BIOS 230

Lecture #30

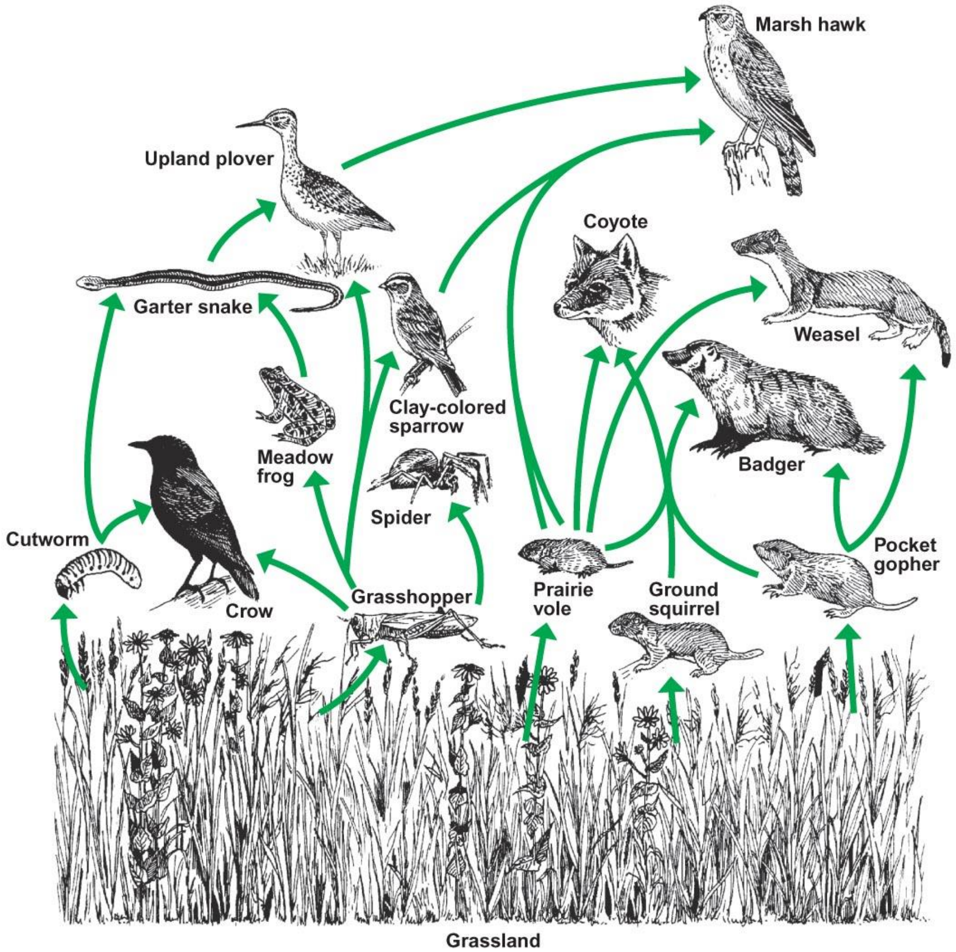
Food Webs

- An abstract representation of feeding relationships within a community is the **food chain**
  - A descriptive diagram that represents the flow of energy from prey to predator

    Grass → grasshopper → sparrow → hawk
- Feeding relationships in nature are more complex
- **Food webs** are highly interwoven, with linkages representing a wide variety of species interactions

Food Webs

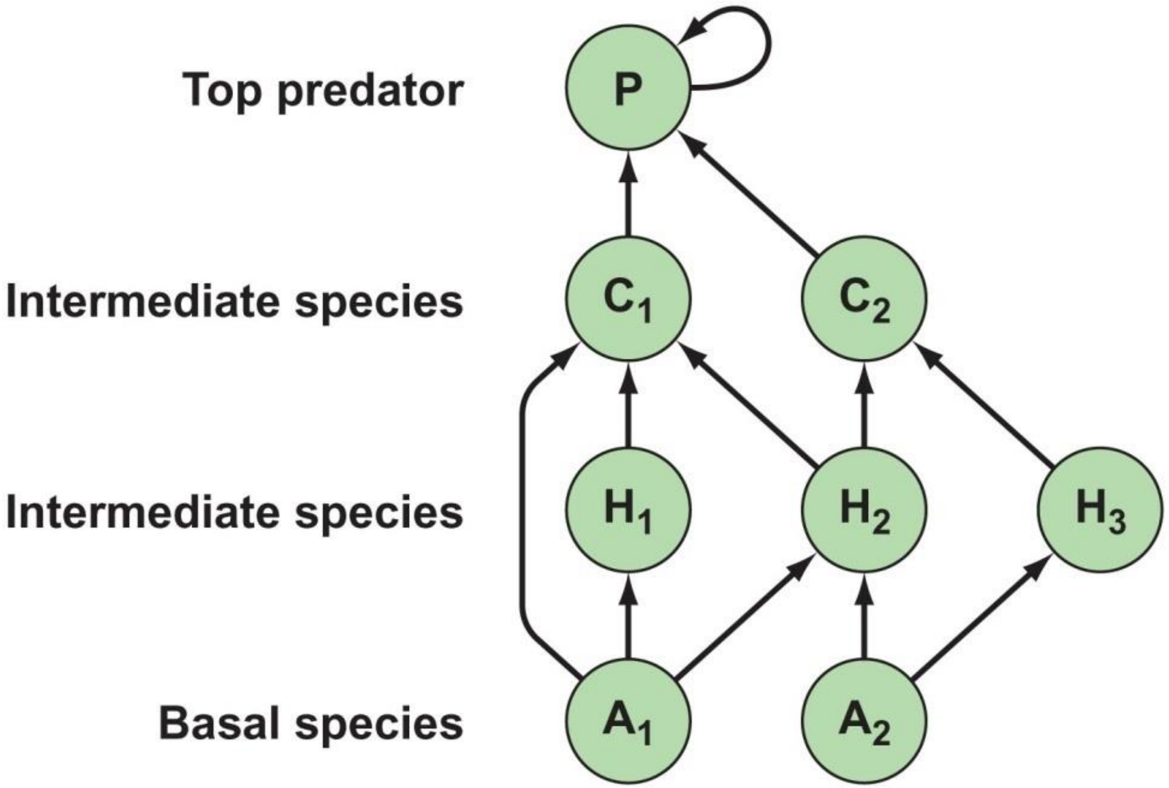
- Basic terminology is associated with food web structure
  - **Links** are the arrows from one species to another and indicate flow of energy
  - **Basal species** feed on no other species but are fed upon by others
  - **Intermediate species** feed on other species, and they themselves are prey of other species
  - **Top predators** prey on intermediate and basal species



A food web for a prairie grassland community in the midwestern US

Food Webs

- Ecologists often simplify the representation of food webs by grouping species into **trophic levels**
  - broader categories that represent general feeding groups based on the source from which they derive energy
    - Autotrophs or primary producers
    - Heterotrophs or secondary producers
      - Herbivore
      - Carnivore
      - Omnivore

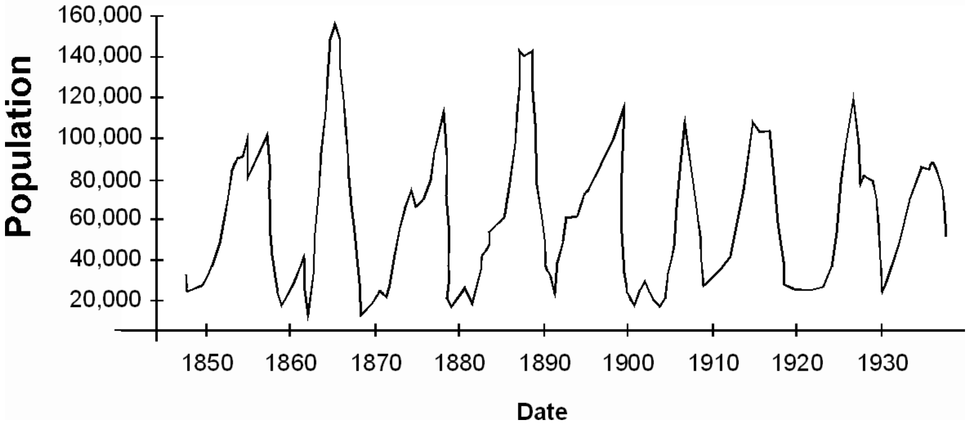


Hypothetical food web illustrating the various categories of species.

Food Webs

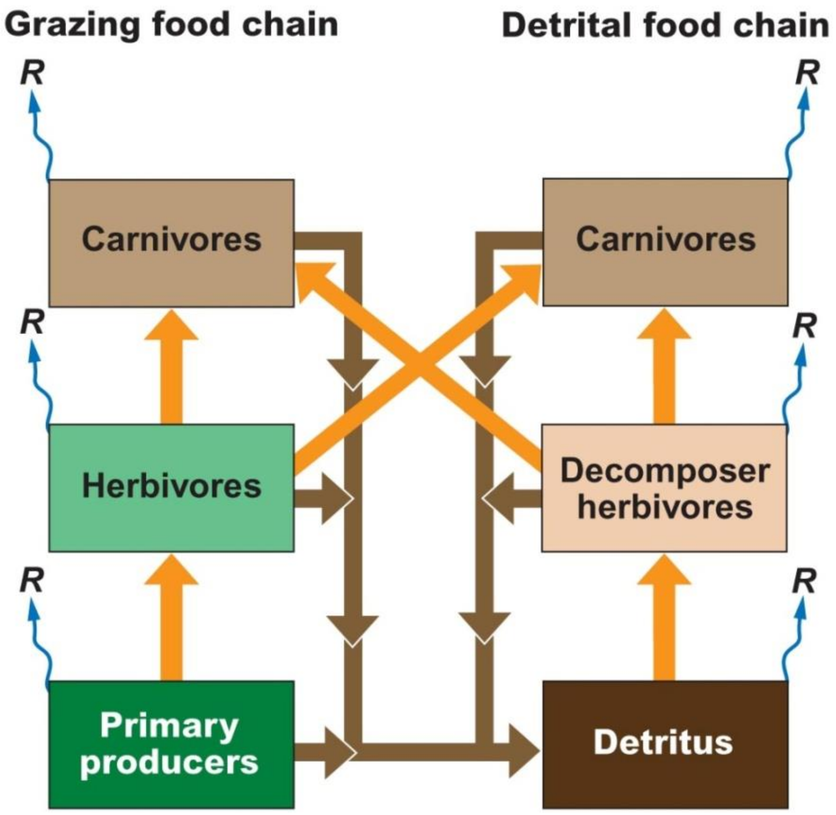
- Species interactions in communities may be underestimated because they are diffuse, involving a number of different species
- Food webs can illustrate these diffuse interactions
- Diffuse predator–prey interactions
  - In the boreal forest, the lynx, coyote, and horned owl are responsible for the periodic cycles in the snowshoe hare population

Fig. 1.1 Population cycles of the snowshoe hare, based on pelts received by the Hudson Bay Company (after Kormondy, 1969)



Food Webs

- Carnivores feed on lower trophic level in either chain
- The two chains are linked
- Grazing food chain is unidirectional; decomposer chain is not



Two parts of any ecosystem
Orange arrows represent ingestion
Brown arrows represent unconsumed dead biomass and waste products
Blue arrows represent loss of energy through respiration

Food Chains

- Energy flows through trophic levels can be quantified

- The energy available to a given trophic level (*n*) is the production of the next-lower level (*n* – 1)
  - Net primary production (P_1) is the available energy for grazing herbivores (trophic level 2)

Energy Flow Through Trophic Levels

- The quantity of energy flowing into a trophic level decreases with each successive trophic level
  - not all energy is used for production

- Only ~10% of biomass in a given trophic level is converted to biomass at the next-higher trophic level
  - Herbivores eat 1000 kcal of plant
    - → 100 kcal converted to herbivore tissue
    - → 10 kcal into first-level carnivore production
    - → 1 kcal into second-level carnivore production

Energy Flow Through Trophic Levels

- Herbivores eat 1000 kcal of plant

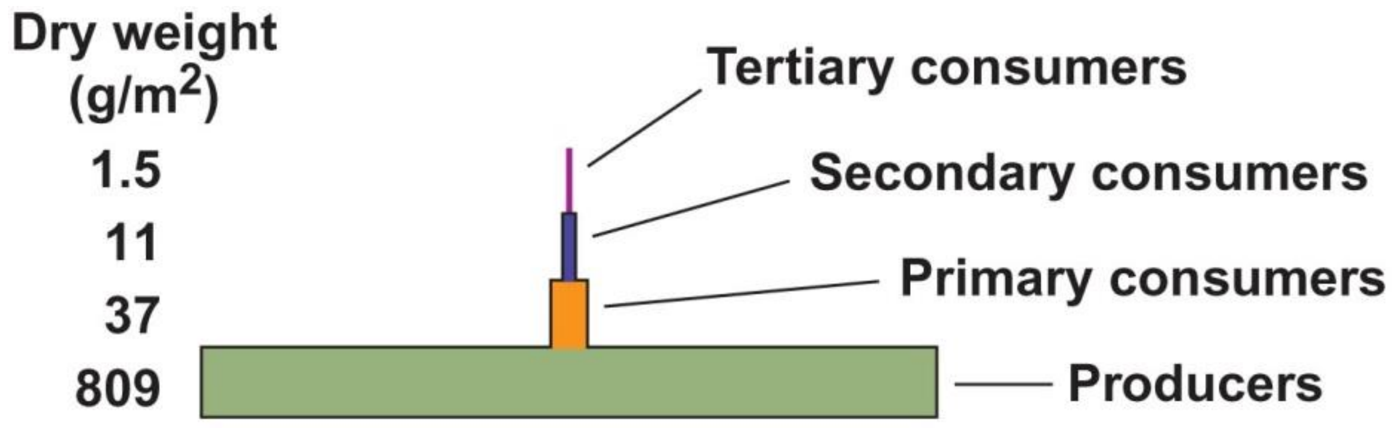
  - 100 kcal converted to herbivore tissue

    - 10 kcal into first-level carnivore production

      - 1 kcal into second-level carnivore production

Energy Flow Through Trophic Levels

- A consequence of decreasing energy transfers is a corresponding decrease in biomass at each trophic level
- Ecosystem pyramids can be constructed by summing the biomass in each trophic level
- A narrowing of the pyramid with increase in trophic level is seen in terrestrial systems



Keystone Species Also Demonstrate the Importance of Species Interactions in Shaping Communities

- Sea otters act as a keystone predator by eating sea urchins
  - maintains kelp beds, which are important habitat for many species

- Pisaster (sea stars)
- When removed from intertidal zone, the number of other species was reduced
- A mussel species came to dominate the community

Keystone Predation Illustrates Indirect Effects

- **Keystone predation** - the predator enhances one or more inferior competitors by reducing the abundance of the superior competitors

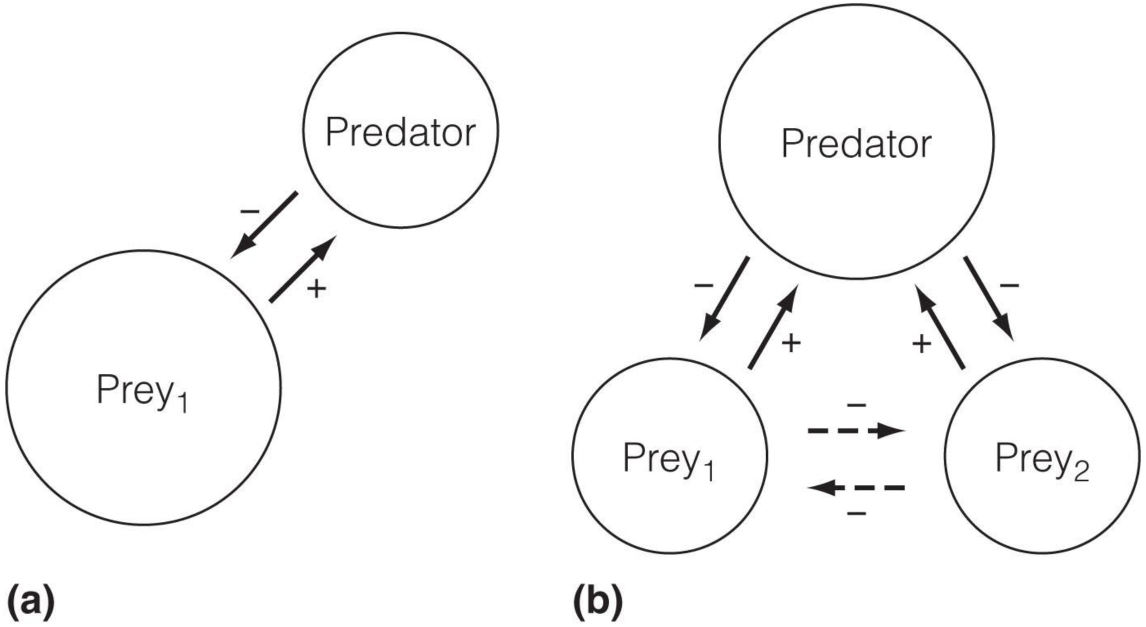
- **Indirect effects** occur when one species does not interact with a second species directly, but instead influences a third species that *does* directly interact with the second

Apparent Competition is Another Example of Indirect Effects

- **Apparent competition** occurs when a single species of predator feeds on two prey species
- When the predator species is absent, each population of the two prey species is regulated by purely intraspecific, density-dependent mechanisms
  - Neither species competes, directly or indirectly, with the other
- However, predator abundance increases due to the the combined abundance of both prey species

Apparent Competition

- Lower abundance of both prey species is caused by the greater abundance of the predator population supported by both prey species

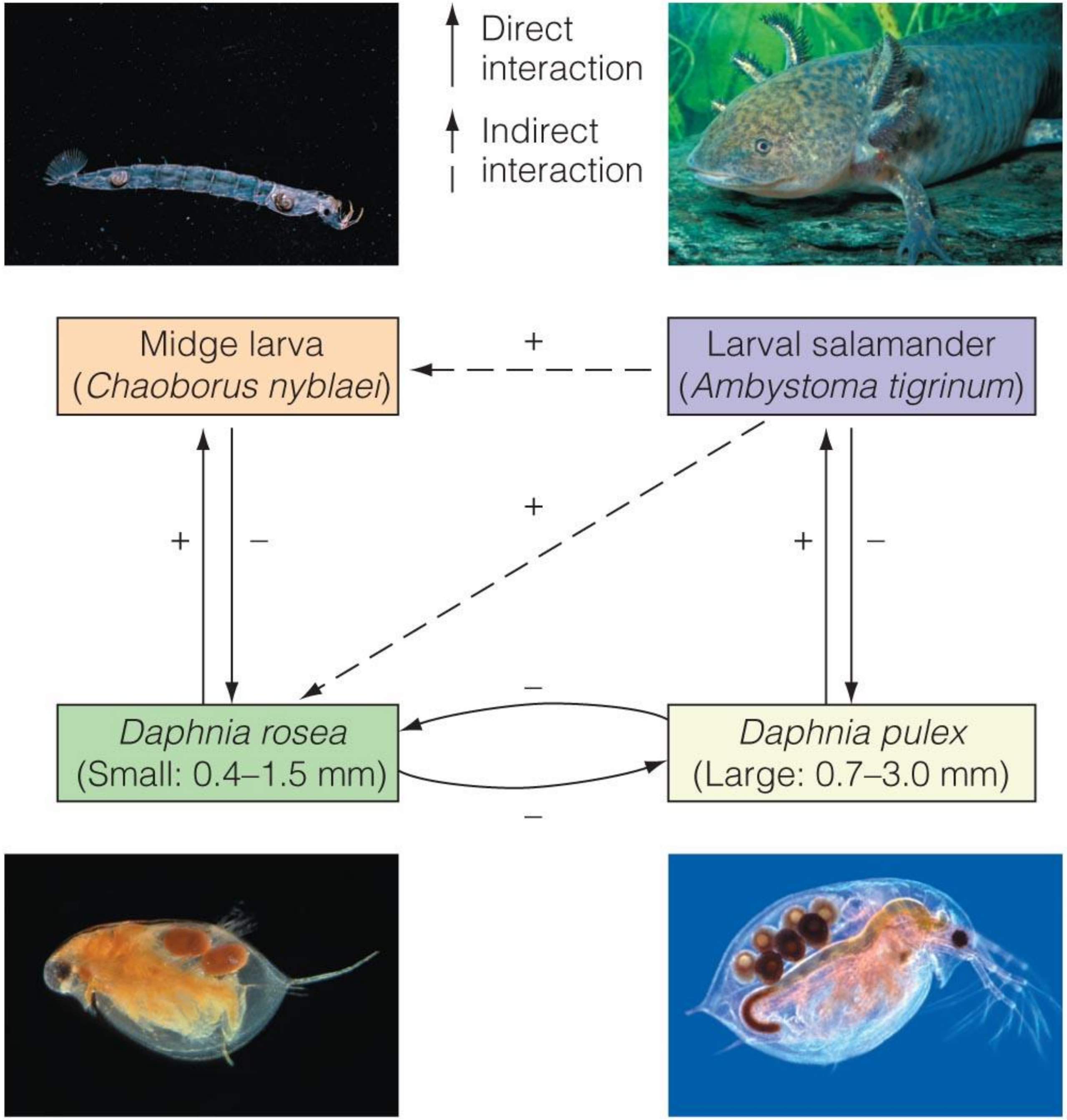


Indirect Interactions can also be Positive

- Two herbivorous species of *Daphnia* and their predators (a midge larva and larval salamander)
  - Midge larva $\rightarrow$ small *Daphnia* species
  - Larval salamanders $\rightarrow$ larger *Daphnia* species
  - **Indirect commensalism** between midge larvae and salamander

Survival of the small *Daphnia* (and thus midge larvae) is dependent on the predation of salamanders on the larger *Daphnia*

Indirect commensalism between midge larvae and salamander



Controls on Community Structure

- Given the complexity of food web interactions, how do we understand which interactions are important in controlling community structure?

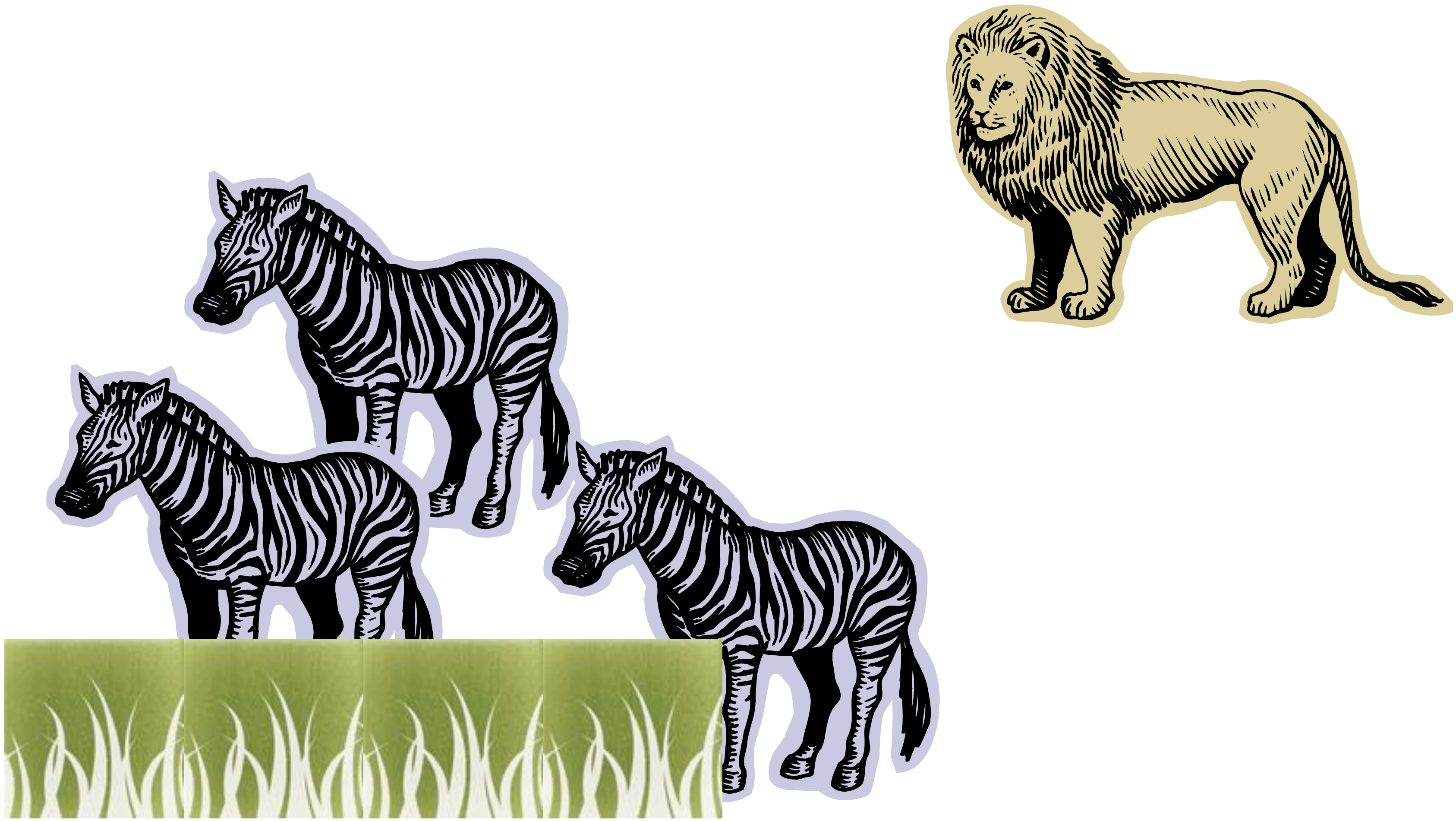
- Bottom-up versus top-down control

Controls on Community Structure

- In **bottom-up control**, the structure of food chains and food webs is controlled (limited) by the productivity and abundance of populations in the trophic level below

- In **top-down control**, the predator populations control the abundance of prey species, and the prey of the prey, and so on

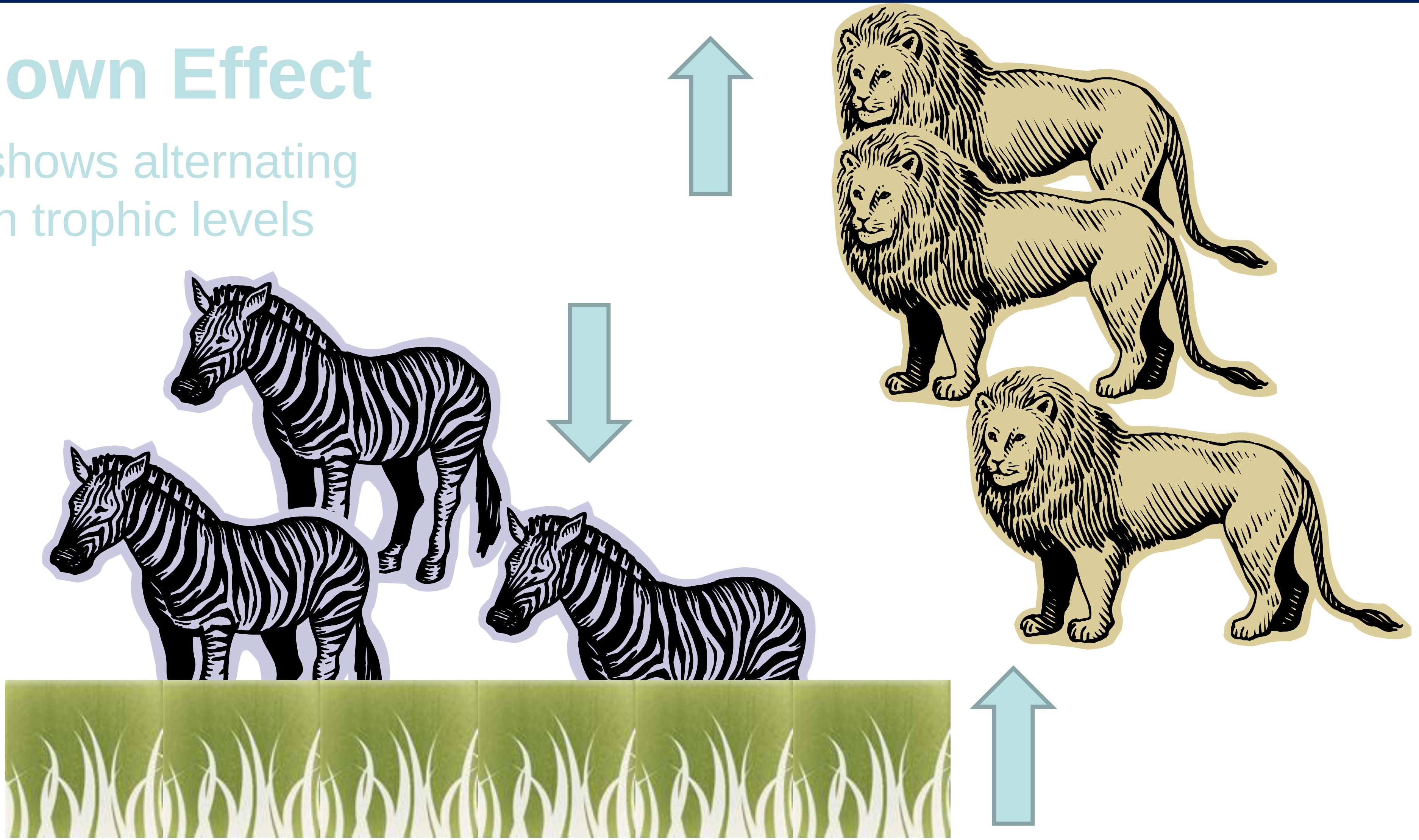
Top-Down Versus Bottom-Up Effects



Top-Down Versus Bottom-Up Effects

Top-down Effect

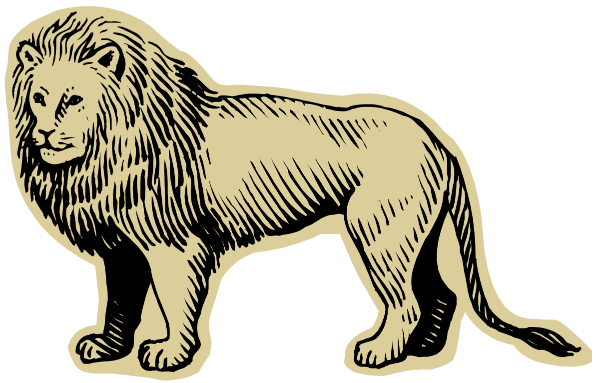
Usually shows alternating effects on trophic levels

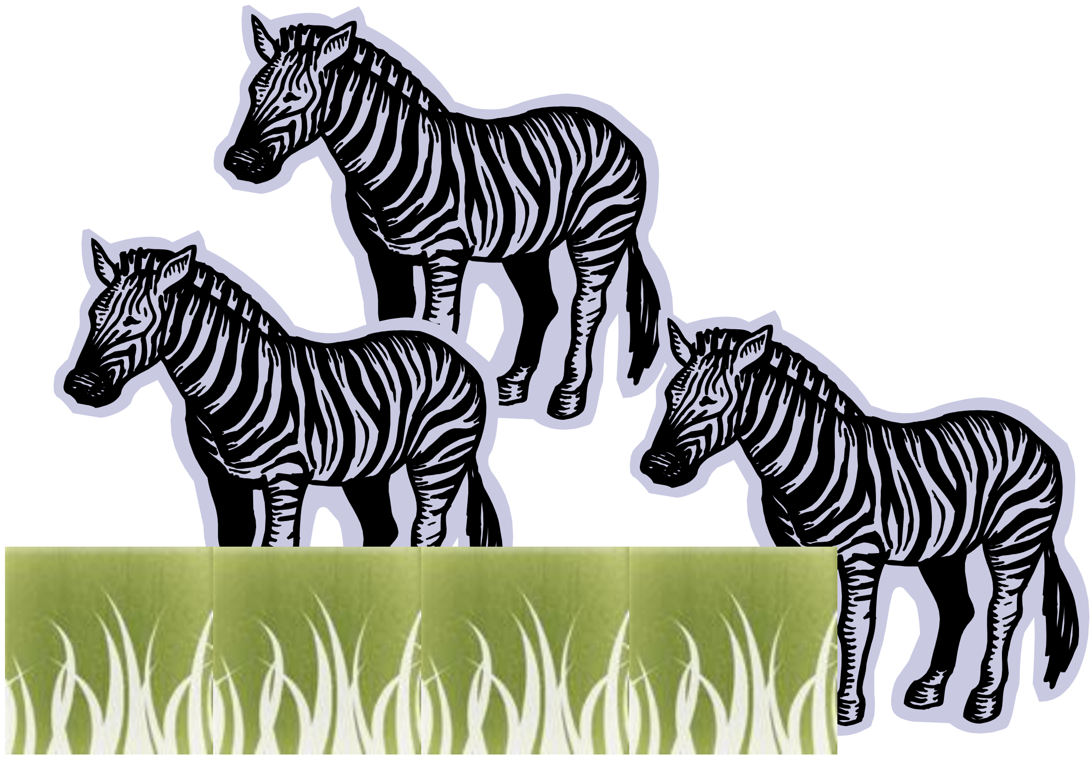


Top-Down Versus Bottom-Up Effects

Bottom-up Effect

Effects on trophic levels usually occur in the same direction





Top-Down Versus Bottom-Up Effects

- In 1960 Hairston, Smith, and Slobodkin wrote one of the most influential papers in the history of ecology, a four-page essay in *The American Naturalist*
- HSS (as the paper is often referred to) offered a simple hypothesis for the regulation of populations
- The "world is green", they reasoned, despite the insatiable appetite and enormous diversity of herbivores, because herbivore populations are held in check by their own natural enemies—predators, parasitoids, parasites, and pathogens.
- TOP-DOWN argument