:

The totality of an organism's adaptations, its use of resources, and the lifestyle to which it is fitted

Ecological niche describes an organism's place and function within a complex system of biotic and abiotic factors.

Biological Communities

THE ECOLOGICAL NICHE

Niche includes the local environment in which an organism lives- its **habitat**.

An organism is potentially capable of using much more of its environment's resources. It is also capable of living in a wider assortment of habitats than it actually does.

FUNDAMENTAL NICHE

The potential, idealized ecological niche of an organism

REALIZED NICHE

Various factors, e.g. competition with others, usually exclude an organism from part of its fundamental niche

Biological Communities

THE ECOLOGICAL NICHE

Fundamental Niche – Realized Niche

Southern Florida:
Green anole, a lizard, perches on trees, shrubs, walls, or fences during the day and waits for the insect and spider prey
These lizards were widespread in Florida in the past

Southern Florida:
Brown anole, introduced from Cuba and quickly became common
Green anoles became rare, driven out of their habitat by competition from the slightly larger brown lizards
Green anoles were still around, however, now confined largely to the vegetation in wetlands, where they were less obvious

Biological Communities

THE ECOLOGICAL NICHE

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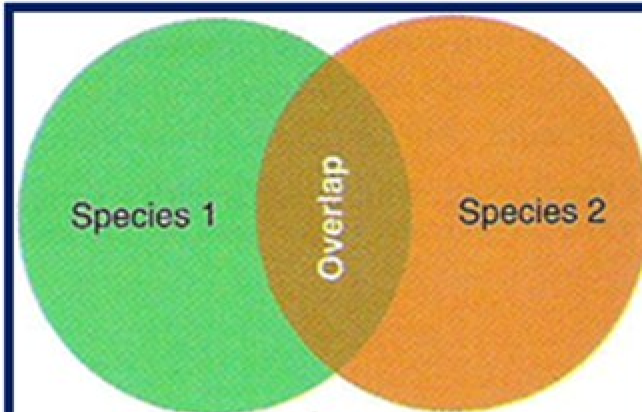
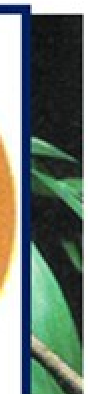


The fundamental niches of the 2 lizards initially overlapped



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Biological Communities

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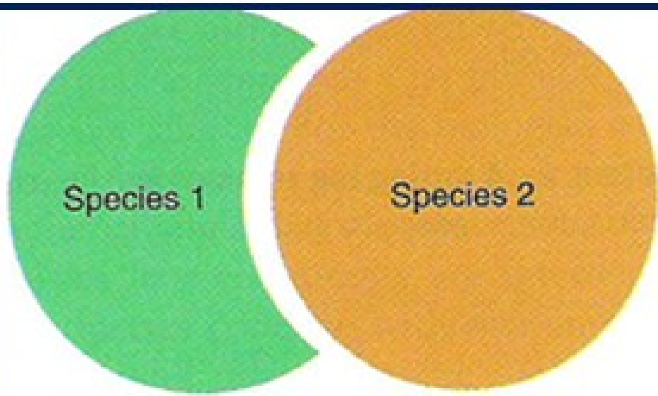

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The brown anole outcompeted the green anole, restricting its niche

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Biological Communities

THE ECOLOGICAL NICHE

Most limiting resources are simple variables such as,

- Mineral content of soil
- Extremes of temperature
- Amount of precipitation

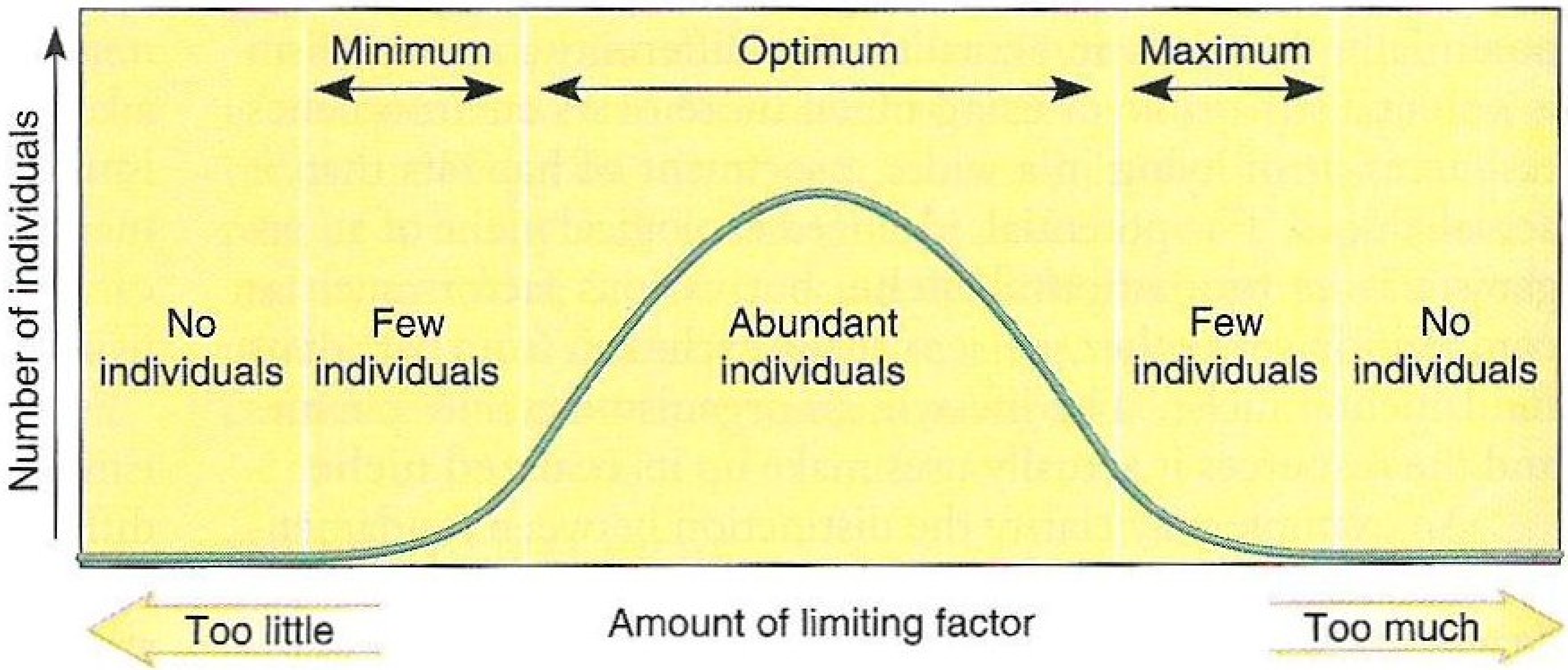
Any resource that
exceeds an organism's tolerance
is present in quantities smaller than the minimum required

↓

limits the occurrence of that organism in an ecosystem

Biological Communities

THE ECOLOGICAL NICHE



Limiting resource

An organism is limited by any environmental resource that exceeds its tolerance or is less than its required minimum