Autecology, Population Ecology and Community Ecology

Autecology

Ecological life cycle of plants

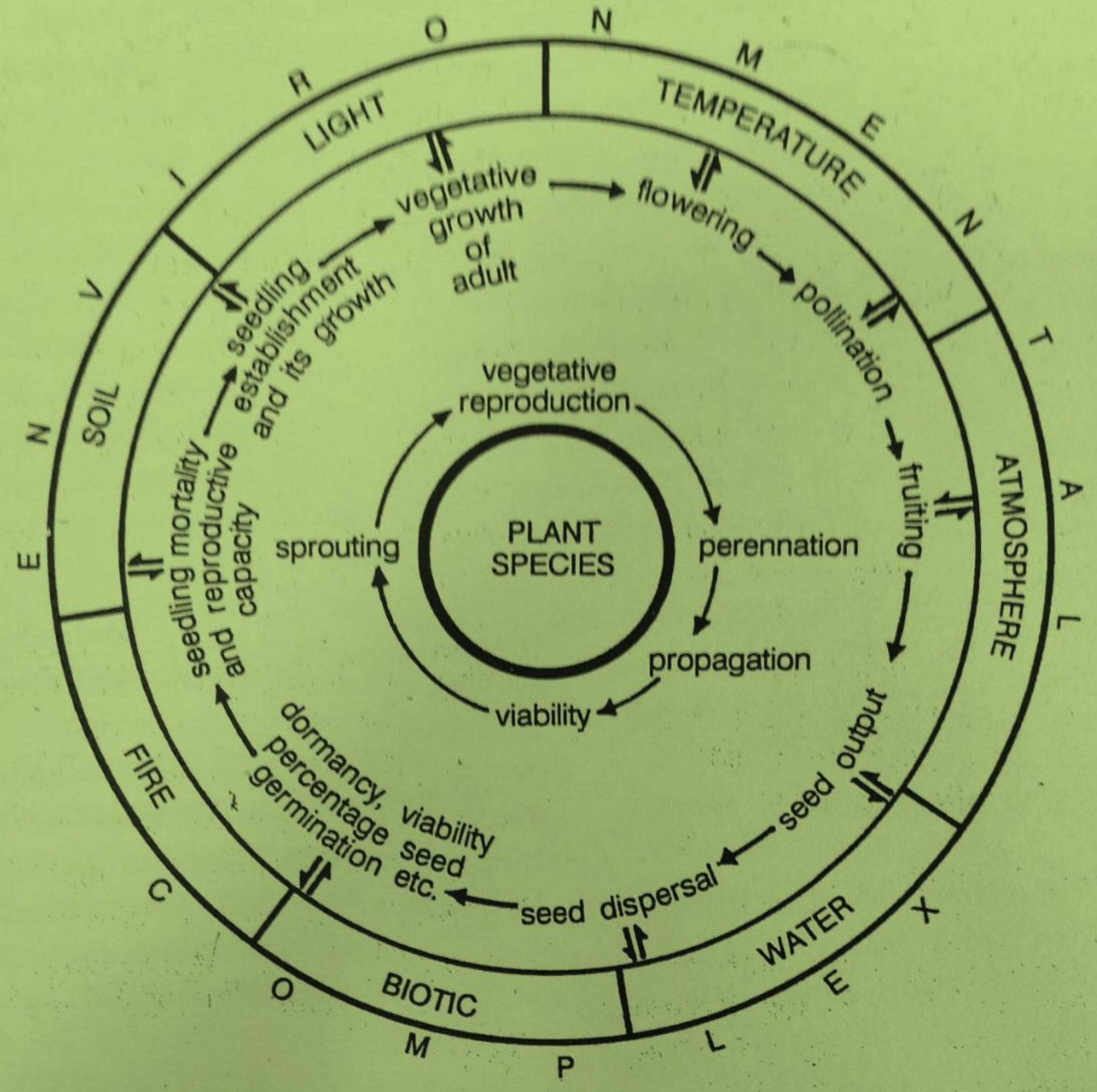
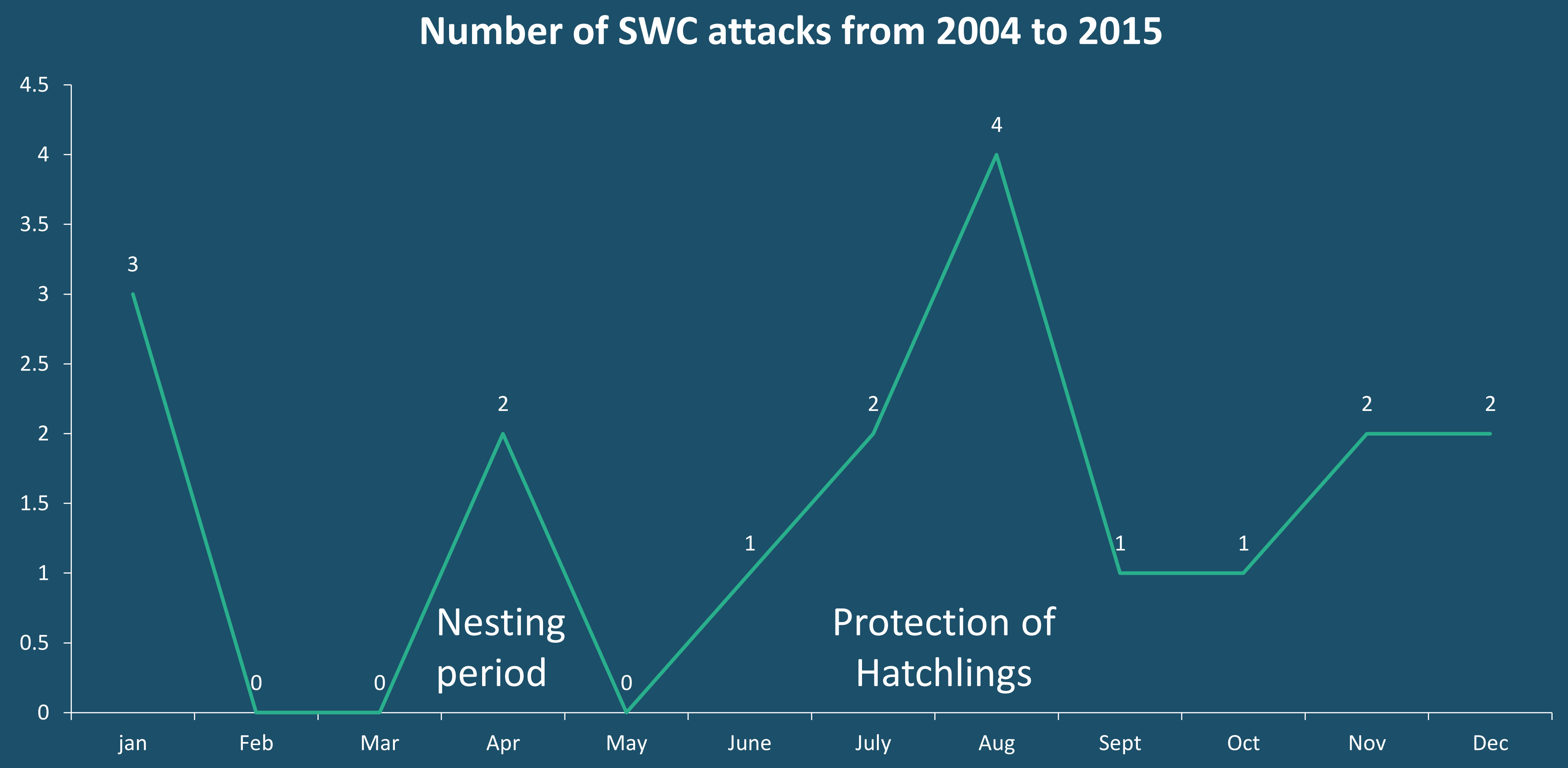


Fig. 6.1. Ecological life cycle of a plant—an ecological or biological clock. Note that each stage in the life cycle is actually influenced by so many factors operating in conjunction as an environmental complex and not as shown in the diagram, that only one particular factor influences particular stage(s) of the life cycle of a plant.

Human crocodile-conflict

A & N Islands



Principles of Relationship between Organisms & their Environment

- Everything influencing the life processes of an organism constitutes its environment.

- Environment in a habitat - biotic and abiotic components and its combined effects affects activities of the organisms.

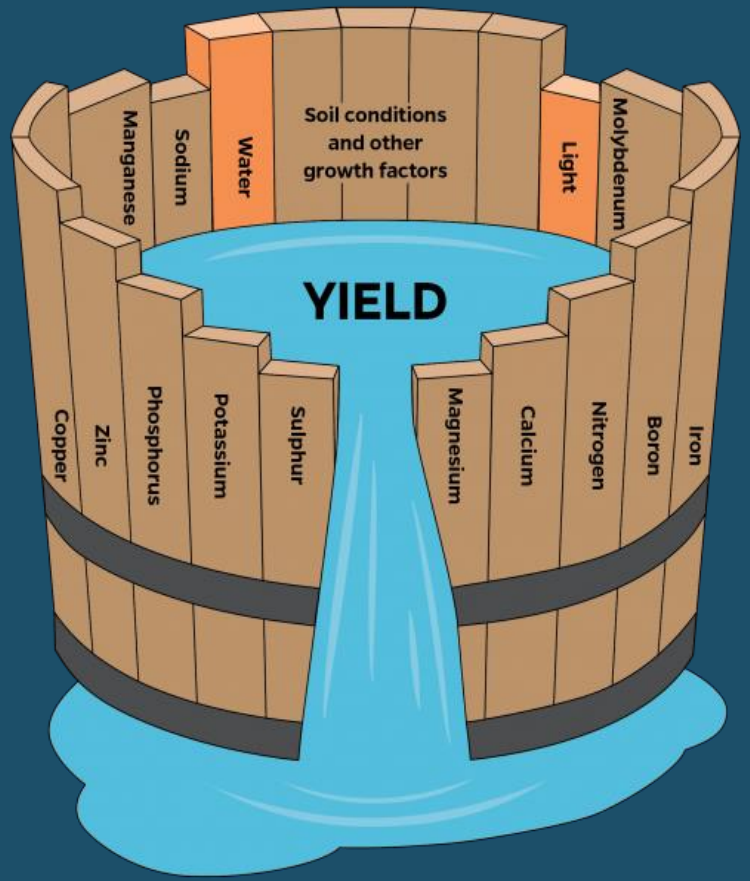
- Materials and energy of the environment and energy exchange process between the organism and environment sustains life

- An organism **cannot exist in vacuum**.

- The environment requirements of different organisms differ from individual to individual and also with age and need.

- Life activities are influenced by that environmental component which occurs in **minimum quantity** (Liebig's law of limiting factor). A minimum quantity of every essential element is necessary for the growth of an organism. The growth of an organism is limited by whatever essential element is in short supply, regardless of whether the total amount required is large or small.

- Life activities of an organism are influenced by the minimum or maximum quantity of the environmental component or factor, as for example, nutrients, light, temperature, moisture. Based on this principle Shelford founded the law of tolerance.

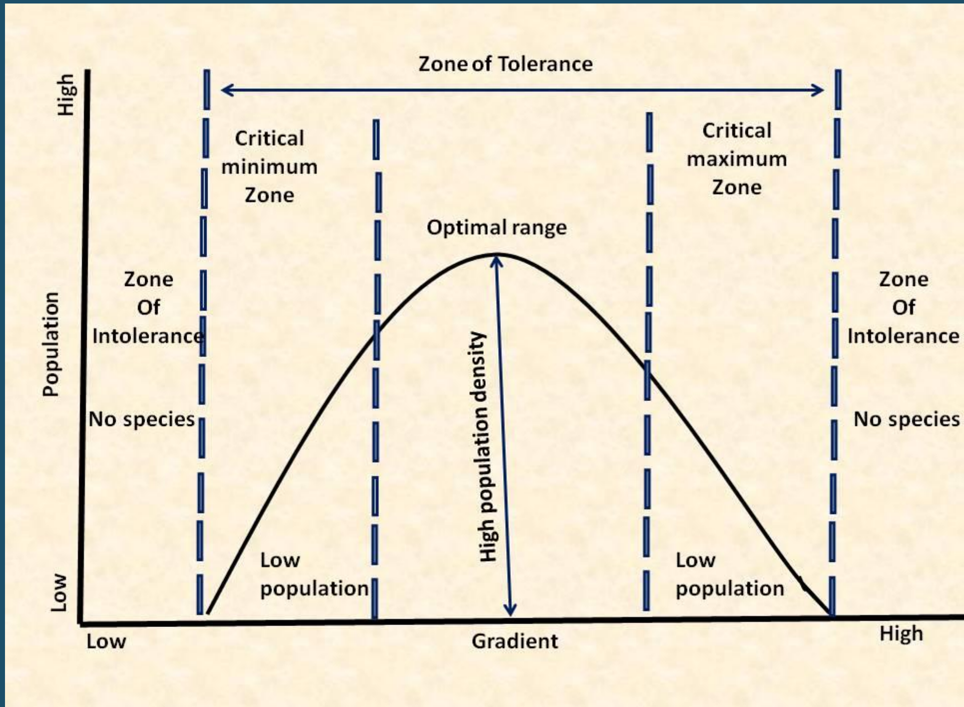


- **<u>Tolerance limits</u>** of an individual for different environmental factors may be different.

- An organism may show <u>different tolerance limit for a particular environmental factor in different habitats and at different age</u> and stage of life history. **(Law of optimum)**

- Organisms having **wide tolerance** limits for many environmental factors are widely distributed. Eg. Crow, Cockroach)

- An <u>organism is a product of nature</u> (genetic set-up) & nurture (environmental upbringing). The inherited qualities are unfolded in proper environment.



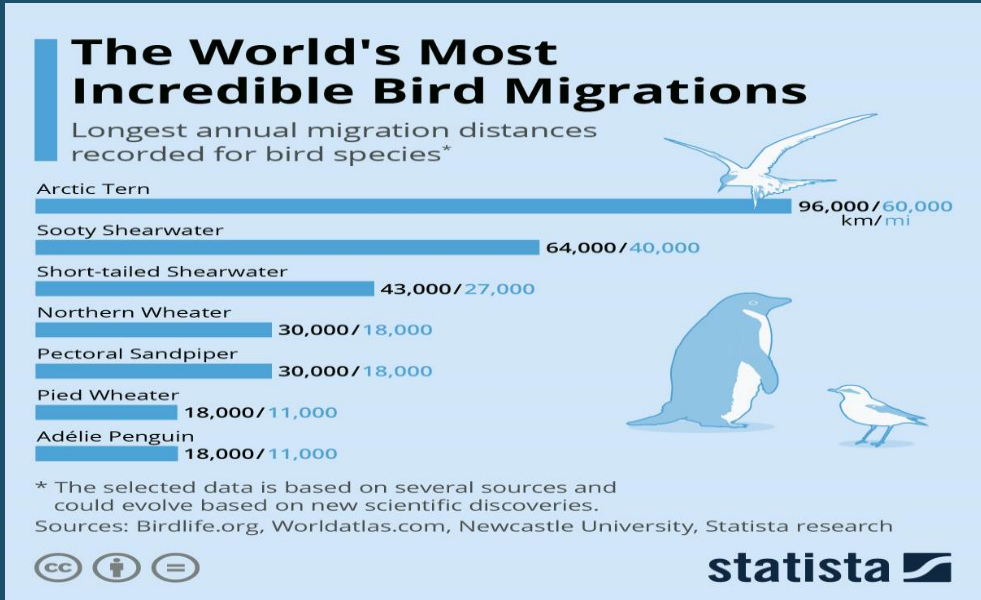
13. Organisms **react with the external stimuli** caused by the environmental changes. The reactions may be exhibited by movements **(migration) or adaptational changes** in the body or physiological activities. All such adaptations have survival value.

14. Widely distributed species are adapted to various habitat conditions by evolving **ecotypes.**

15. Every habitat has potential to support a certain number of organisms. This is known as **carrying capacity** of the habitat. Knowledge of carrying capacity is essential for proper management of the habitat.

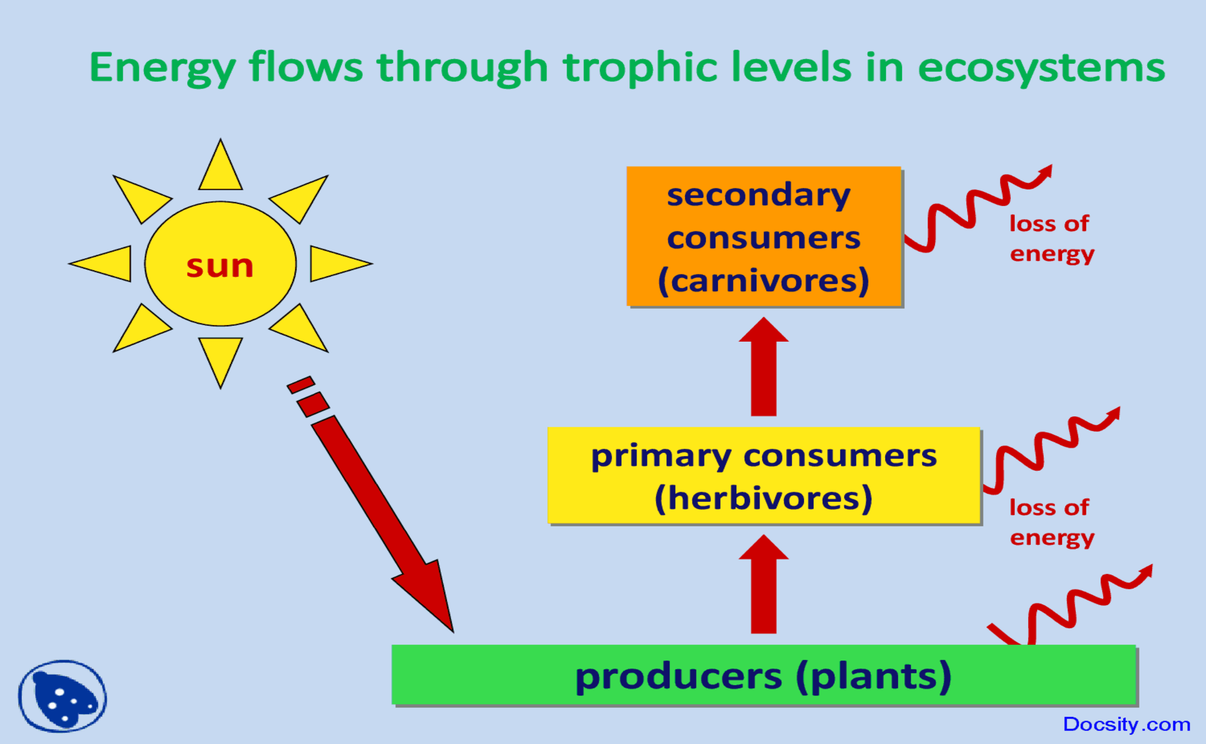
Earth Worms Ecotypes

Earthworm	Living Environment
Compost earthworm	Live in warm and moist environment with a ready supply of fresh compost material.
Epigeic earthworm	Live on the surface of soil in leaf litter and tend not to make burrows but live in feed on the leaf litter.
Endogeic earthworm	Live and feed on the soil, making horizontal burrows through the soil to move around and to feed and they will reuse these burrows to certain extent.
Anecic earthworm	They make permanent vertical burrows in soil, feeding on leaves on the soil surface that they drag into the burrows.



- **Energy flow** from the sun to the plant to the other organisms and then to the space is always **unidirectional.** Niche place vital role in organism survival

- Energy and space relationships of the organisms cause niche differentiation within the habitat which brings about ecological stability in the community life. In any habitat a community is born, it grows with passage of time and through succession it is stabilized to form **a climax community.**



NICHE

Functional address of the organism in a system w.r.t. to specific parameters.

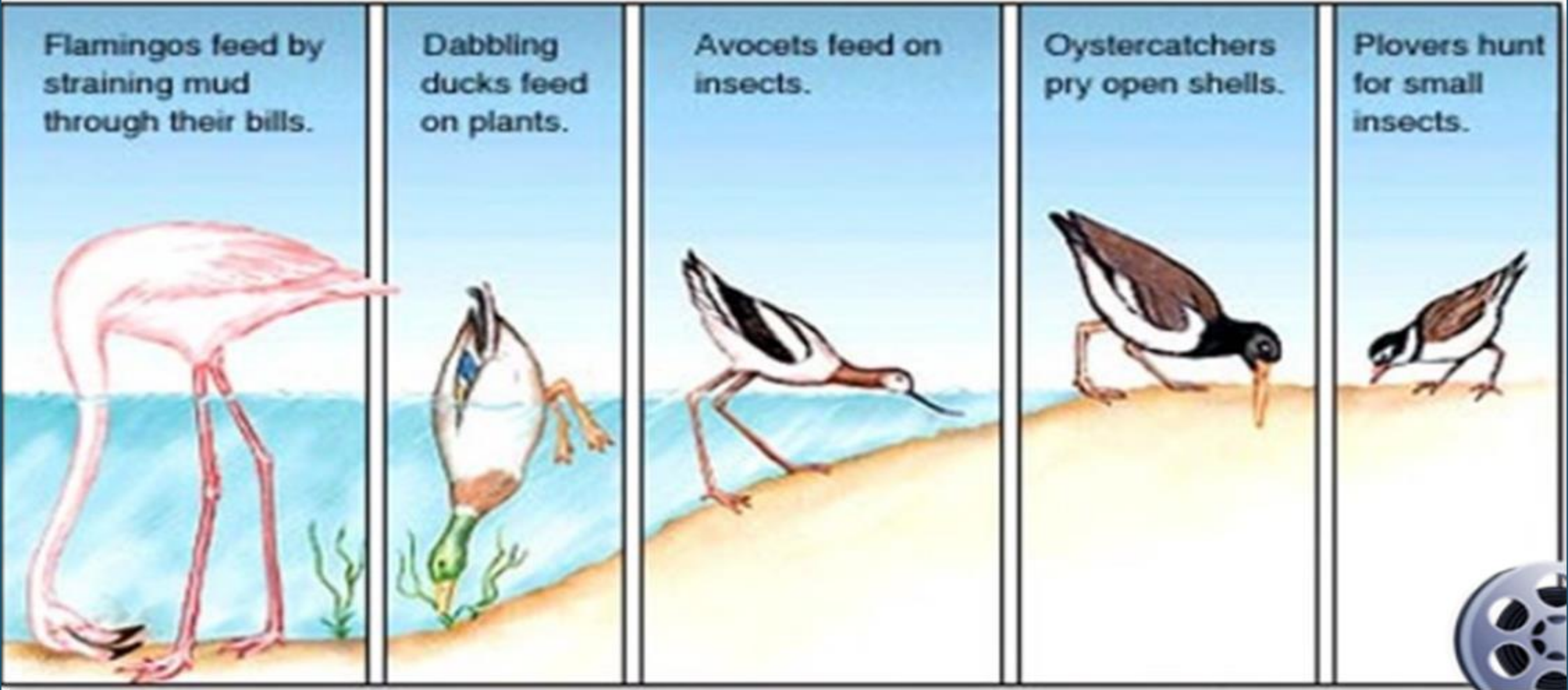
Or the profession of an organism in the system (activity or parameter)

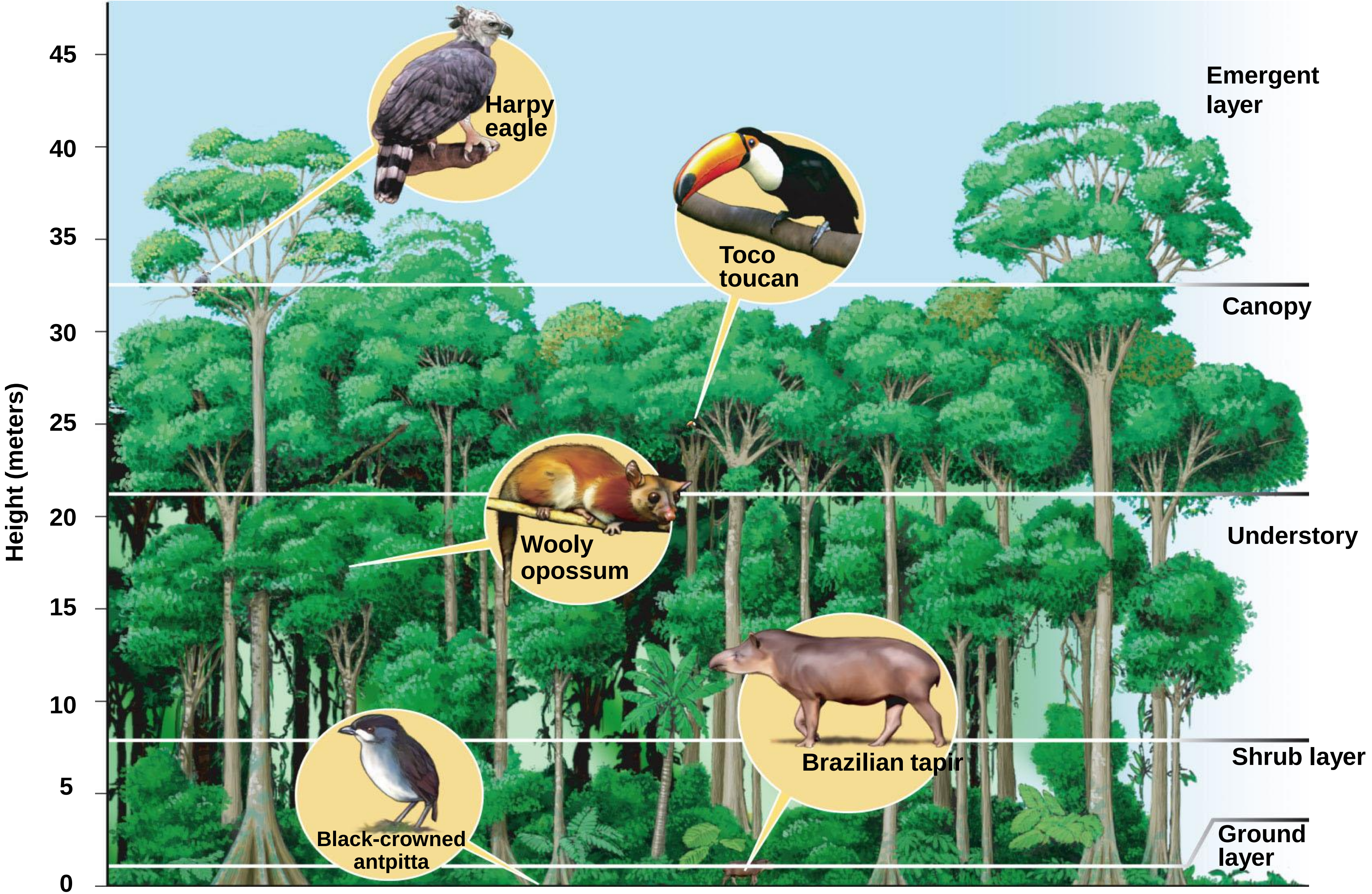
NICHE WIDTH

High N.W : species is generalist, can survive overlapping of species - with limited resources, the competition will set.

- **Broad Niches - less species but more numbers**
- **Narrow Niches - more species & less abundance if resources are constant**

An organism's **habitat** is its "**address**" while its **niche** is its "**occupation**"





Height (meters)
45
40
35
30
25
20
15
10
5
0
Harpy eagle
Toco toucan
Wooly opossum
Brazilian tapir
Black-crowned antpitta
Emergent layer
Canopy
Understory
Shrub layer
Ground layer

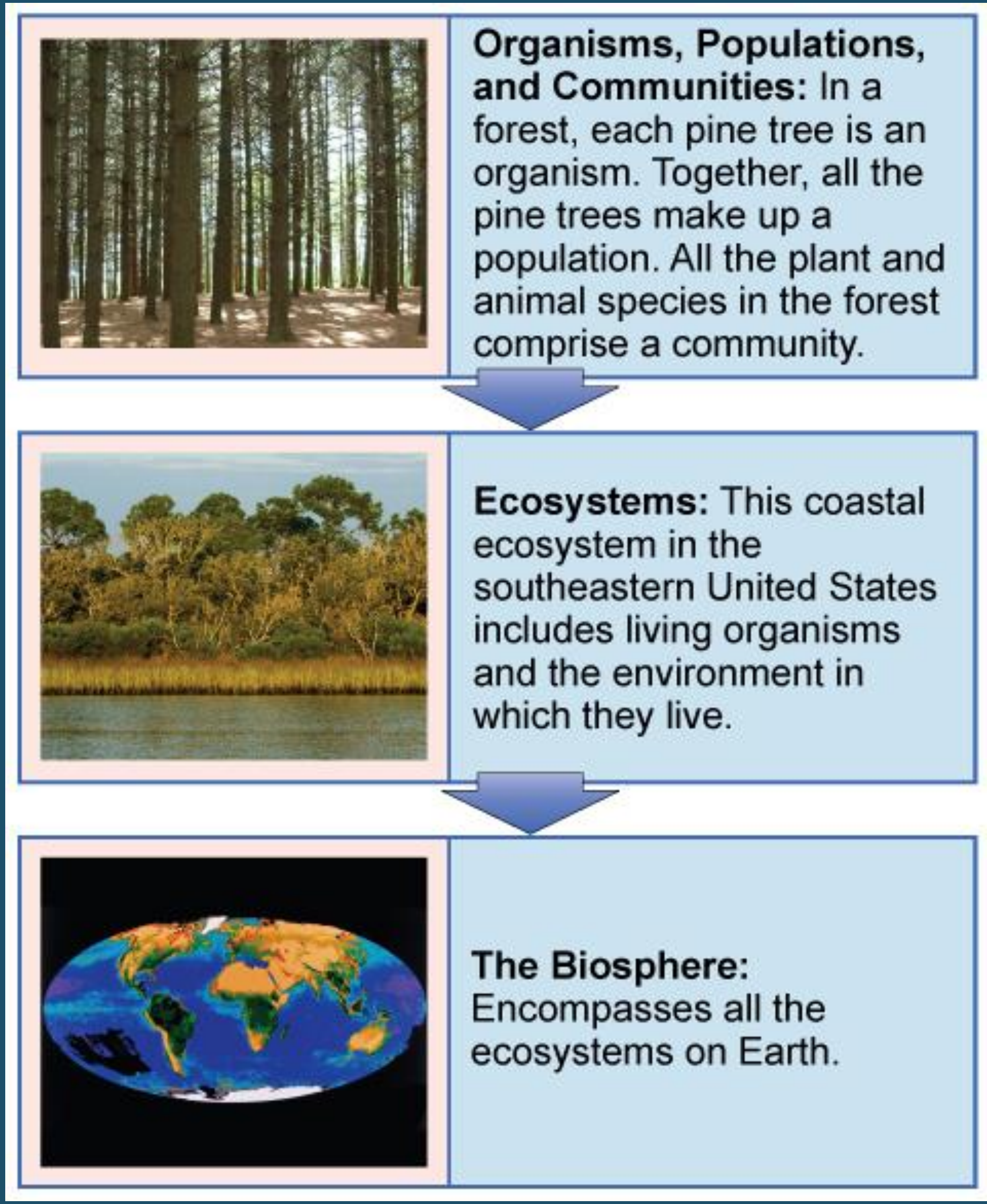
Fig. 7-15, p. 135

Population ecology

- Population ecology is the study of populations in relation to environment, including environmental influences on density and distribution, age structure, and population size.

- A population is a group of individuals of a single species living in the same general area

- **Population**
  - Ecological
    - Group of organisms or individuals of the **same species occupying a particular space at a particular time**
- Mono specific (individual of same sp.)
  - no. of animals of a species inhabiting a common geographic area
- Poly specific (individual of several sp.)
  - an assemblage or collective group of organism (plant or animal) of several closely related sp. occupying a definite area



BIOLOGICAL ATTRIBUTES/ CHARACTERISTICS OF POPULATION STRUCTURE (COMPONENTS)

Density: the size of a population in relation to a definite unit of space is its density.

Density varies with seasons, weather conditions, and food supply.

- Density is **determined by energy flow, resources availability and utilization, physiological stress, dispersal and productivity of a population**

No. of animals/ unit area

- **Crude density** : no. Of individual/ unit of total area
- **Ecological density** : no……/ unit of area it actually occupies

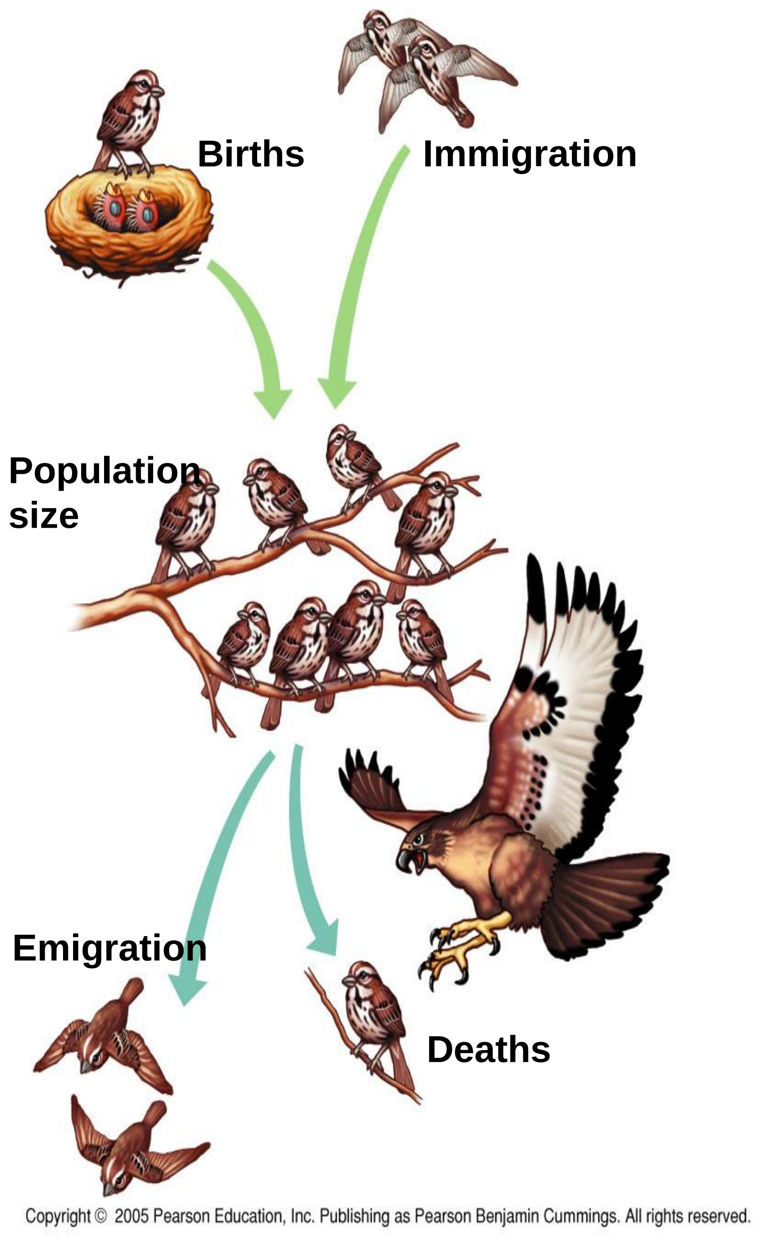
- Density is the result of an interplay between processes that add individuals to a population and those that remove individuals

Dispersion

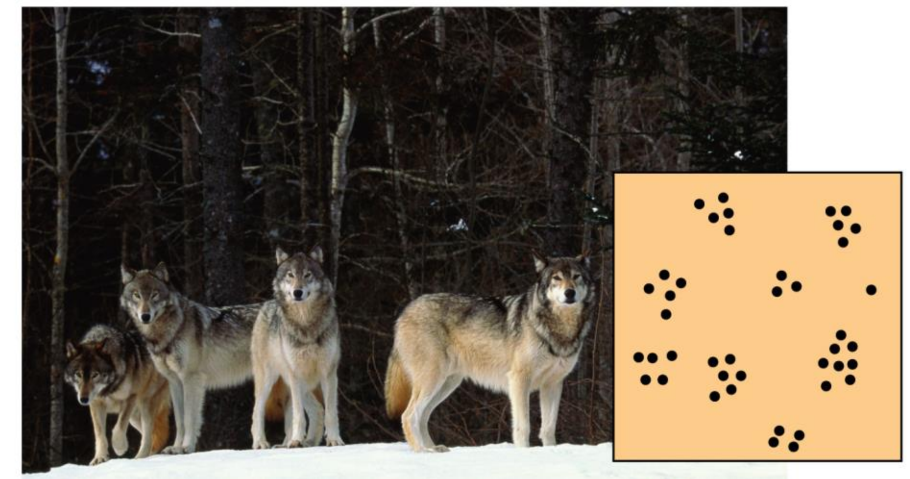
- Dispersion is the pattern of spacing among individuals within the boundaries of the population

  Spatial Distribution

  - Pattern of dispersion **results from responses by plants and animals to habitat differences, daily and seasonal weather and environmental changes,** reproductive pattern and social behaviour.
  - **Temporal dispersion**
    - **Daily changes in light and dark**, humidity and temperature, seasons, lunar cycle and tidal cycles.
    - **Seasonal changes:** migration of birds, blooming of wild flowers
  - **Causes**: Insufficient resources, deteriorating habitats, alleviation of inbreeding.
  - Benefits: Improve potential fitness, colonization of new area, expansion of species range, spread of genes.
  - **Types**: Emigration /: one way movement, out of a habitat.
    - Immigration: one way movement, into another habitat.
    - Migration: dispersal with a return to the place of origin.



- Environmental and social factors influence spacing of individuals in a population
- In a clumped dispersion, individuals aggregate in patches
- A clumped dispersion may be influenced by resource availability and behavior



Clumped. For many animals, such as these wolves, living in groups increases the effectiveness of hunting, spreads the work of protecting and caring for young, and helps exclude other individuals from their territory.

(c) Random. Dandelions grow from windblown seeds that land at random and later germinate.

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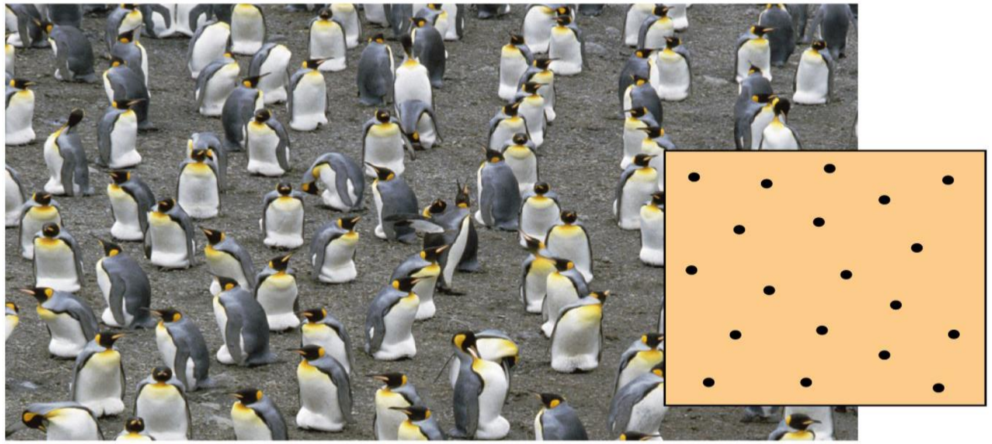

(b) Uniform. Birds nesting on small islands, such as these king penguins on South Georgia Island in the South Atlantic Ocean, often exhibit uniform spacing, maintained by aggressive interactions between neighbors.

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2. SEX RATIO

- It is expressed by convention as **males per 100 females**
- computing sex ratio :

raw data 3males, 7 females $\frac{3}{7} = \frac{x}{100}$

x = 43

sex ratio - 43:100

3. AGE RATIO'S

- **Age determination** in the field
  - Age of wild animals is determined **by body size, weight, hair, feather colour** and texture, stage of feather, moult, changes in anatomical structures**, teeth, horns, antlers, eye lenses, ear lobes**

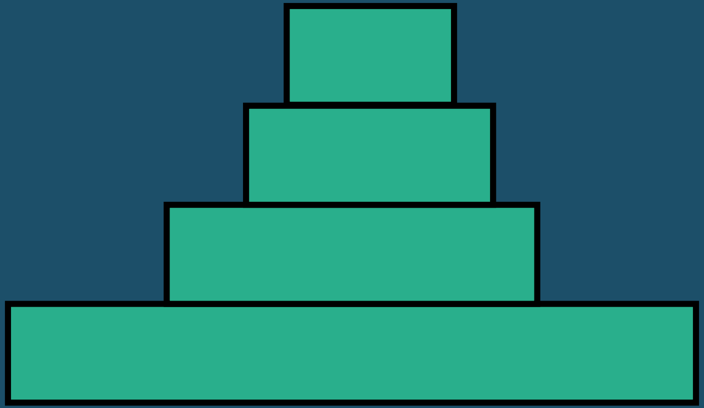
- **Age classification**
  - Young, sub-adult, adult
  - Pre-reproductive; Reproductive and post-reproductive stages

- Age ratio suggests pop' productivity, vulnerability and hunting pressure

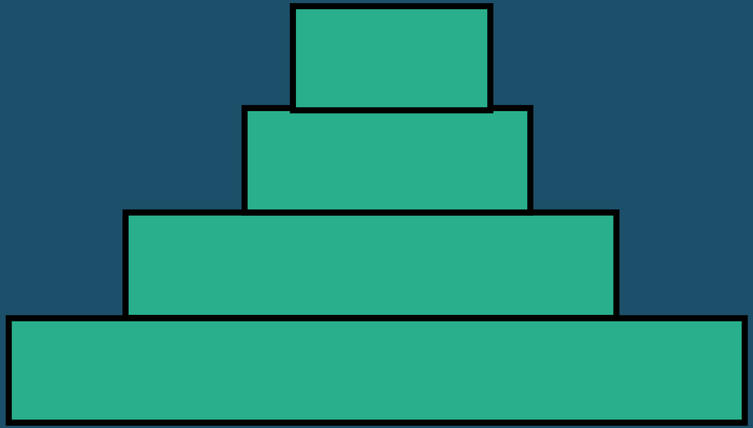
-Three types of indication on pop' growth age pyramid

A. <u>EXPANDING OR INCREASING POP'</u>

AGE CLASS		PROPORTION IN EACH AGE CLASS (%)
HIGHER		-4-
MIDDLE		-8-
		-12-
LOWER		-76-



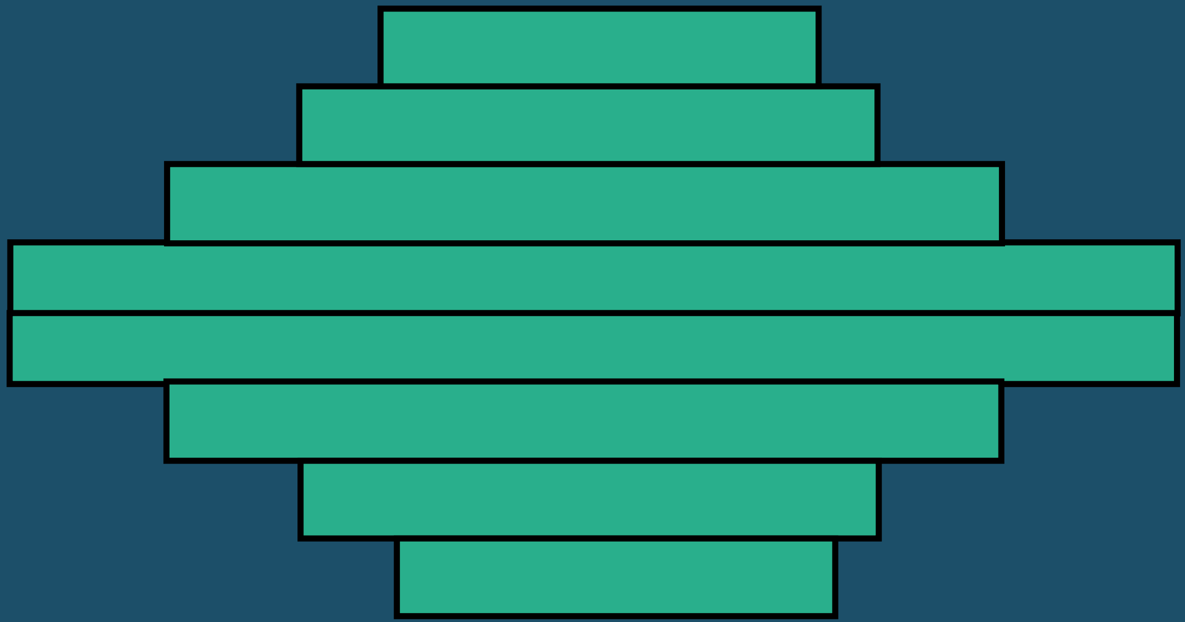
B. STABLE POP



-4-
-18-
-24-
-54-

- NARROW BASE AND TAPERS LESS SHARPLY

C. DECLINING POP'



4. NATALITY

- The production of new individuals in a population

- **Individuals produced per unit of time (natality rate**) or per unit time per breeding individual (specific natality rate) in a pop'

- NET REPRODUCTION RATE:
- No of young surviving till some pre-specified age

- It is the **total young born minus the death in the 1st year of life** (or some specified time)

NATALITY IS DEPENDENT ON

1. Clutch /litter size

   a) Genetic build up of the species

      litter size

      -Sambar-1 ; Chital-1-3 ; Tiger- 1- 4 ; Elephant- 1-2

2. Parental care
3. Length of breeding season and no. Of clutches or litter/year
4. Breeding age
5. Sex ratio and mating habit
6. Density
7. Potential natality

Allocation of energy to

- **egg production**
- **Avoidance of Predators**
- **Competitive ability (*Cody 1966*)**

Temperate areas→ Climatic catastrophes→ Pop **below carrying capacity**

Tropical areas → stable climates→ Pop near carrying capacity→ more energy in competition

MORTALITY

No of individuals which die per unit of time

Potential or minimum mortality:

- no. of deaths occurring per unit of time under ideal natural condition

Realized mortality :

actual no of individuals which die per unit of time

DECIMATING FACTORS

A) **Predation**

- **killing of any animal by other animal**
- **natural balance in ecosystem**
- **generalized predators**

  leopard, tiger, lion, owl
- **specialized predators**

  cheetah, clouded leopard, fishing eagles

  sp. dependent on the abundance of special prey

- Predation success rate - 7% in wolves, Tiger - one in 20 attempts

PREDATION DEPENDS ON

a. **Species specific predatory behaviour**
b. **Prey species richness**
c. **Prey species biomass**
d. **Cover**
e. **Density and quality of alternate food to predator**
f. **Prey defenses: protective colouration, alertness swiftness, high reproductive rates**
g. **Predators ability :speed, strength in claws and teeth, smell, vision**

PREY - PREDATOR RELATIONSHIP

Prey pop' high - predators increase; Increased predation - prey pop' falls

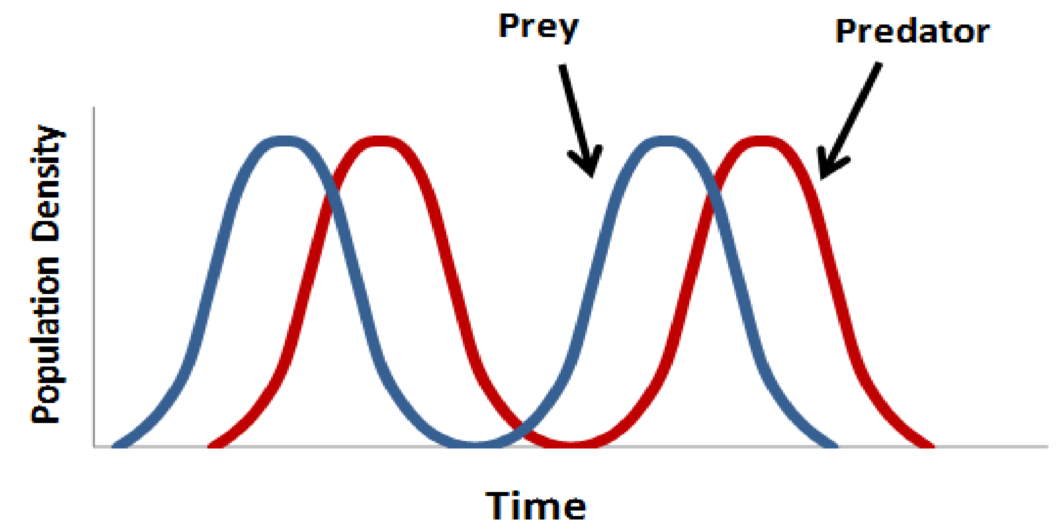
Low prey pop' - predators decrease

- Social intolerance in predators when pop' high

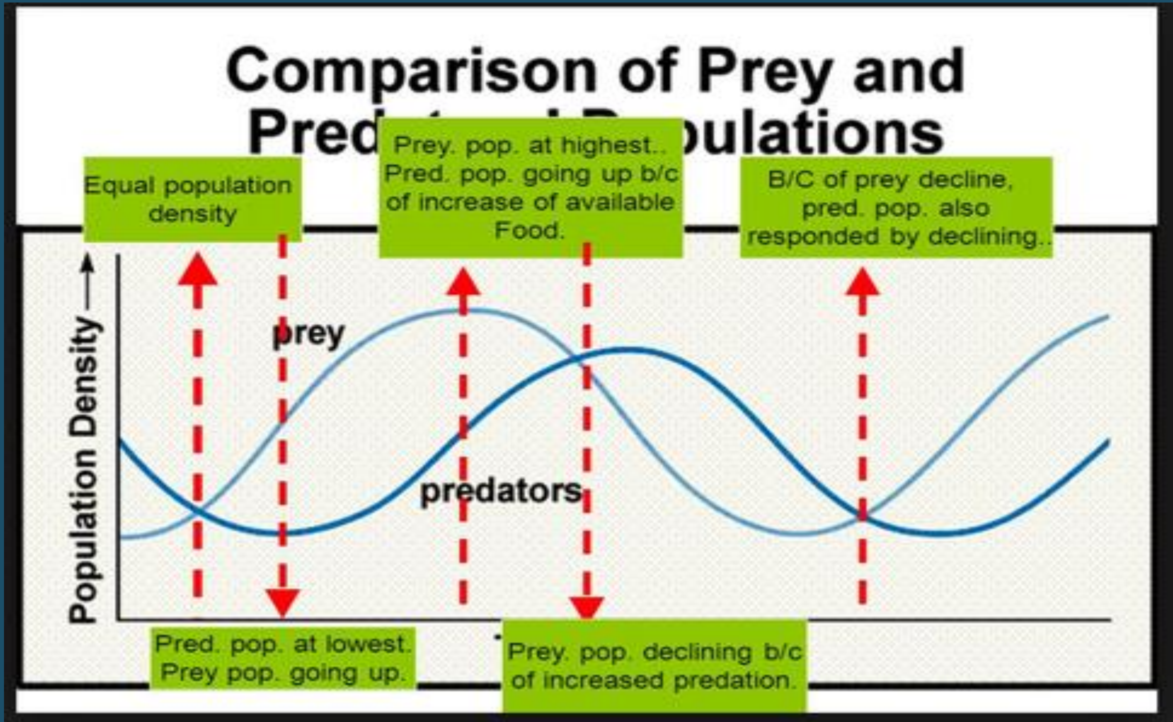
Energy and time budgeting is essential for a predator to survive depredation

a. Mutual depredation
   - predators fight and kill each other

b. Chance depredation
   - sudden encounter



Predation as a density dependent factor.
Predation regulates population size of prey, and prey size regulates population size of predator.



B) Disease and Parasites

- **Small population : often more vulnerable (inbreeding depression)**
- **Domestic or wild animals may serve as reservoirs or vectors**

Rinderpest - Mudumalai Gaur pop. almost eliminated – 1968

Periyar - 1974

<u>Frequency of disease is density dependent</u>

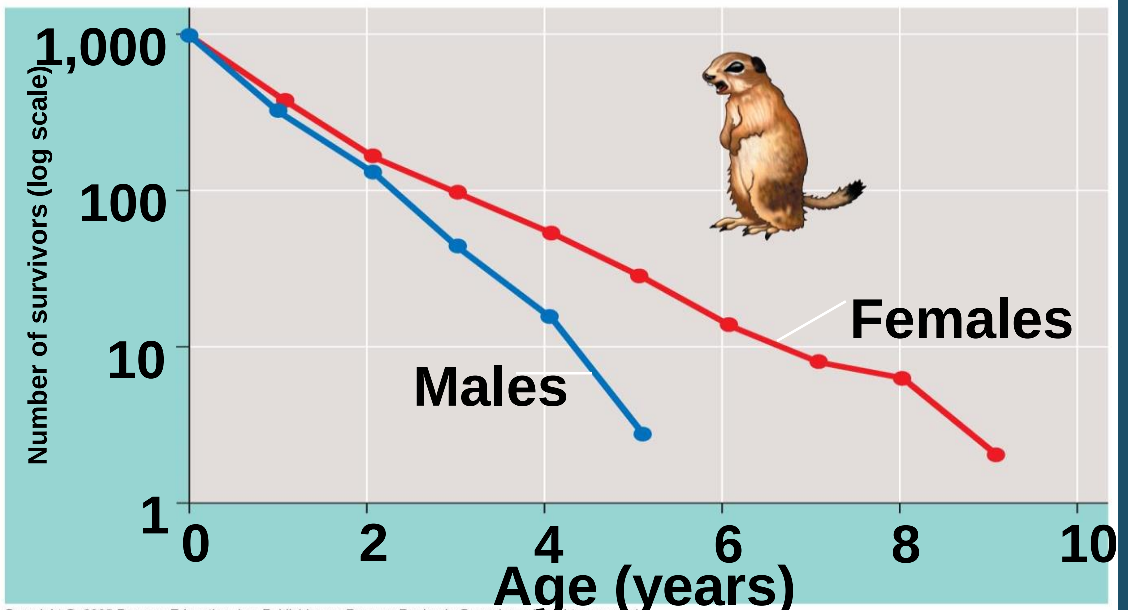
- <u>Demography</u> is the study of the <u>vital statistics</u> of a population and how they change over time
- <u>Death rates and birth rates</u> are of particular interest to demographers
- A <u>life table</u> is an <u>age-specific summary</u> of the <u>survival pattern of a population</u>
- It is best made by following the fate of a cohort
- **cohort** is a <u>group of subjects who have shared a particular event together</u> during a <u>particular time span</u> (e.g., people born in India between 1918 and 1939)
- The life table of Belding's ground squirrels reveals many things about this population

Table 52.1 Life Table for Belding's Ground Squirrels (*Spermophilus beldingi*) at Tioga Pass, in the Sierra Nevada Mountains of California*

	FEMALES					MALES				
Age (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)	Number Alive at Start of Year	Proportion Alive at Start of Year	Number of Deaths During Year	Death Rate†	Average Additional Life Expectancy (years)
0–1	337	1.000	207	0.61	1.33	349	1.000	227	0.65	1.07
1–2	252††	0.386	125	0.50	1.56	248††	0.350	140	0.56	1.12
2–3	127	0.197	60	0.47	1.60	108	0.152	74	0.69	0.93
3–4	67	0.106	32	0.48	1.59	34	0.048	23	0.68	0.89
4–5	35	0.054	16	0.46	1.59	11	0.015	9	0.82	0.68
5–6	19	0.029	10	0.53	1.50	2	0.003	0	1.00	0.50
6–7	9	0.014	4	0.44	1.61	0				
7–8	5	0.008	1	0.20	1.50					
8–9	4	0.006	3	0.75	0.75					
9–10	1	0.002	1	1.00	0.50					

*Males and females have different mortality schedules, so they are tallied separately.
†The death rate is the proportion of individuals dying in the specific time interval.
††Includes 122 females and 126 males first captured as one-year-olds and therefore not included in the count of squirrels age 0–1.

Source: Data from P. W. Sherman and M. L. Morton, "Demography of Belding's Ground Squirrel," *Ecology* 65(1984): 1617–1628.



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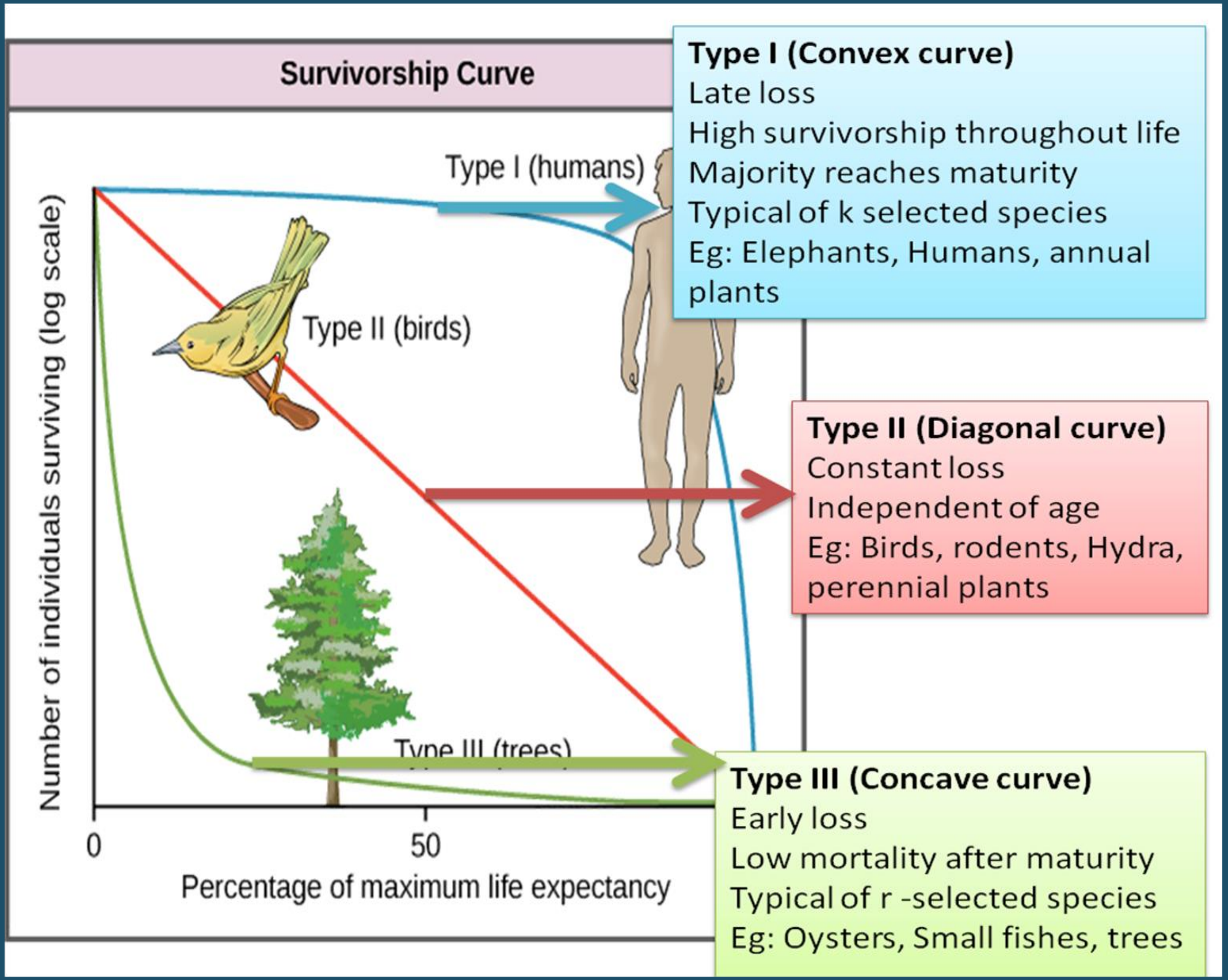
Survivorship Curves

- A survivorship curve is a graphic way of representing the data in a life table
- The survivorship curve for Belding's ground squirrels shows a relatively constant death rate
- Survivorship curves can be classified into three general types: Type I, Type II, and Type III



- A <u>reproductive table</u>, or fertility schedule, is an <u>age-specific summary of the reproductive rates in a population</u>. It describes <u>reproductive patterns of a population</u>

Table 52.2 Reproductive Table for Belding's Ground Squirrels at Tioga Pass

Age (years)	Proportion of Females Weaning a Litter	Mean Size of Litters (Males + Females)	Mean Number of Females in a Litter	Average Number of Female Offspring*
0–1	0.00	0.00	0.00	0.00
1–2	0.65	3.30	1.65	1.07
2–3	0.92	4.05	2.03	1.87
3–4	0.90	4.90	2.45	2.21
4–5	0.95	5.45	2.73	2.59
5–6	1.00	4.15	2.08	2.08
6–7	1.00	3.40	1.70	1.70
7–8	1.00	3.85	1.93	1.93
8–9	1.00	3.85	1.93	1.93
9–10	1.00	3.15	1.58	1.58

*The average number of female offspring is the proportion weaning a litter multiplied by the mean number of females in a litter.

Data from P. W. Sherman and M. L. Morton, "Demography of Belding's Ground Squirrel," *Ecology* 65 (1984): 1617–1628.

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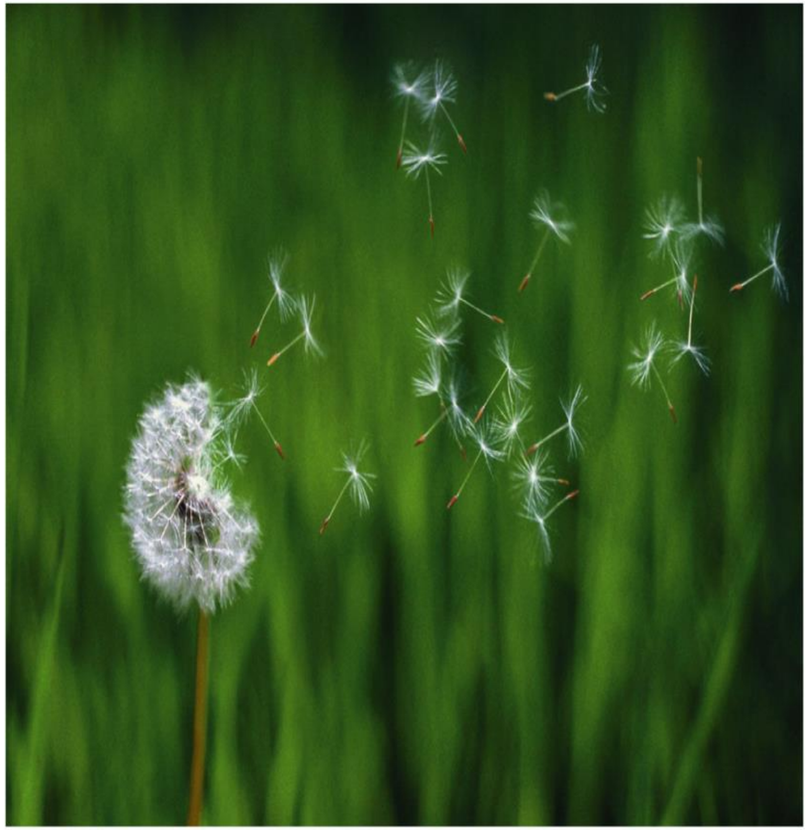

(a) **Most weedy plants, such as this dandelion, grow quickly and <u>produce a large number of seeds</u>, ensuring that at least some will grow into plants and eventually produce seeds themselves.**

(b) **Some plants, such as this coconut palm, produce a moderate number of very large seeds. The <u>large endosperm provides nutrients for the embryo, an adaptation that helps ensure the success of a relatively large fraction of offspring</u>.**

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The exponential model describes population growth in an idealized, unlimited environment

- It is useful to study population growth in an idealized situation
- Idealized situations help us understand the capacity of species to increase and the conditions that may facilitate this growth
- In animals, parental care of smaller broods may facilitate survival of offspring

- If immigration and emigration are ignored, a population's growth rate (per capita increase) equals birth rate minus death rate
- Zero population growth occurs when the birth rate equals the death rate
- Most ecologists use differential calculus to express population growth as growth rate at a particular instant in time:

$$\frac{dN}{dt} = rN$$

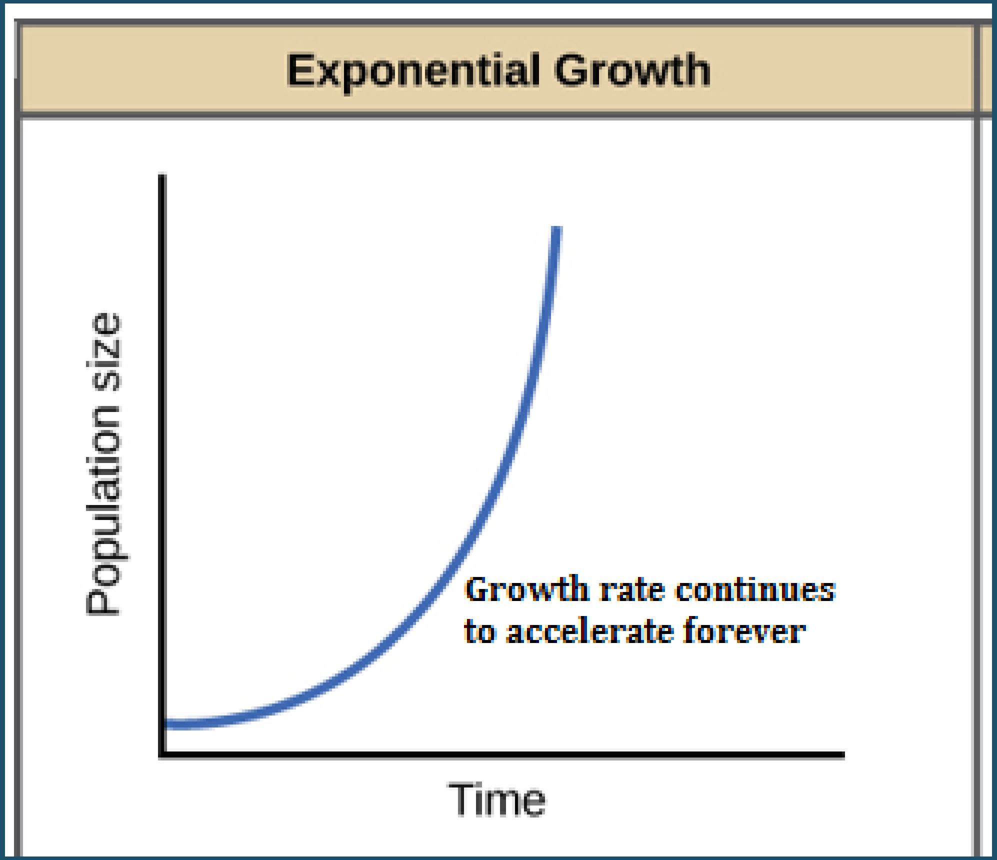
N is the number of individuals,
Tt is time

Exponential Growth

- Exponential population growth is population increase under idealized conditions
- Under these conditions, the rate of reproduction is at its maximum, called the intrinsic rate of increase

$$\frac{dN}{dt} = r_{max}N$$

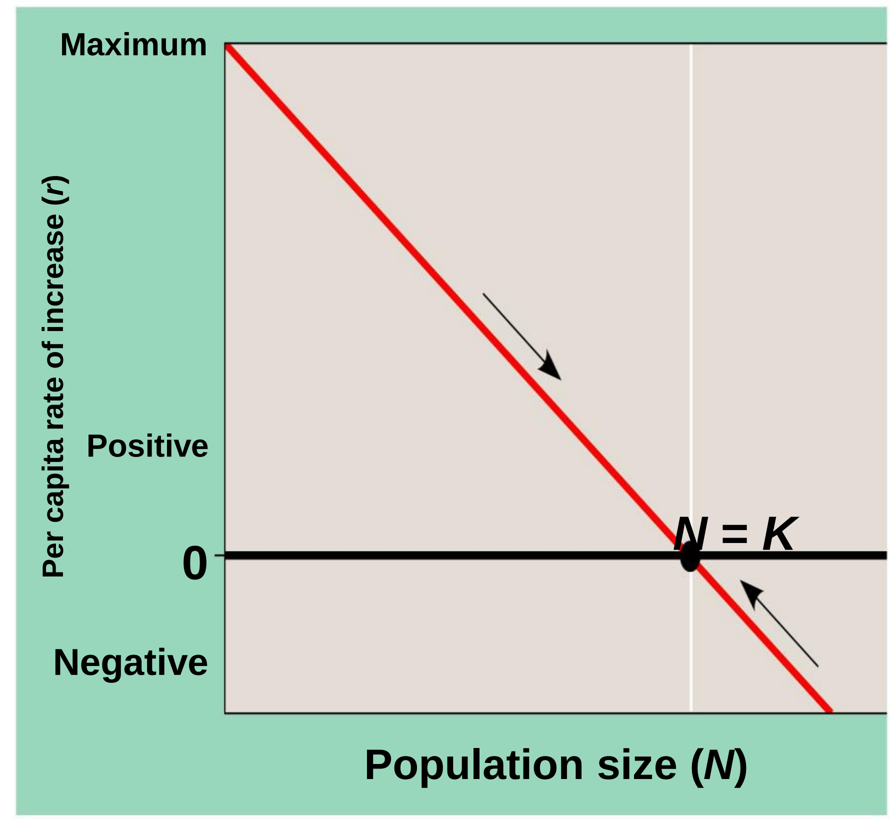
r_{max} is the maximum rate of growth,
N is the number of individuals,
K is the carrying capacity
t is time



- Exponential population growth results in a J-shaped curve

The logistic growth model includes the concept of carrying capacity

- Exponential growth cannot be sustained for long in any population
- A more realistic population model limits growth by incorporating carrying capacity
- Carrying capacity (*K*) is the maximum population size the environment can support
- In the logistic population growth model, the per capita rate of increase declines as carrying capacity is reached
- We construct the logistic model by starting with the exponential model and adding an expression that reduces per capita rate of increase as *N* increases



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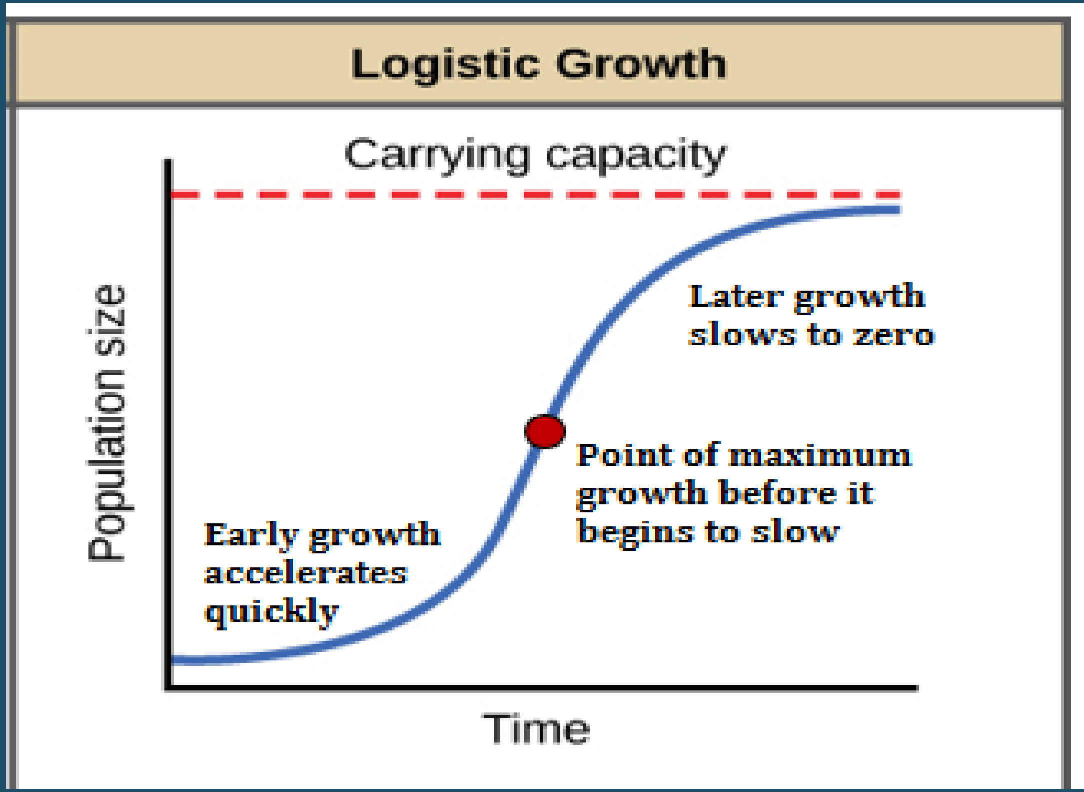
K comes from the German word for capacity is **Kapazität**

- The logistic growth equation includes *K*, the carrying capacity

$$\frac{dN}{dt} = r_{max} N \frac{(K - N)}{K}$$

r_{max} is the maximum rate of growth,
N is the number of individuals,
K is the carrying capacity
t is time



- The logistic model of population growth produces

a sigmoid **(S-shaped) curve**

Table 52.3 A Hypothetical Example of Logistic Population Growth, Where $K = 1{,}000$ and $r_{max} = 0.05$ per Individual per Year

Population Size: N	Intrinsic Rate of Increase: r_{max}	$\left(\frac{K-N}{K}\right)$	Per Capita Growth Rate: $r_{max}\left(\frac{K-N}{K}\right)$	Population Growth Rate:* $r_{max}N\left(\frac{K-N}{K}\right)$
20	0.05	0.98	0.049	+1
100	0.05	0.90	0.045	+5
250	0.05	0.75	0.038	+9
500	0.05	0.50	0.025	+13
750	0.05	0.25	0.013	+9
1,000	0.05	0.00	0.000	0

*Rounded to the nearest whole number.

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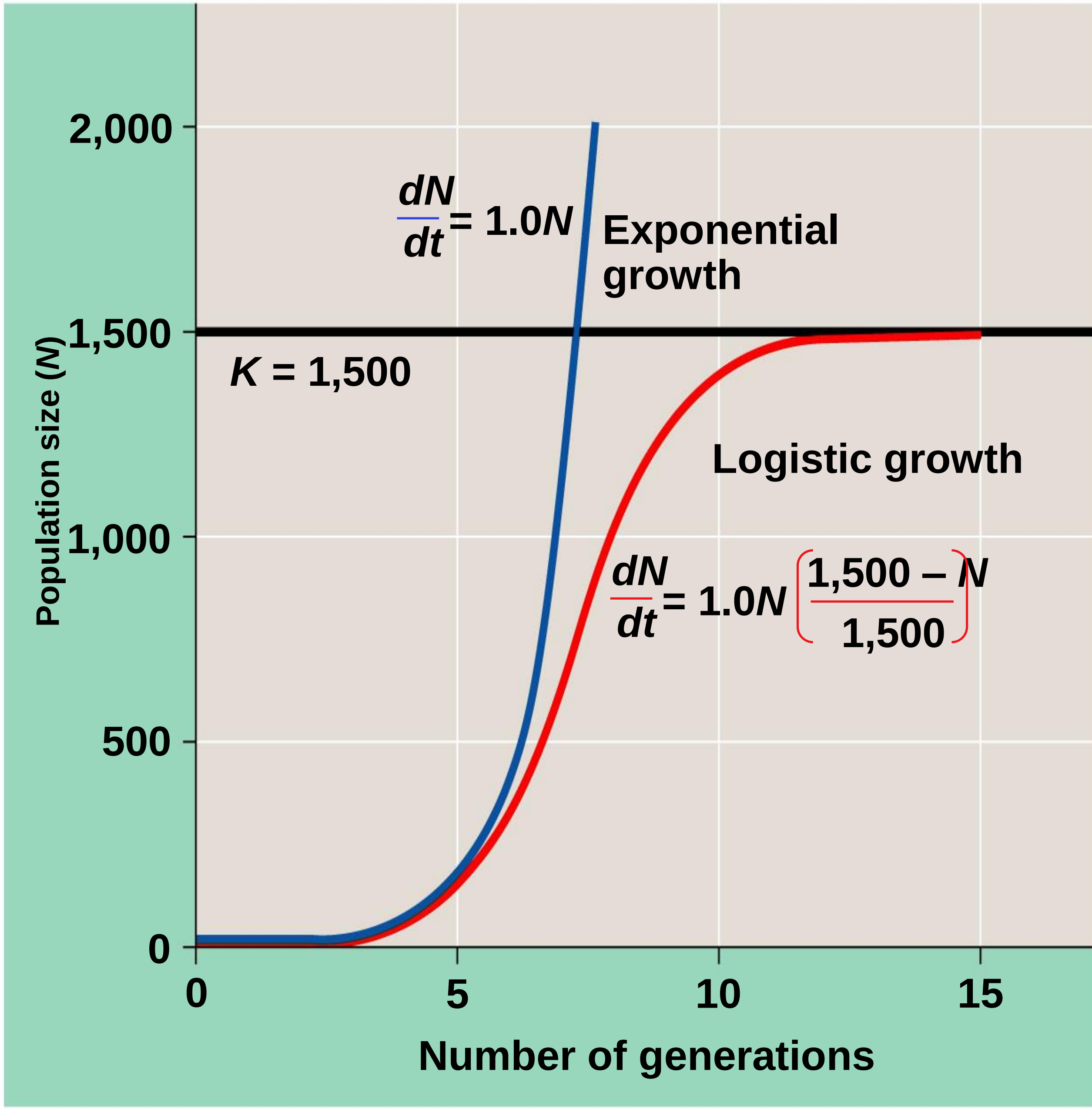

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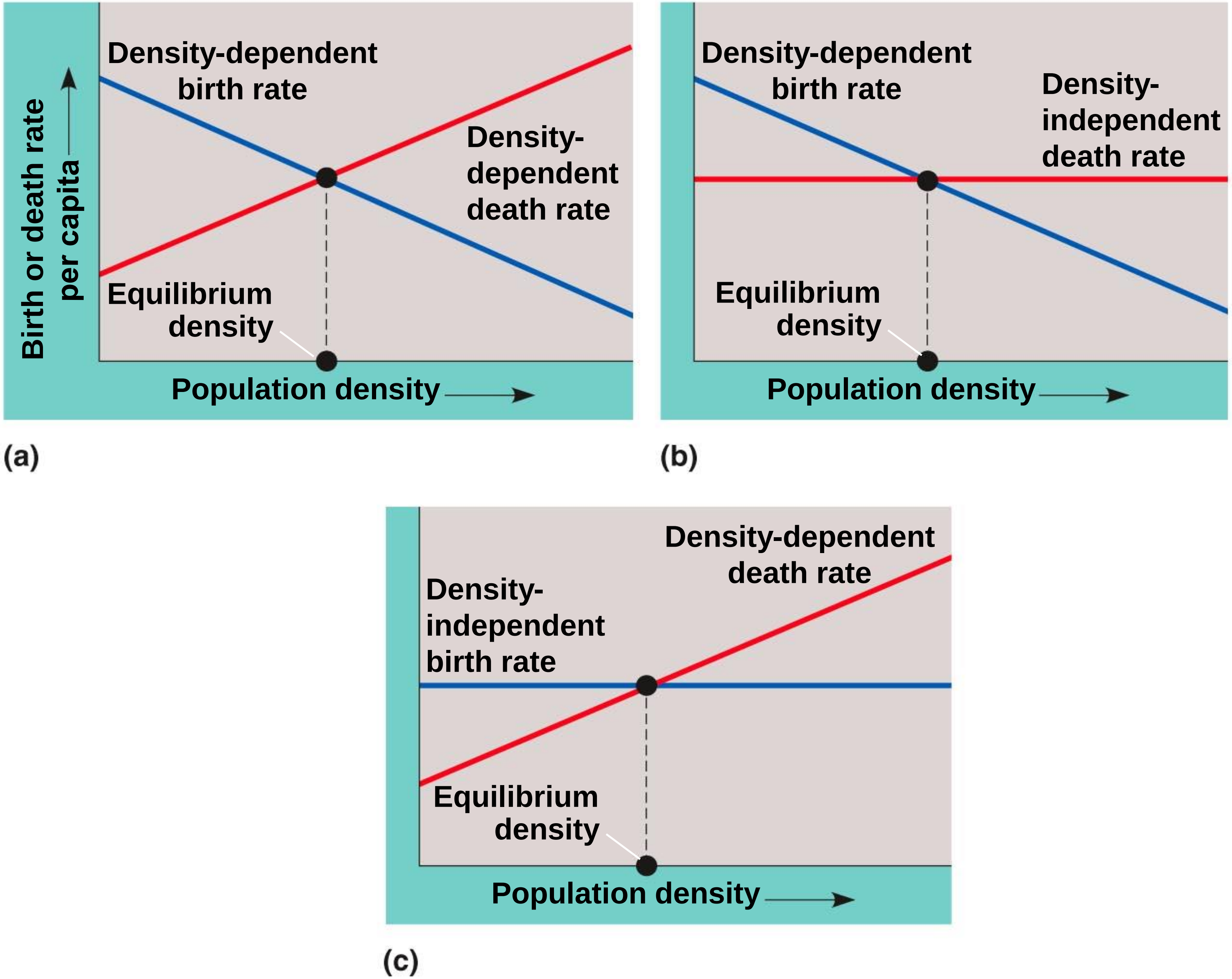
Factors Limiting Populations

- **Density-Dependent factors** intensify as the size of a population increases.
- **Examples**: Suitable nesting sites for cliff nesting birds such as gannets, competition for light and water among prairie grasses.
- **Density-Independent factors** are independent of population size.
- **Examples:** Winter temperatures greatly affect the populations of yellowjackets, sawflies and *Melanopus* grasshoppers.

Population Change and Population Density

- **In density-independent populations**, birth rate and death rate do not change with population density

- Density-dependent birth and death rates are an example of **negative feedback that regulates population growth**
- They are affected by many factors, such as competition for resources, territoriality, health, predation, toxic wastes, and intrinsic factors
- In crowded populations, increasing population density intensifies intraspecific competition for resources
- In density-dependent populations, birth rates fall and death rates rise with population density



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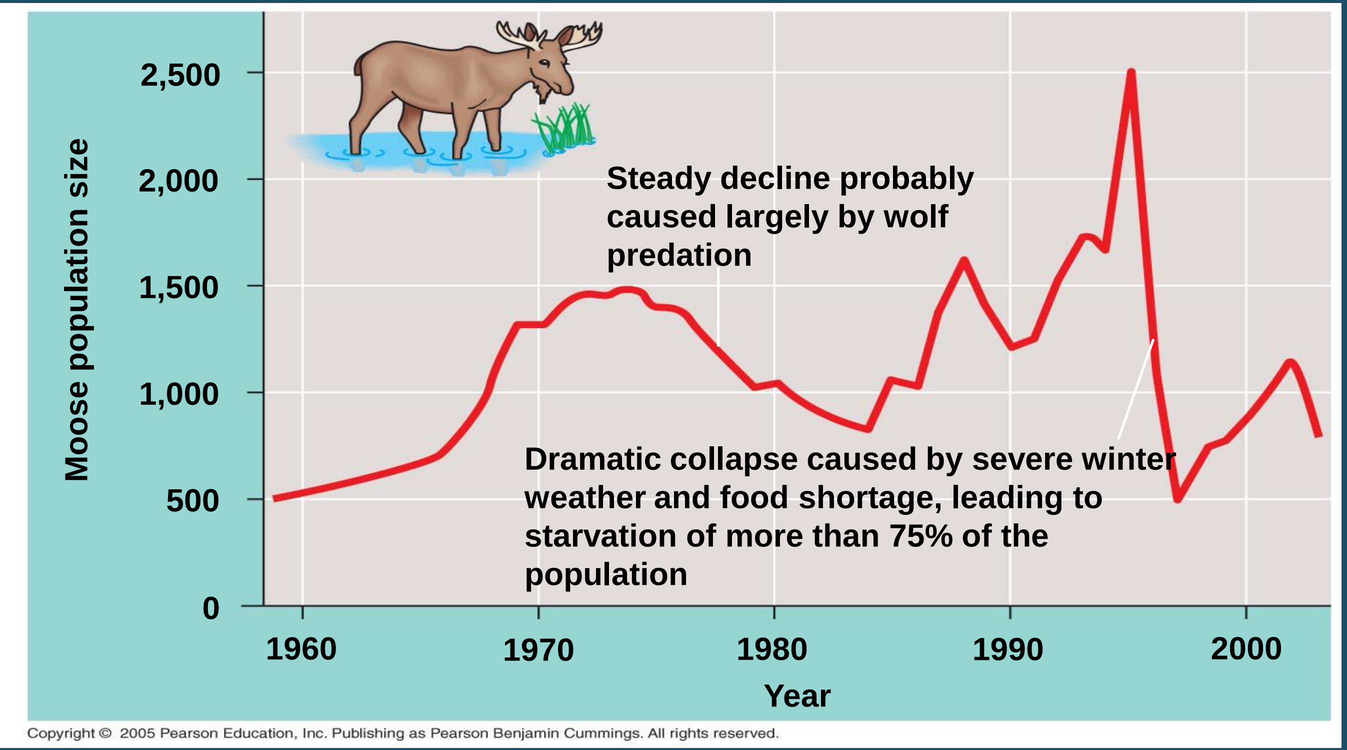
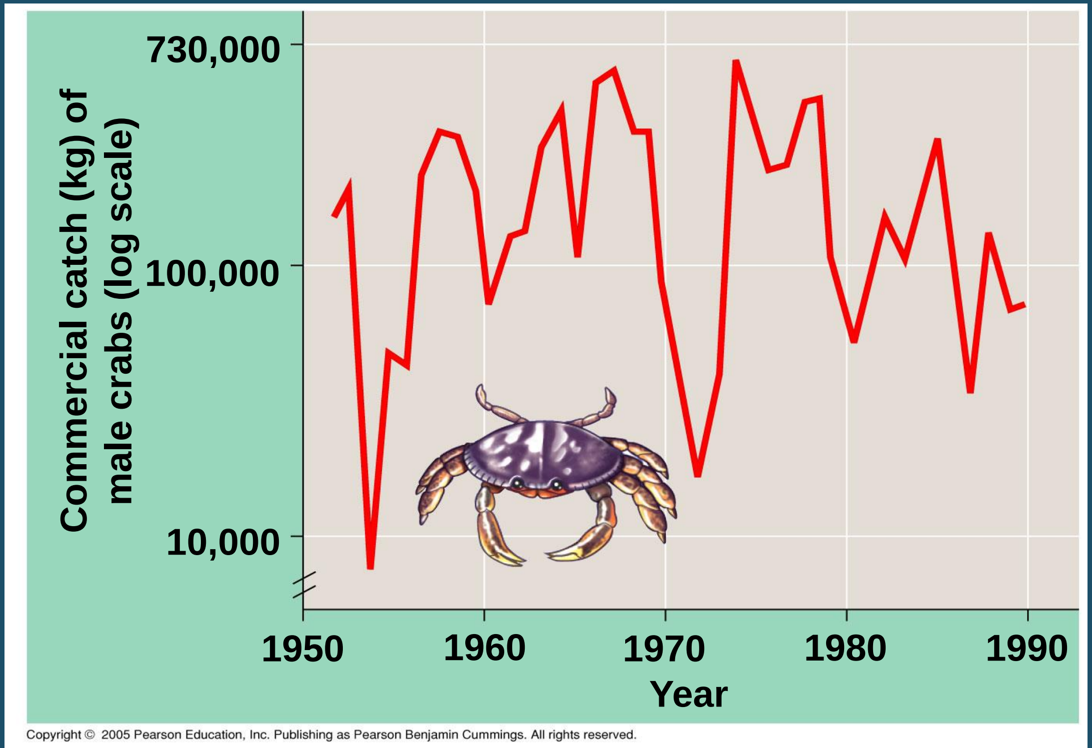
The Logistic Model and Life Histories

- Life history traits favored by natural selection may vary with population density and environmental conditions
- ***K*-selection**, or density-dependent selection, selects for life history **traits that are sensitive to population density**
- ***r*-selection**, or density-independent selection, selects for life history traits that **maximize reproduction**
- The concepts of *K*-selection and *r*-selection are somewhat controversial and have been criticized by ecologists as oversimplifications

Population Dynamics, *Stability and Fluctuation*

- The study of population dynamics focuses on the complex interactions between biotic and abiotic factors that cause variation in population size
- Long-term population studies have challenged the hypothesis that populations of large mammals are relatively stable over time
- <u>Extreme fluctuations in population size are typically more common in invertebrates than in large mammals</u>





EVOLUTIONARY STRATEGIES

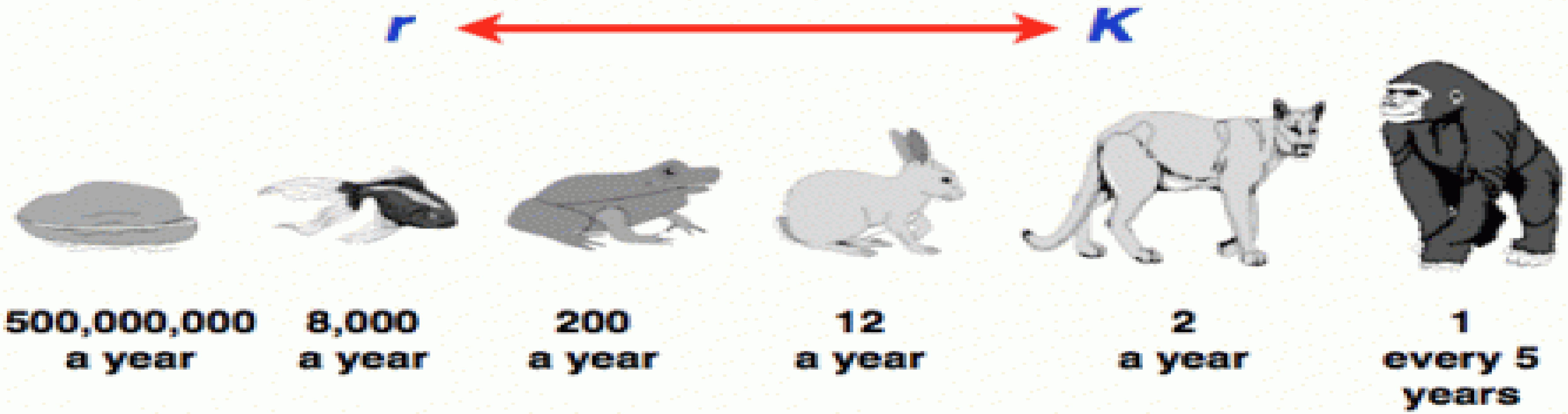
K-selected species - Reproductive Strategies

- Species **high on the food chain** / Few effective enemies
- **Stable environments-** climax vegetation
- Less energy devoted for reproduction and care of young / Usually **large body size**
- Can reach high levels of abundance- **energy devoted to intraspecific interactions**: territoriality, aggression, cannibalism, specialization
- **Population live near carrying capacity**(k)

r-SELECTED SPECIES - Reproductive Strategies

- **Low on the food chain**
- Occupy marginal or **early succession habitats** where resources are temporarily abundant
- **Rapid rate of reproduction**
- **Generalist** species
- **High dispersal ability**
- **Small size:** energy devoted to reproduction; **Less on intra-specific conflicts**
- Rodents, quails, flocking birds (starlings, quellas, sparrows)
- **Explosive populations**

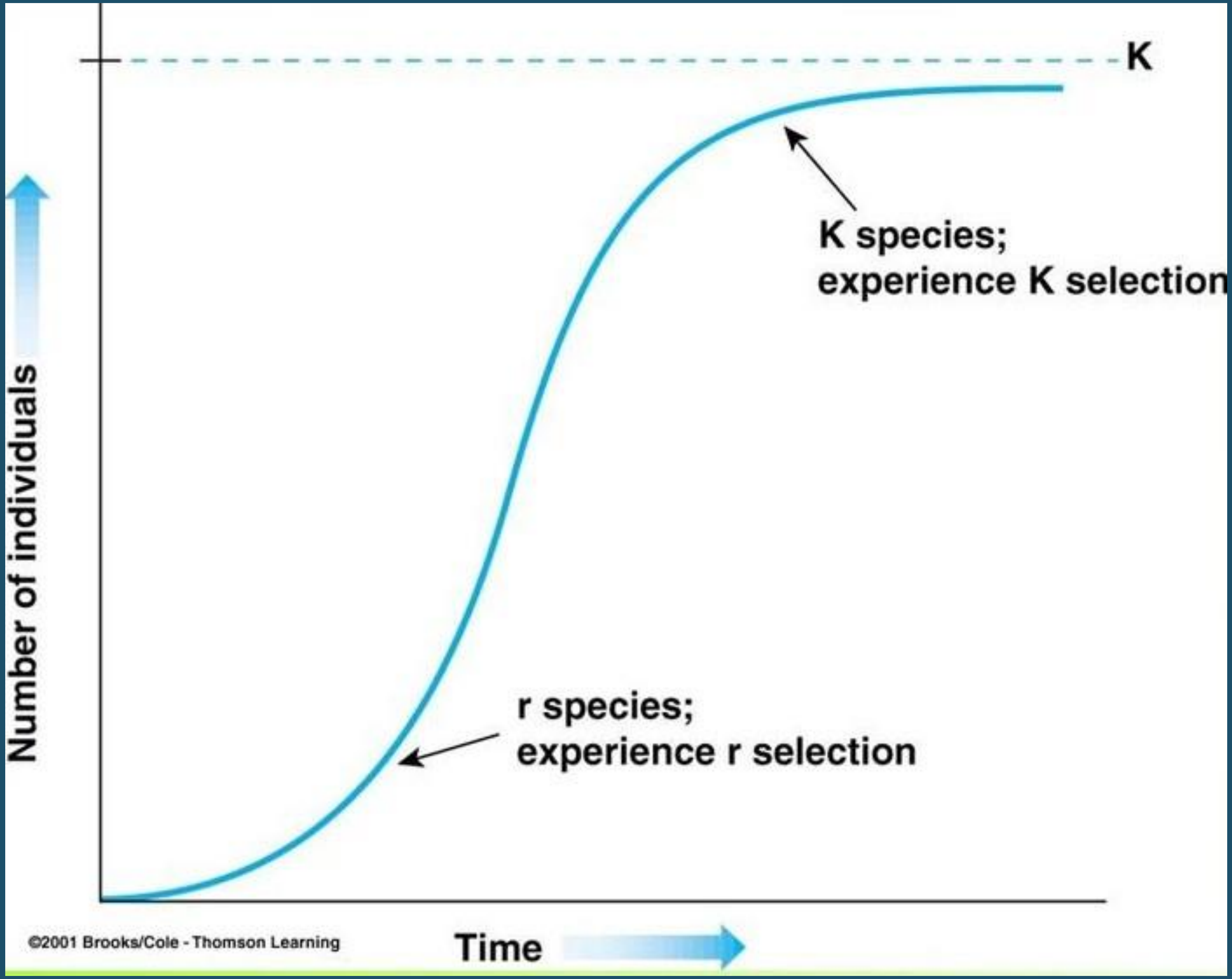
The r-K Scale of Reproductive Strategy: Balancing Egg Output versus Parental Care



Oysters are an example of a very *r*-strategy. They produce 500 million fertilized eggs per year and provide no parental care. The great apes are an example of a very *k*-strategy. They produce one infant every five or six years and provide extensive parental care.

Sources: Unabridged edition, ***Race Evolution, and Behavior*** (p 202)

Position of r and k species on the sigmoid population growth curve



	r-selection	*K*-selection
Climate	Variable and unpredictable; uncertain	Fairly constant or predictable; more certain
Mortality	Often catastrophic, nondirected, density independent	More directed, density dependent
Survivorship	Often Type III	Usually Types I and II
Population size	Variable in time, nonequilibrium; usually well below carrying capacity of environment; unsaturated communities or portions thereof; ecologic vacuums; recolonization each year	Fairly constant in time, equilibrium; at or near carrying capacity of the environment; saturated communities; no recolonization necessary
Intra- and interspecific competition	Variable, often lax	Usually keen
Selection favors	1. Rapid development 2. High maximal rate of increase, r_{max} 3. Early reproduction 4. Small body size 5. Single reproduction 6. Many small offspring	1. Slower development 2. Greater competitive ability 3. Delayed reproduction 4. Larger body size 5. Repeated reproduction 6. Fewer, larger progeny
Length of life	Short, usually less than a year	Longer, usually more than a year
Leads to	Productivity	Efficiency
Stage in succession	Early	Late, climax

Community ecology

Community ecology

- Community – Assemblage of interacting species occupying a particular position in the landscape.

- **Biotic community**-an **assemblage of plants, animals, microorganism** that live in an environment and interact with one another, forming a distinctive living system with its own composition, structure, environmental relations, development and function.

- Plant community, Animal community, Microbial community
- **Community vs organism**
  - Born, grow, matures, reproduces and dies

Synecology or Study of Communities

- The study of the relationship of plants and animals making up a natural community is termed as *community ecology or synecology*. A group of individuals of the same species is commonly known as *population*.

- **Community Composition**: The following points characterised the community:

- 1. Species diversity

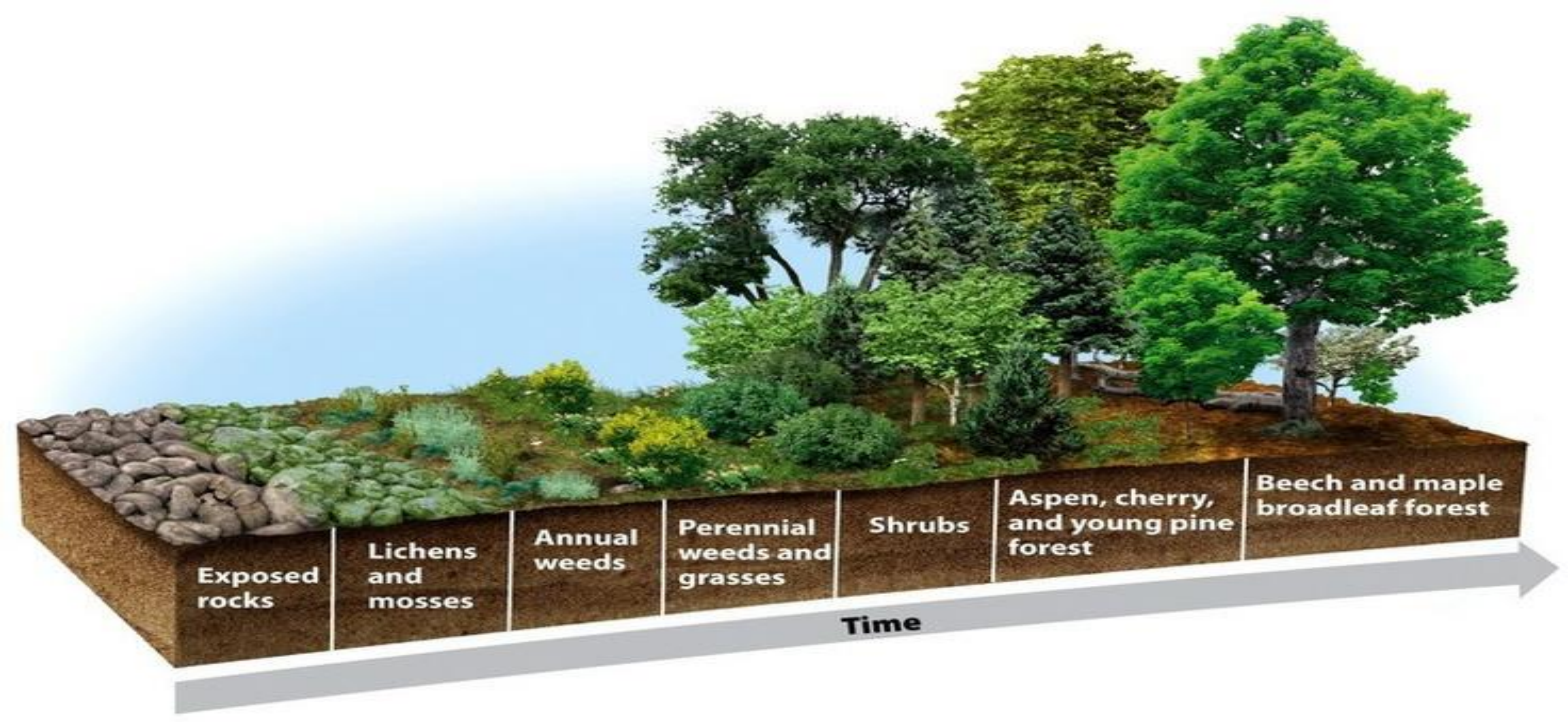
- 2. Coexistence

- 3. Interdependency: Thallophytes, mosses, ferns and many shade loving herbs that are found on the forest floor are dependent on the forest trees because trees provide shadow and moist conditions.

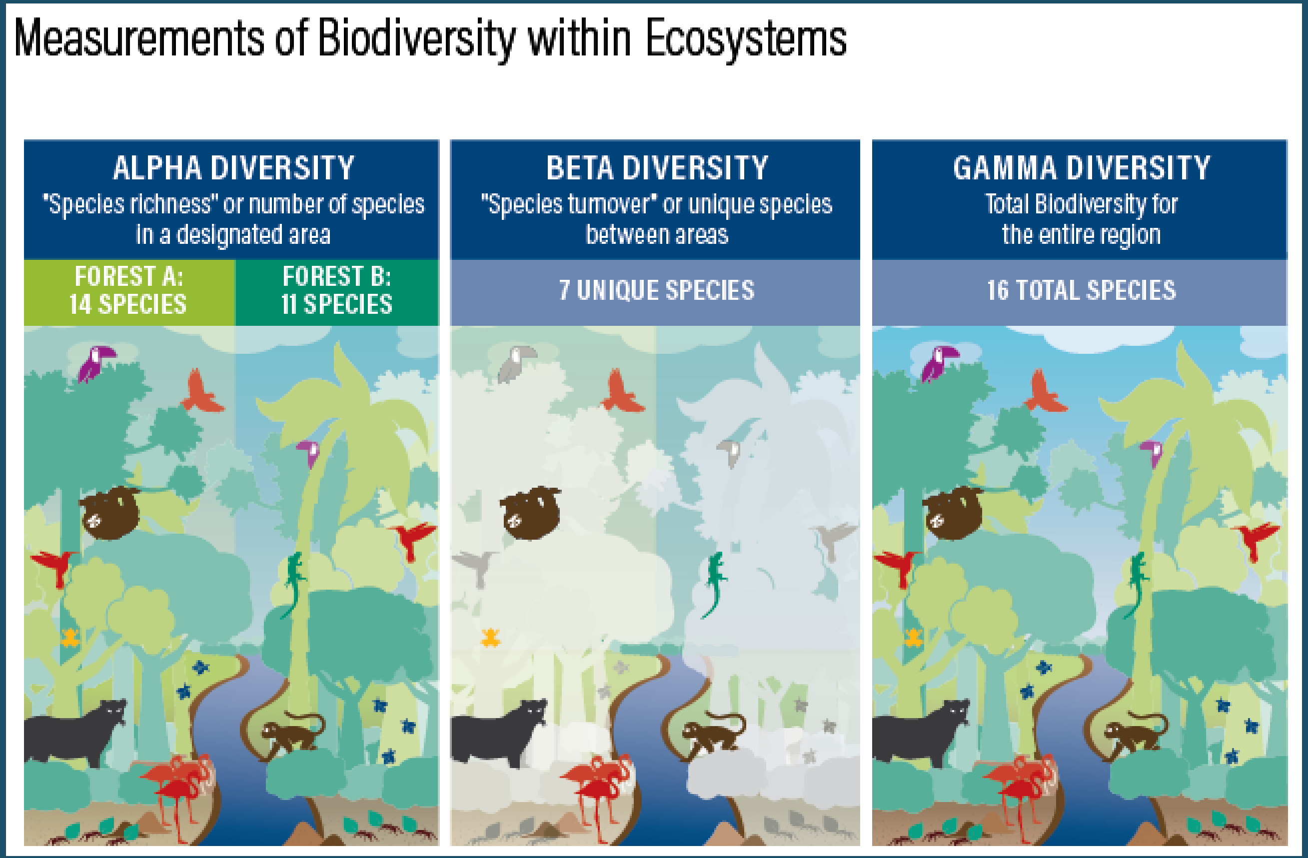
- 4. Species Dominance: in the forest, tallest trees, for example, influence the under-storey plants and ground vegetation not only by decreasing the intensity of light reaching the forest floor and increasing the moisture content of air but also by changing the soil structure and its chemical composition.

- 5. Stratification: In plant community, plants form, more or less, distinct strata or layers or storeys on vertical as well as in horizontal planes. This is characteristically known as *stratification.* The individual of different layers represent different "Life forms". Each layer of community may sometimes include individuals of different morphological classes, as for example, the top layer or canopy of forest may be formed by tallest trees and lianes (woody climbers).

- **6. Succession:** The sequence of communities showing a gradual change in composition is called *continuum* (Curtis 1959). As regards the composition of community, there are two opposing philosophies:



- Biological structure
  - Species diversity
    - Alpha diversity (Local diversity) – variety of organism occupying a <u>given place or </u>habitat.
    - Beta diversity (Regional diversity) – variety of organism occupying a number of <u>different habitat over a region.</u>
    - Gamma diversity – Diversity difference between similar habitats in widely separated <u>geographic regions.</u>



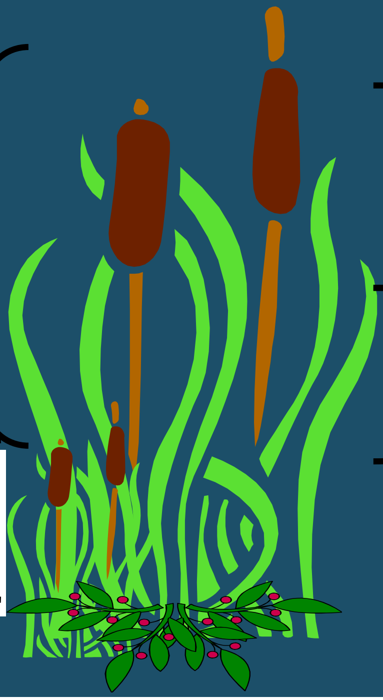
Interaction between species in a community

(2 species system)

Type of Interaction	Effect on species 1	Effect on species 2	Definition
Mutualism	Positive	Positive	Both species 1 and species 2 are benefitted.
Competition	Negative	Negative	Species 1 and species 2 have a negative effect on each other.
Predation or parasitism	Positive	Negative	Species 1 is benefitted and species 2 is harmed.
Commensalism	Positive	None	Species 1 is benefited, but species 2 is neither benefitted nor harmed.
Amensalism	None	Negative	Species 1 has a negative effect on species 2, but species 1 is neither affected nor benefited.
Neutralism	None	None	Species 1 and species 2 interact without affecting each other.

GRASS

FORBS+
HERBS



EATEN BY ZEBRA — GRAZER

WILDER BEAST — GRAZER

THOMSON'S GAZELLE — BROWSER

IN KAZIRANGA

RHINO → SWAMP DEER → HOG DEER

SPACE

Carrying capacity:

- Maximum capacity of habitat to support animals, without damaging future capacities
- Carrying capacity is the user specified quality biomass of a particular species or a group of species, under the influence of social and behavioural constraints, for which a particular area having user specified objectives, will supply all energetic and physiological requirement over a long but specified period

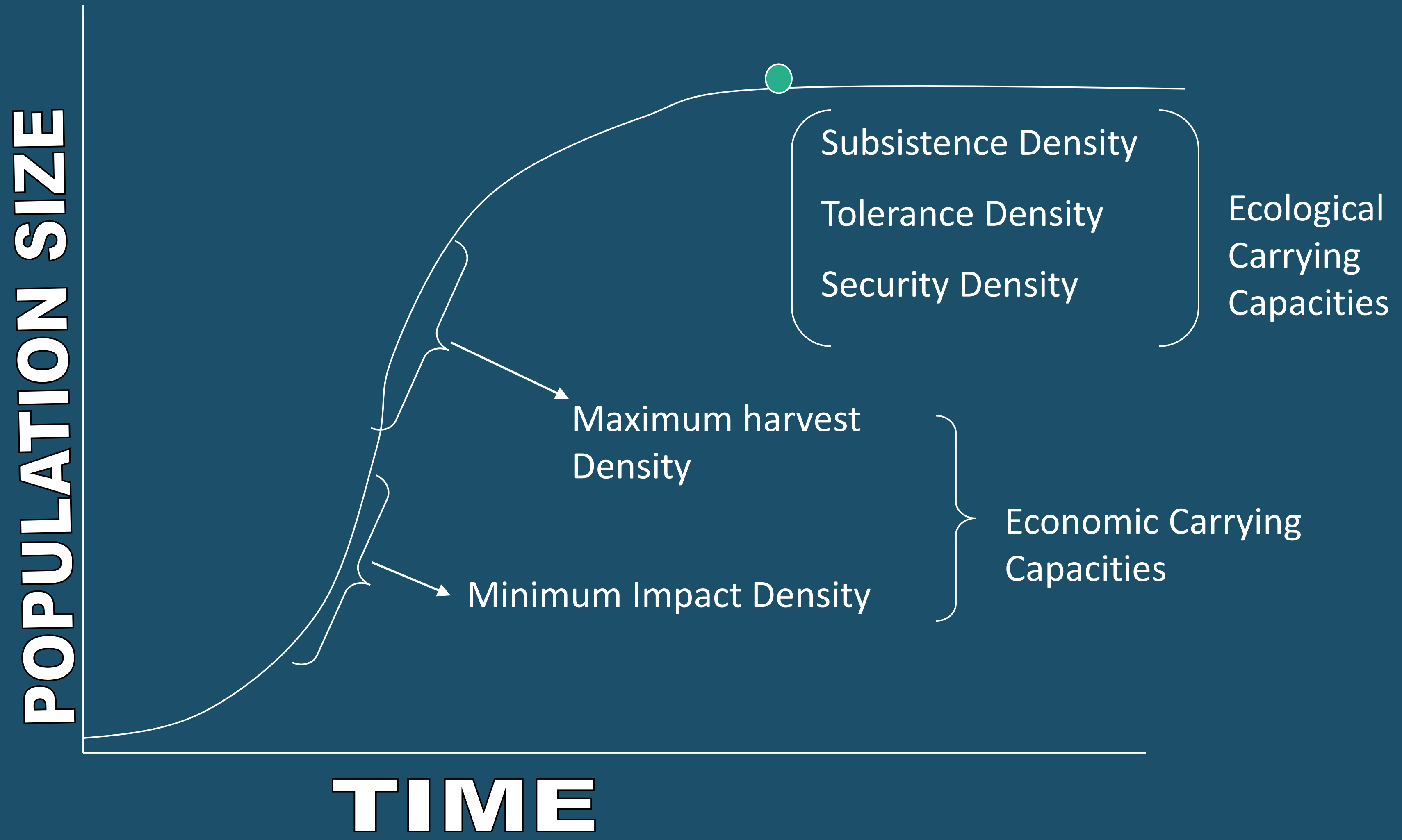
TWO TYPES

: Species specific

: Composite species

Actual C.C. - Current based on local or temporal factors

Potential C.C. -Theoretical maximum under a given set of natural conditions

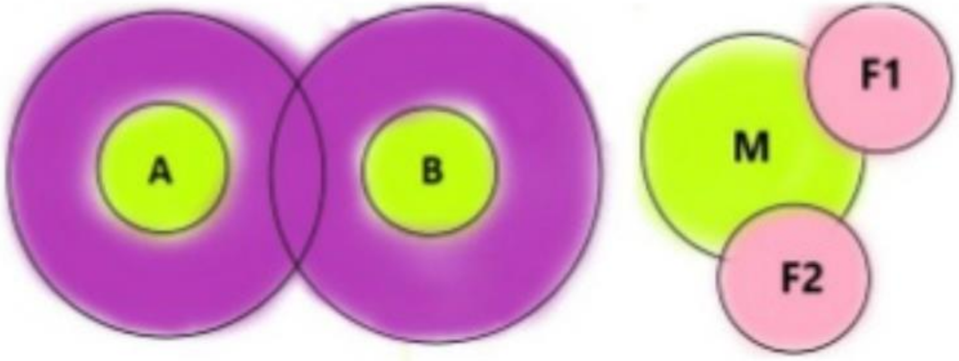


Five types of population regulation in relation to the sigmoid population model.

TERRITORY AND HOME RANGE

- **Territory** relates to a space, which is **vigorously defended** by an animal
- **Home range** is the area where **animal spends most of his time to secure its requirement** for energy (food), shelter, water and breeding space

Marking and active protection of territory by tiger



Home ranges of two male tigers ('A' and 'B') are overlapped but territories never get overlapped. However, terrotories of female (F) get overlapped with that of a male (M). Sometimes territory of a single male is overlapped by more than one female (F1 & F2)

Territorial behavior in tiger:

Home range is a space required for regular activities of an individual e.g. prowling, foraging, water body, mating etc.

Territory is protected strictly for the requirement of basic niche like food, water and shelter. Territories are regularly **marked by urination and defecation.**

TIGER HOME RANGE (km^2)

-**Territorial markings**: to avoid intraspecific encounters as high intolerance and antagonism exists

-Territoriality is an innate species characteristic: mostly seen in mammals, birds and fishes

-Territories are flexible

-**Territorial advertisement**: visual, vocalizations, olfactory, defecation

MALE	FEMALE	LOCATION
60-72	16-20	Chitwan
90-105	26-39	Chitwan
30-35	10-20	Kanha
38-50	12-42	Palamau
800-1000	100-400	USSR

MONITORING OF HOME RANGE IS DONE BY

1. Radio tele metry
2. Capture - mark recapture
3. Tracking and mapping routes followed by animal