Environmental Science, 15e

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5

Species Interactions, Ecological Succession, and Population Control

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Core Case Study: The Southern Sea Otter – A Species in Recovery

- At one time, 13,000-20,000 sea otters lived in the waters off the coast of California
  - By 1938, only about 50 were left
  - In 1977, they were declared an endangered species
  - In 2013, numbers are about 2,900
- How would the loss of the seal otter affect the biodiversity of these coastal waters?

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5.1 How Do Species Interact?

- Five ways in which species interact
  - Interspecific competition
  - Predation
  - Parasitism
  - Mutualism
  - Commensalism
- All of these affect resource use and population size

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Most Species Compete with One Another for Certain Resources

- Species share limited resources
  - Food
  - Shelter
  - Space

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Interspecific Competition

- The most common type of interaction:
  - When two species compete for the same resource, their niches overlap
  - Resource partitioning
    - Occurs when competing species evolve specialized traits that allow them to use shared resources at different times, in different ways, or in different places

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Sharing the Wealth

After R. H. MacArthur, "Population Ecology of Some Warblers in Northeastern Coniferous Forests," Ecology 36:533–536, 1958.

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Predation

- When an individual of one species (predator) feeds directly on another plant or animal species
  - The two species are engaged in a predator-prey relationship
  - This has a strong effect on population size and other factors

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How Do Predators Capture Their Prey?

- Herbivores can walk up to their prey (plants)
- Carnivores have a variety of methods to capture to prey:
  - Running and flying
  - Working together to hunt
  - Ambush
  - Camouflage
  - Attack with chemical warfare

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How Do Prey Species Avoid Predators?

- Run, swim, or fly fast
- Highly developed senses of sight, hearing or smell
- Physical protection – shells, thick bark, spines
- Camouflage – shapes and colors
- Chemical warfare – poisons, irritating (stinging), foul-smelling or bad tasting (can be poisonous)

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Consumer Species Feed on Other Species

- How do prey species avoid predators?
  - Mimicry – when a non-poisonous species looks like (mimics) a species that is poisonous
  - Behavior strategies -- such as scaring off, puffing up, spreading wings, mimicking a predator, living in large groups (schools), or exhibiting warning coloration (indicating “eating me is risky”)

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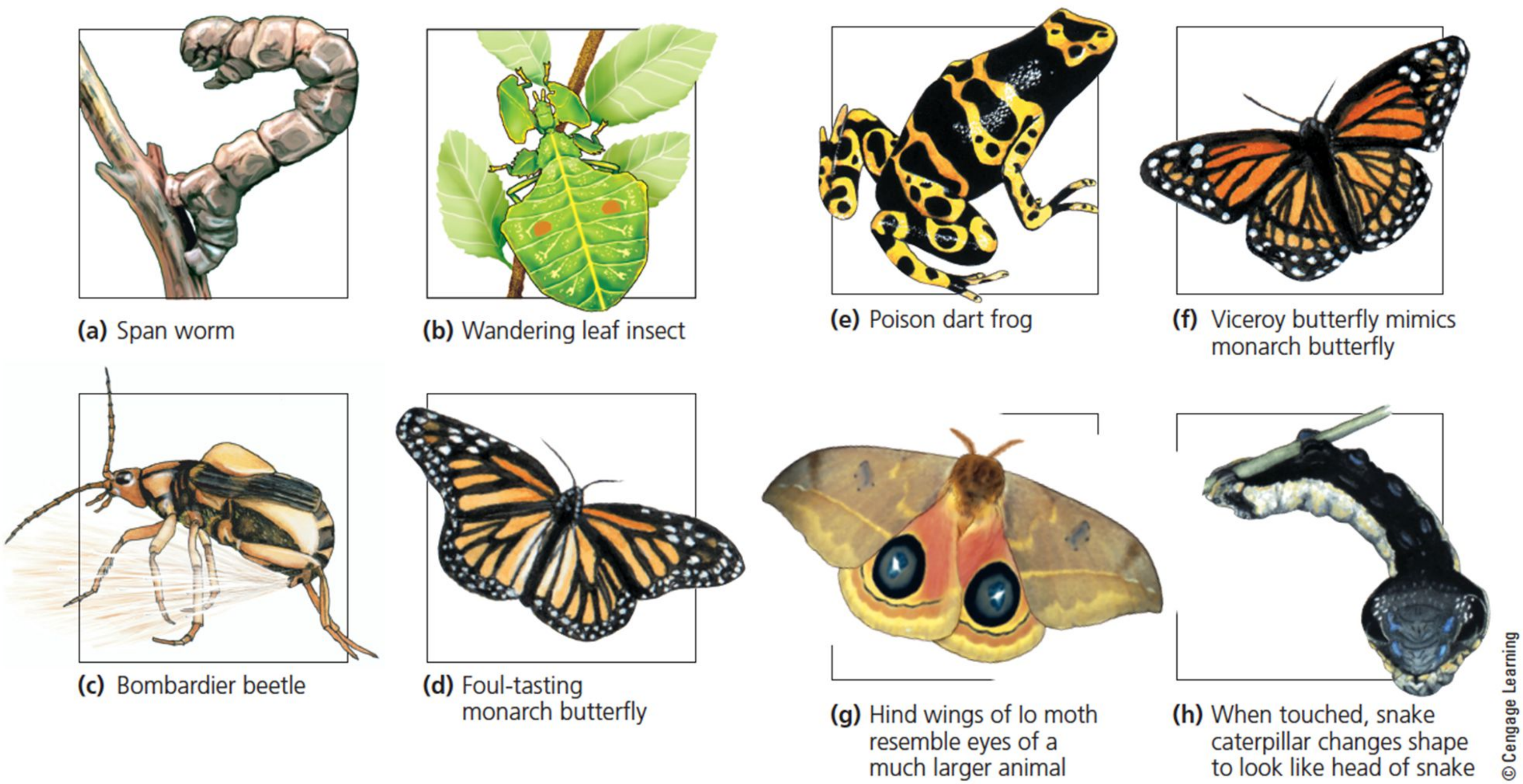

(a) Span worm

(b) Wandering leaf insect

(e) Poison dart frog

(f) Viceroy butterfly mimics monarch butterfly

(c) Bombardier beetle

(d) Foul-tasting monarch butterfly

(g) Hind wings of Io moth resemble eyes of a much larger animal

(h) When touched, snake caterpillar changes shape to look like head of snake

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Interactions Between Predator and Prey Species Can Drive Each Other's Evolution

- Coevolution -- when populations of two different species interact over a long period of time, changes in the gene pool of one species can lead to changes in the gene pool of the other
- Complex predator-prey relationships play an important role in controlling population growth and providing ecosystem services
  - The introduction of nonnative predator species can disrupt these relationships

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Some Species Feed Off Other Species by Living On or Inside Them

- Parasitism occurs when one species (parasite) feeds on the body of, or the energy used by another organism (host) – usually by living on or in the host
  - A parasite is usually much smaller than its host and rarely kills it
  - Parasites can live inside the host (tapeworms)
  - Others are attach themselves to the outside of host (mistletoe, sea lampreys)

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Parasitism

Great Lakes Fishery Commission

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In Some Interactions, Both Species Benefit

- Mutualism occurs when two species behave in ways that benefit both
  - Providing each with food, shelter, protection, or some other resources
  - Examples:
    - Birds that ride on the backs of large animals and remove pests (African buffalo)
    - Bacteria that live in our intestines and help us digest food

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Mutualism

Villiers Steyn/Dreamstime.com

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In Some Interactions, One Species Benefits and the Other is Not Harmed

- Commensalism occurs when one species benefits from species interaction, and the other is not affected or harmed at all
  - Example: air plants known as epiphytes attach themselves to the trunks or branches of large trees to access sunlight

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5.2 How Do Communities Ecosystems Respond to Changing Environments?

- Ecological succession
  - The normal, gradual change in species composition in a given geographic area
  - The species composition of an ecosystem or community can change in response to changing environmental conditions
  - Primary and secondary succession are examples of natural ecological restoration

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Primary Ecological Succession

- The gradual establishment of biotic communities in lifeless areas where there is no soil in a terrestrial ecosystem or no bottom sediment in an aquatic system
  - Takes hundreds to thousands of years

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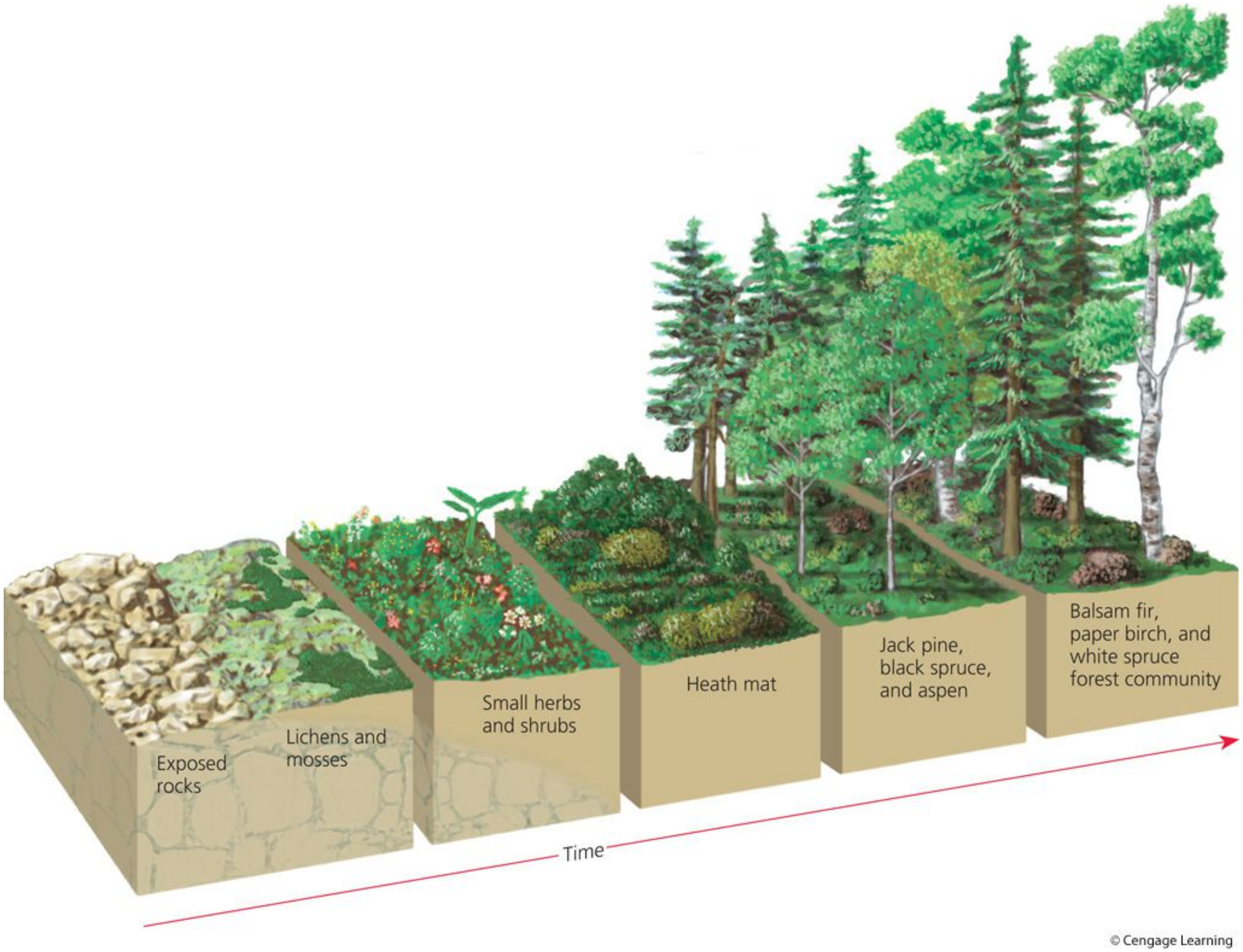
Primary Ecological Succession – Illustrated



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Secondary Ecological Succession

- Occurs where communities or ecosystems have been disturbed, removed or destroyed, but retain some soil or bottom sediments
- Enriches biodiversity of communities and ecosystems by increasing species diversity and interaction among species

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Secondary Succession Also Enhances Sustainability

- Promotes population control
  - Increases the complexity of food webs
  - Enhances energy flow
  - Increases nutrient cycling

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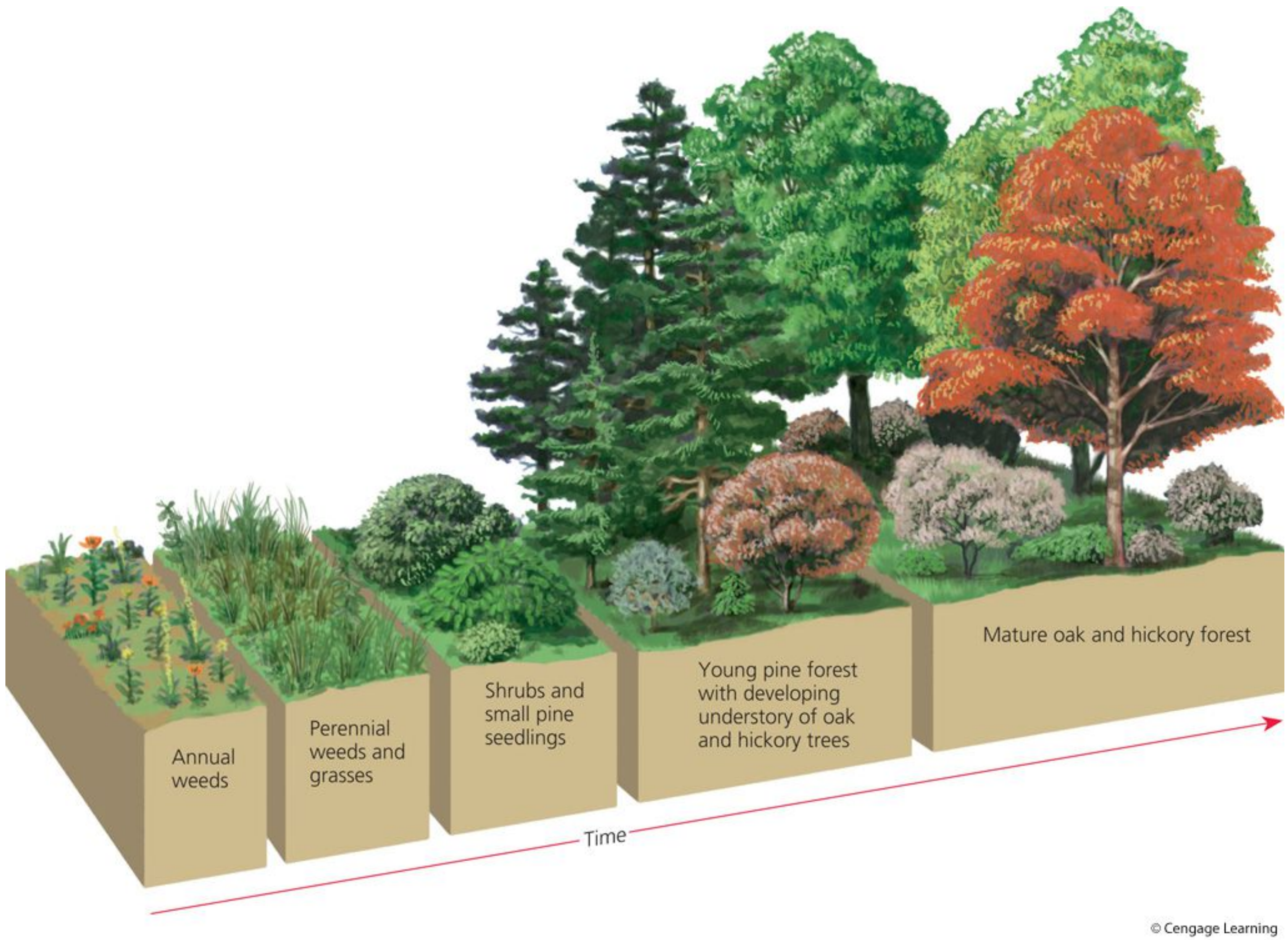
Secondary Ecological Succession – Illustrated



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Living Systems Are Sustained Through Constant Change

- Contain complex processes that interact to provide some degree of stability or sustainability
  - Withstand external stress in response to changing environmental conditions
- Two aspects of stability/sustainability:
  - Inertia (persistence)
  - Resilience

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5.3 What Limits the Growth of Populations?

- Populations cannot grow indefinitely due to:
  - Limitations on resources
  - Competition among species for these resources

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Populations Can Grow, Shrink, or Remain Stable

- A population is a group of interbreeding individuals of the same species, living together in the same geographic area
- Population size can change based on:
  - Births/deaths
  - Immigration (arrival of individuals from outside the population)
  - Emigration (departure of individuals from the population)

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Some Factors Can Limit Population Size

- Each population in an ecosystem has a range of tolerance – its ability to survive under various physical and chemical environmental conditions
  - Some individuals in a population may also have different ranges of tolerance for temperature or other physical or chemical factors – known as limiting factors

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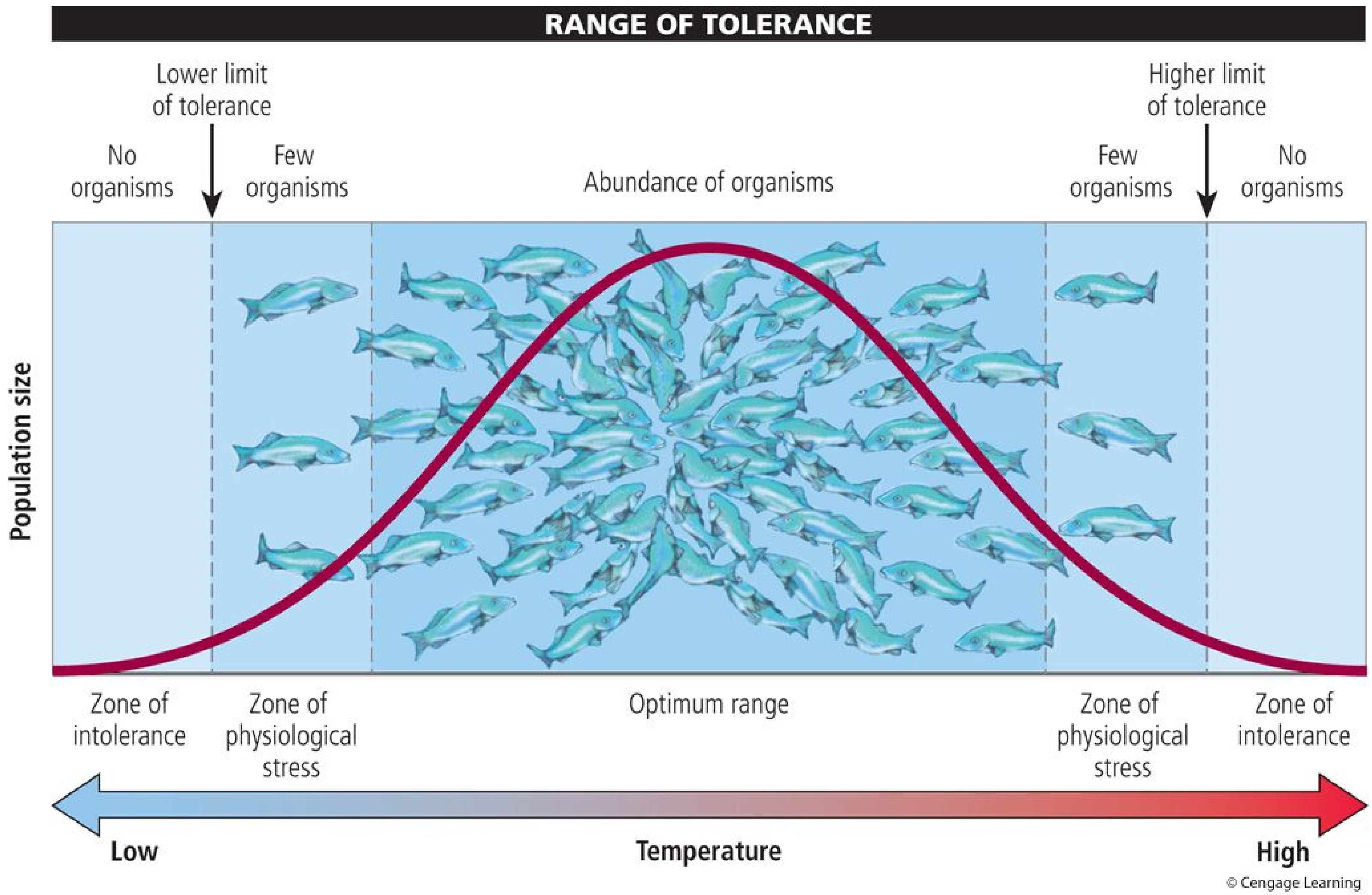
Range of Tolerance



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Limiting Factors Can be Physical or Chemical

- Examples
  - On land, precipitation is often a limiting factor
  - In aquatic ecosystems, limiting factors can be:
    - Temperature, water depth, clarity (allowing for more or less sunlight), nutrient availability, acidity, salinity, and the level of oxygen in the water
- An excess of a limiting factor can itself be limiting
  - Too much water on land or too much acidity in aquatic environments

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Density-Dependent and Density-Independent Factors

- Population density: the number of individuals in a given geographic area
  - Density-dependent factors become more important as a population size increases
    - Parasites and diseases spread more easily
    - Sexually reproducing individuals can find mates more easily
  - Density-independent factors
    - Drought and climate

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No Population Can Grow Indefinitely: J-Curves

- Some species reproduce and grow exponentially
- Plotting this data generates a J-curve showing exponential growth
  - Members reproduce at an early age; many offspring in each generation; time between generations is short
- All species have population growth limits
  - Sunlight, water, temperature, space, nutrients

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No Population Can Grow Indefinitely: S-Curves

- Environmental resistance
  - The sum of all factors that limit the growth of a population
- Carrying capacity:
  - The maximum population of a given species that a habitat can sustain indefinitely
  - As the population approaches its carrying capacity, its J-curve becomes an S-curve of fluctuating logistic growth

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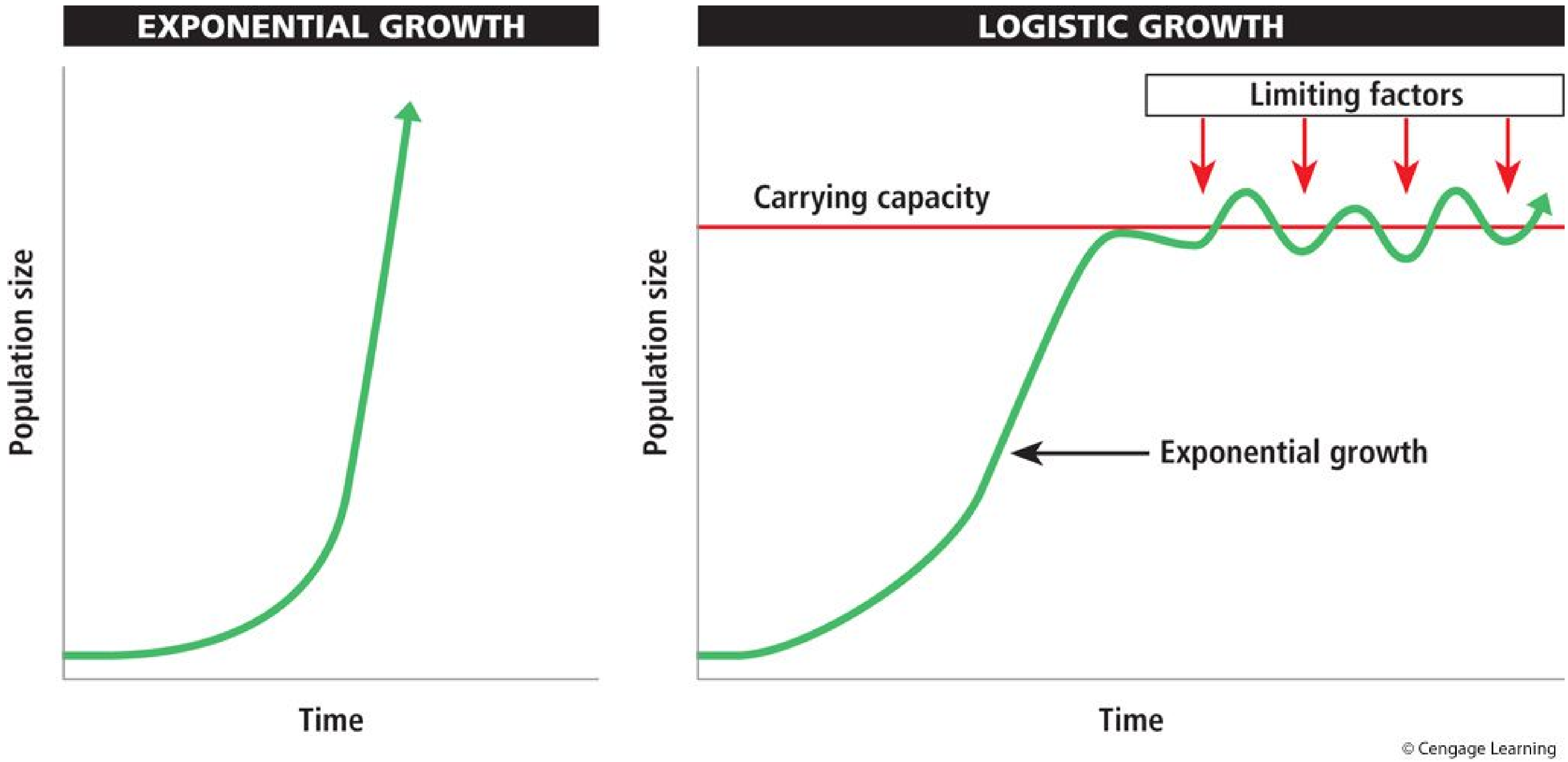
J-Curves and S-Curves – Illustrated



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No Population Can Grow Indefinitely: Population Crash

- When a population overshoots the carrying capacity, the population sharply declines
  - Dieback, or population crash
- Now a population must either:
  - Stabilize its population
  - Switch to new resources
  - Move to a new geographic area

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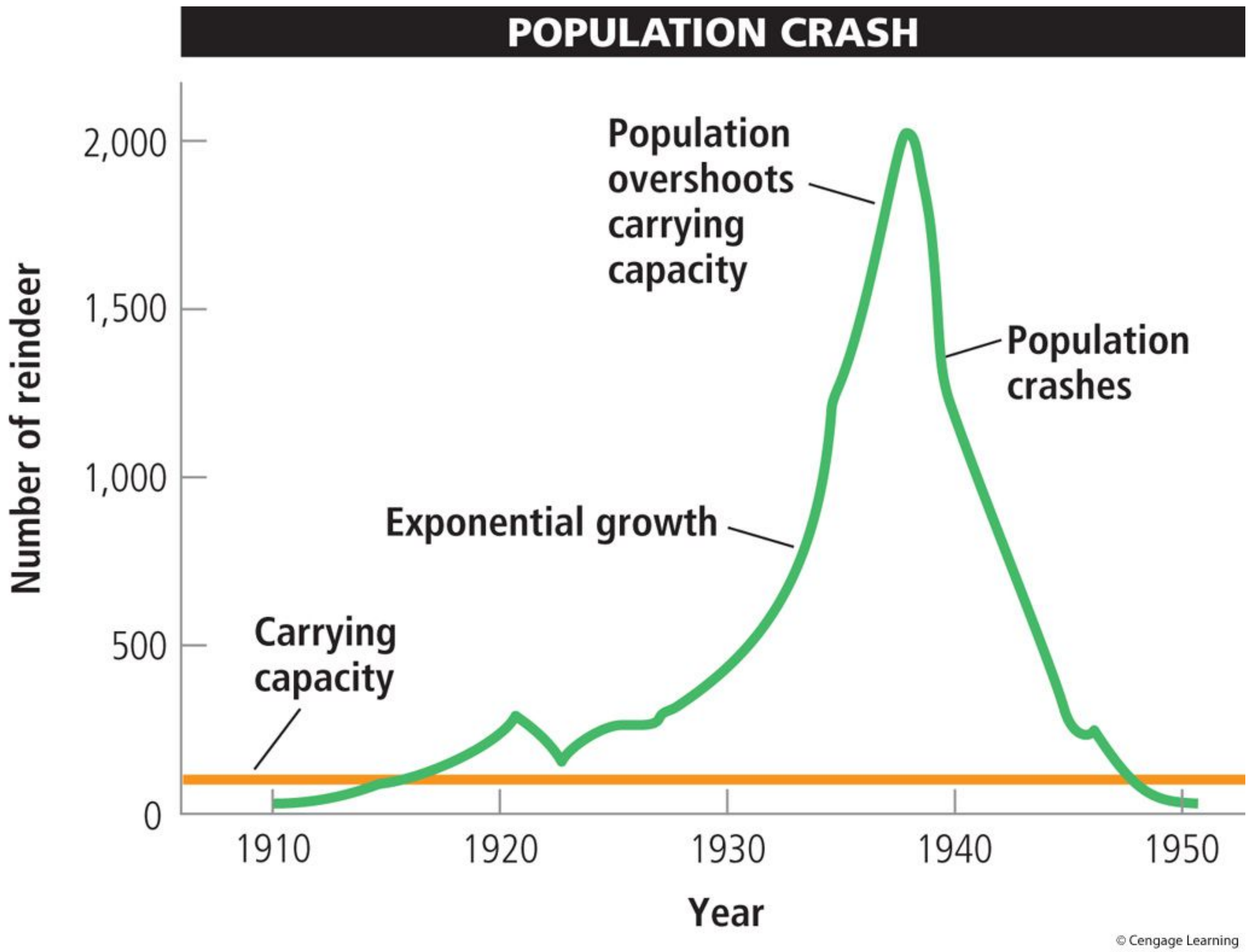
Population Crash – Illustrated



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Species Have Different Reproductive Patterns – *r*-selected species

- *r*-selected species have a capacity for a high rate of population increase
  - Have short life spans
  - Have many, usually small offspring
  - Do not provide much parental care/protection
    - Offspring loss is overcome by massive offspring production, so that at least a few will survive

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Species Have Different Reproductive Patterns – Opportunists

- Opportunists reproduce rapidly under favorable environmental conditions
  - Often occurs after a fire or clearing an area that opens up a new habitats or niches for invasion of a new species
  - May crash after growth or when yet another species invades the area
  - Go through irregular and unstable boom-and-bust cycles

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Species Have Different Reproductive Patterns – *k*-Selected Species

- *k*-selected species do well in competitive conditions when population size nears carrying capacity
  - Reproduce later in life
  - Have smaller numbers of offspring with longer life spans
  - Typically develop inside their mothers and are born fairly large
  - After birth, they mature slowly and are protected by one or both parents

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Species Vary in Their Typical Life Span

- Because different species have different reproductive rates, they also have different life expectancies (illustrated by survivorship graphs)
- Three kinds of survivorship curves:
  - Late loss
  - Early loss
  - Constant loss

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Humans Are Not Exempt from Nature's Population Controls

- Human populations can crash
  - Ireland's 1845 population crash after a fungus destroyed the potato crop
  - The 14th century plague – spread through crowed cities with poor sanitary conditions
- The earth's carrying capacity for humans is expanding due to technological, social, and cultural changes

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Additional Case Study: The Giant Sequoia – In Competition

- Giant sequoia trees live in old growth forests in the Sierras
  - To succeed, these trees must compete for light, grow very tall, develop extensive roots and, live a long life
- After 150 – 200 years, these trees become reproductive and release thousands of seeds from pine cones

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Additional Case Study: The Giant Sequoia – An Uncertain Future

- This stable ecosystem is rapidly changing due to global warming – affecting water availability/temperature (limiting factors)
  - Are sequoia trees *k*-selected species, *r*-selected species, or somewhere in-between?
  - Can sequoia trees successfully reseed themselves outside of their natural habitat?
  - Can humans change the effects of warming temperatures/drier conditions on sequoias?

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Sequoias and the Big Three

- Giant sequoia trees must compete with all old growth forest species for light – which is scarce and limits their population size
  - Climate change is drying and warming their natural habitat – if left unchecked, changes in species composition (ecological succession) could follow
  - Moisture and temperature are significant limiting factors to the population growth of giant sequoia trees

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