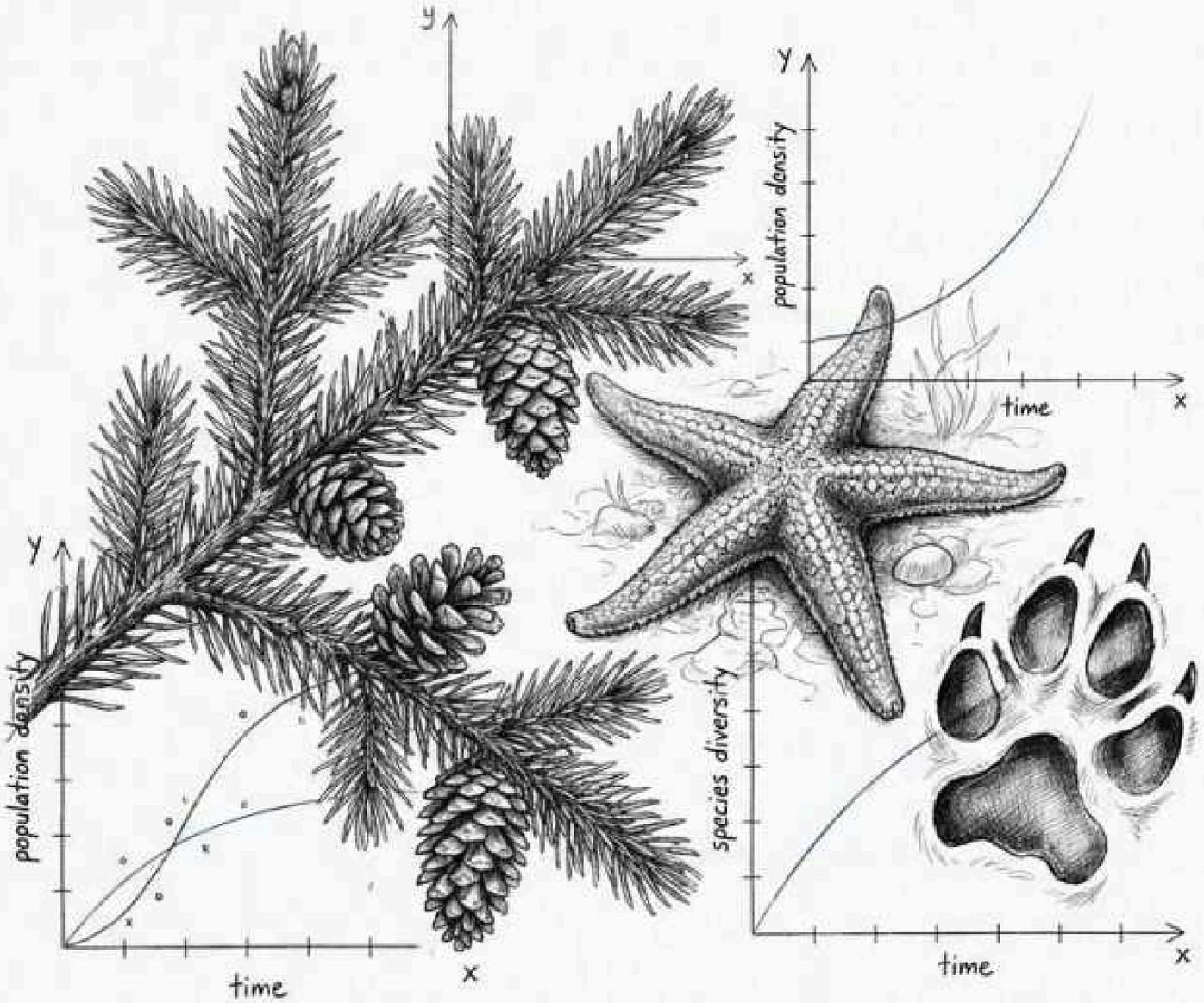
BIO 220 B

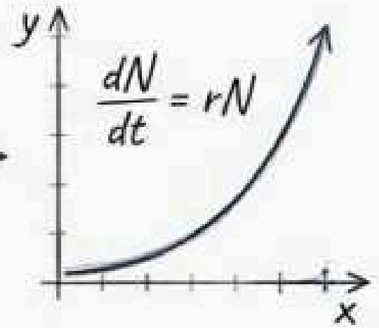


Populations and Communities

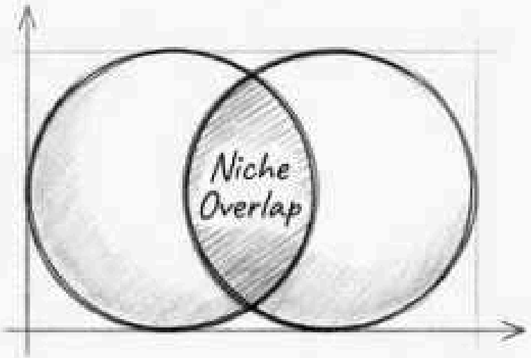
The Mechanics of Ecology: From Equations to Ecosystems

¶ 4.1

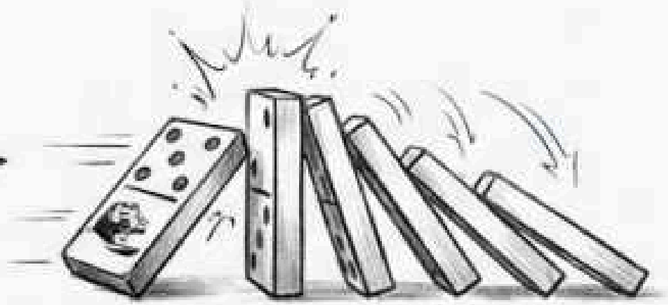
Lecture 4 Objectives



How do populations grow, and what limits them?

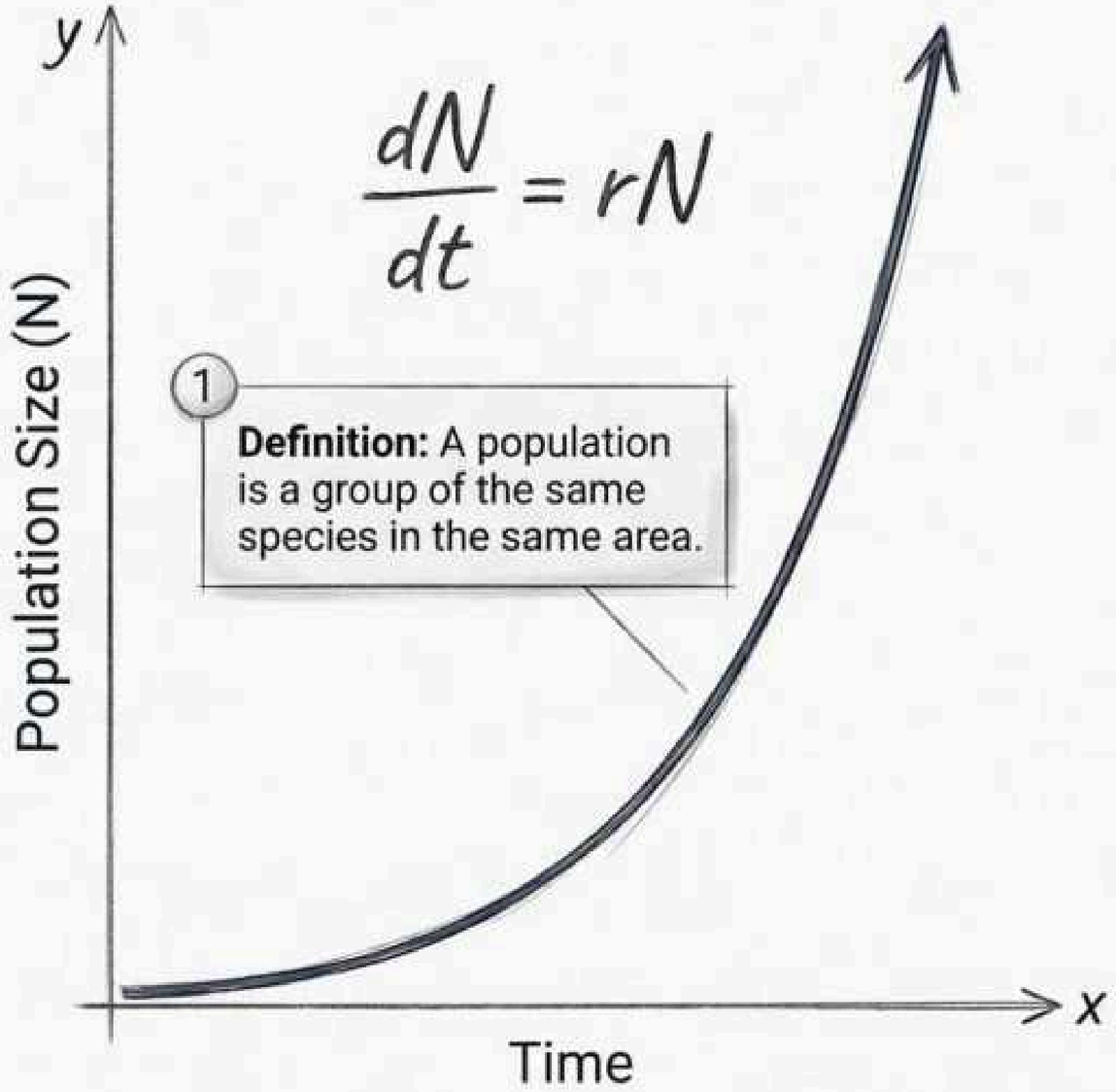


How do species interact through competition, predation, and cooperation?

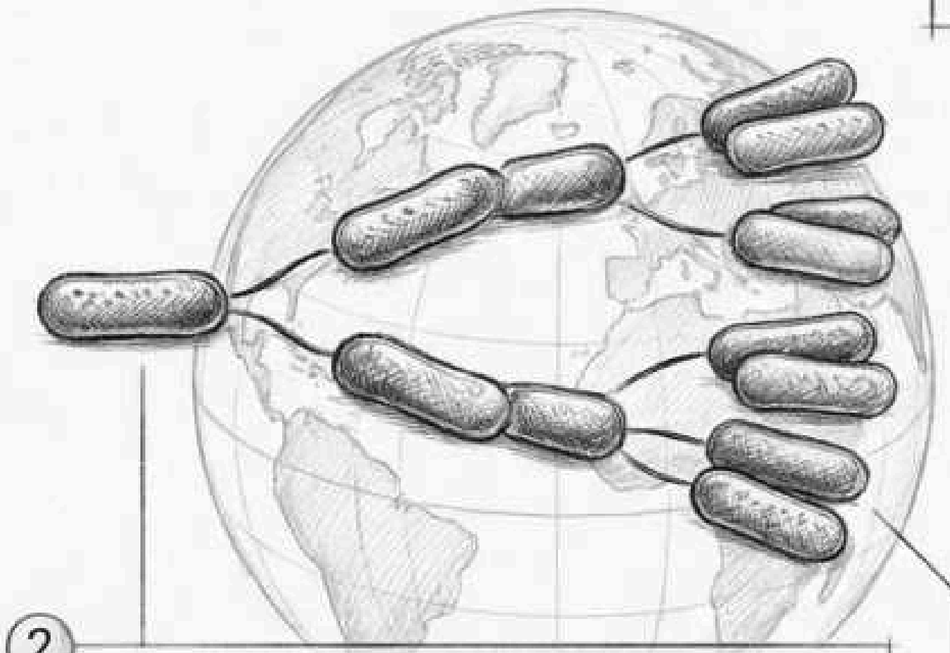


Why can removing one species transform a whole community?

¶ 4.2

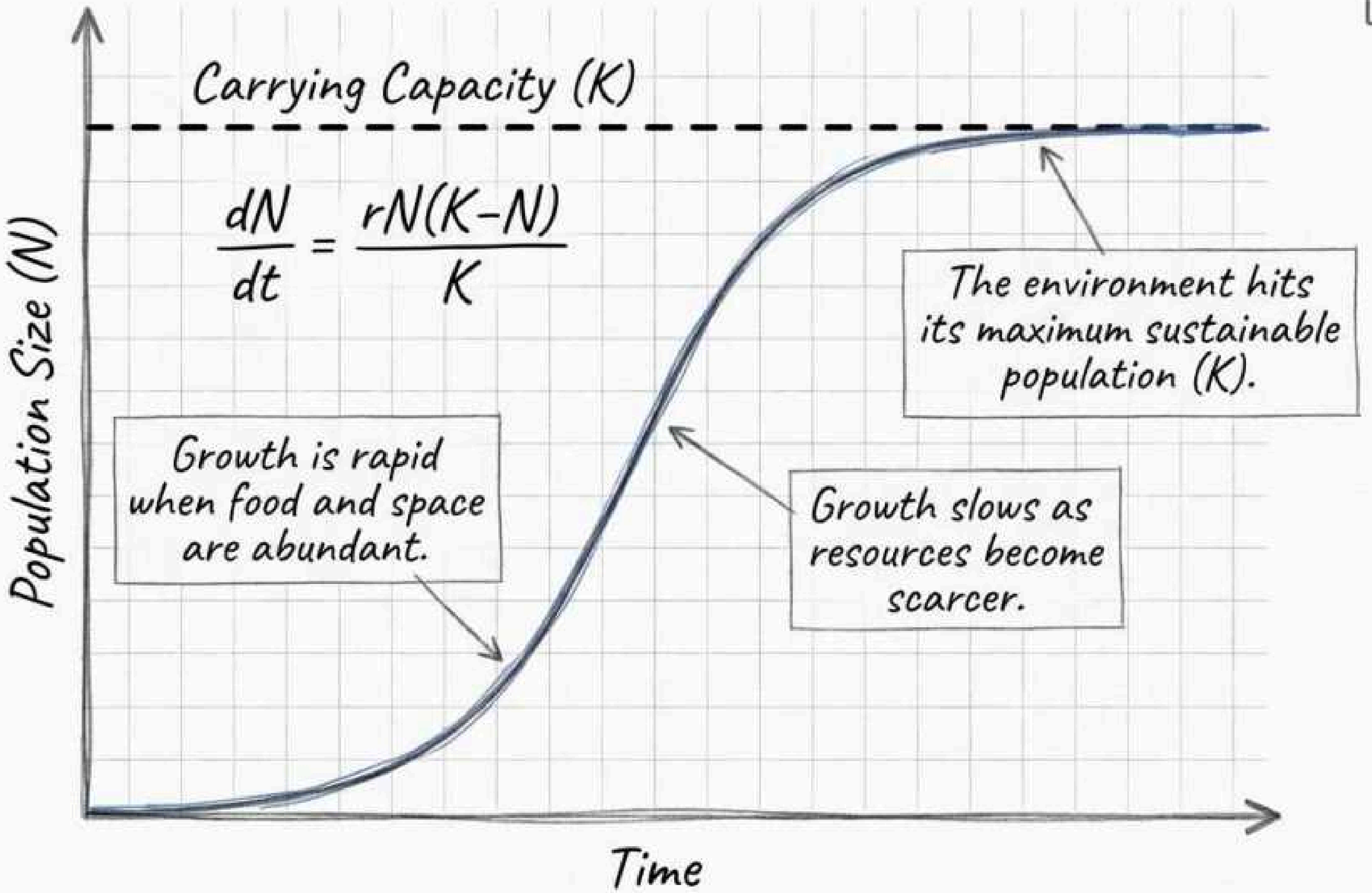


1 **Definition:** A population is a group of the same species in the same area.



2 **The Theoretical Limit:** With unlimited resources, growth doubles continuously. A bacterium dividing every 20 minutes could exceed Earth's mass in days.

3 **Historical Anchor:** This mathematical power heavily influenced both Malthus and Darwin.



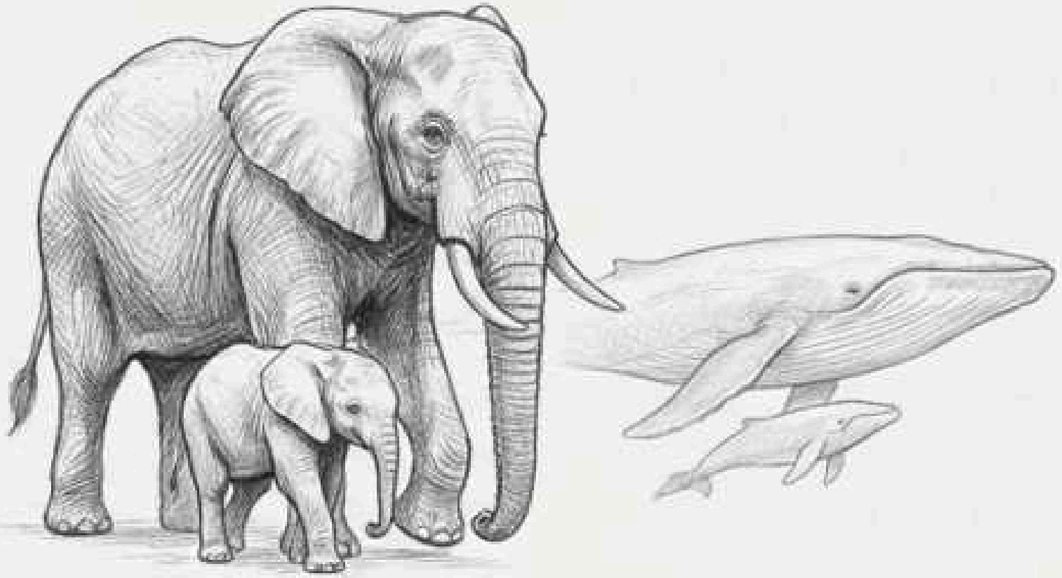
Modeled by Pierre-François Verhulst (1838).

r-Strategy (Unstable Environments)



- Many offspring produced quickly.
- Low investment per individual.
- Thrives in volatility.

K-Strategy (Stable Environments)

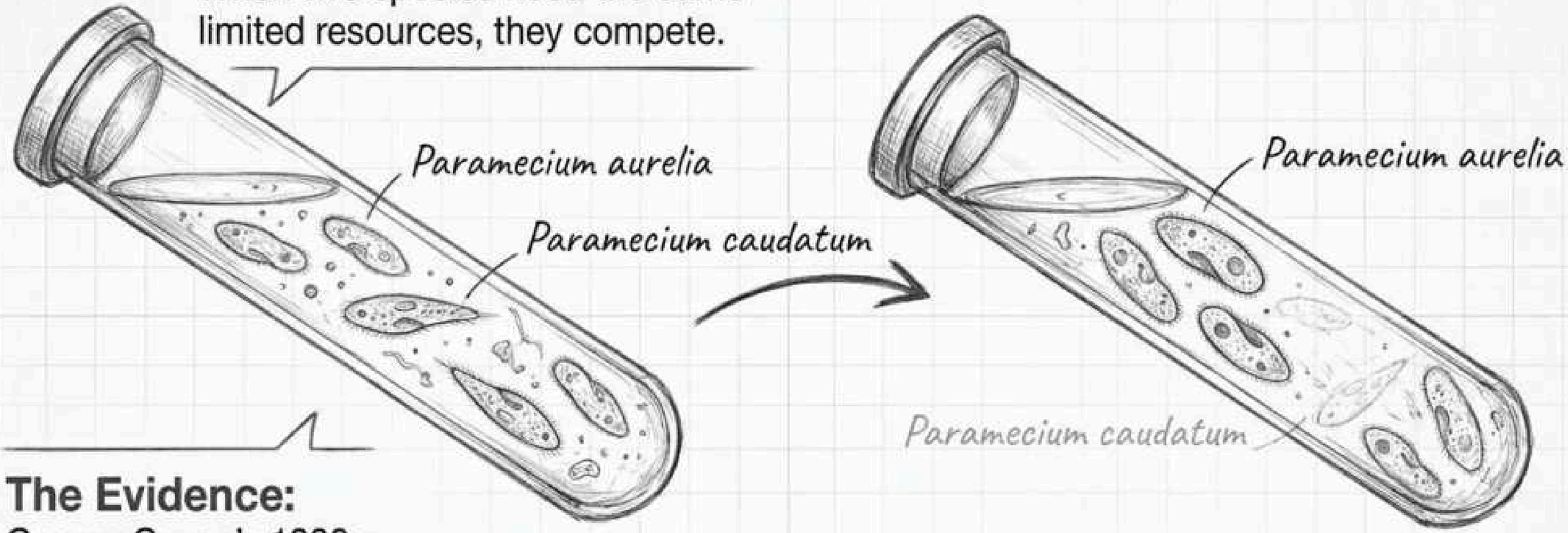


- Few offspring produced slowly.
- High investment per individual.
- Thrives near carrying capacity (K).

Most species fall on a spectrum between these two extremes.

The Catalyst:

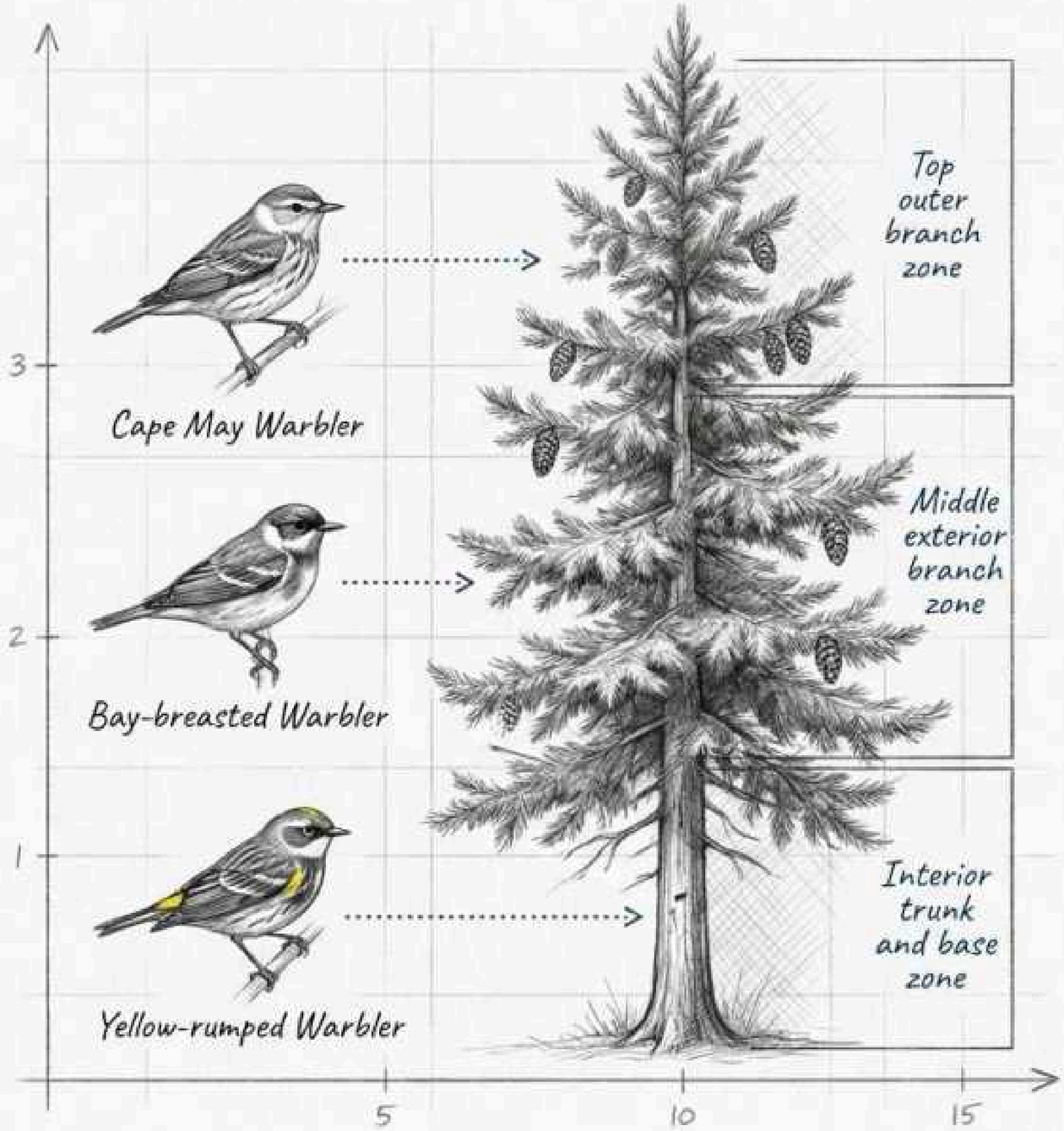
When two species need the same limited resources, they compete.



The Evidence:

Georgy Gause's 1930s experiments with *Paramecium* competing for food.

Competitive Exclusion Principle:
Two species cannot occupy exactly the same niche indefinitely; one **always** drives the other out.



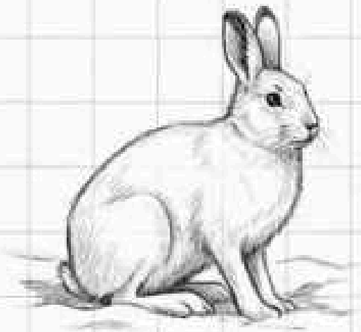
¶ 4.6

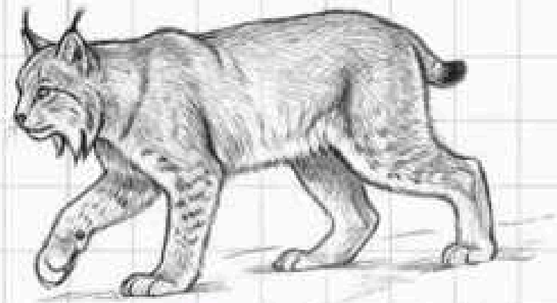
Niche Defined: A species' role in its environment (what it eats, where it lives, when it is active).

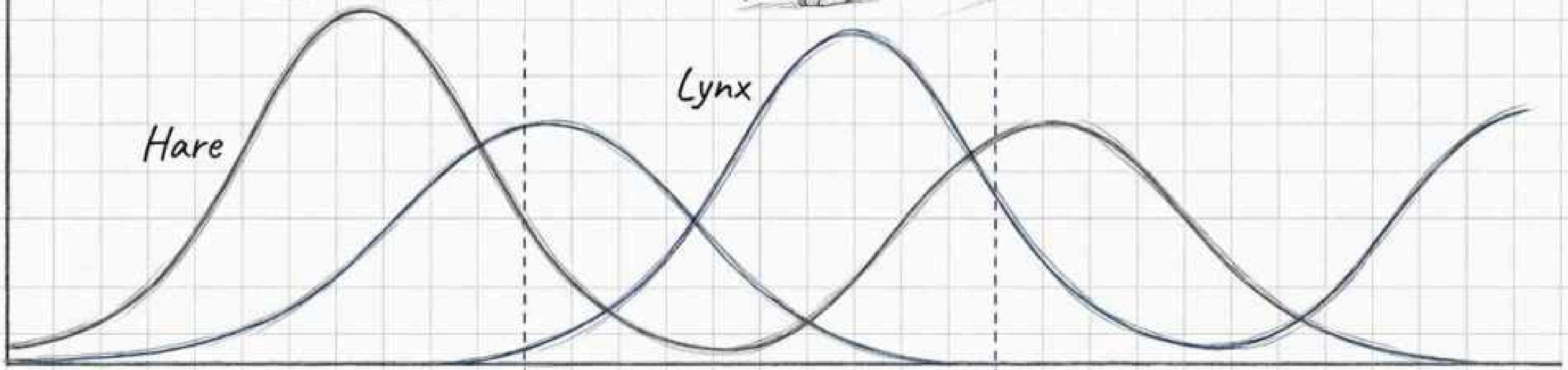
The Solution: Resource Partitioning. Competing species coexist by dividing resources.

Historical Anchor: Robert MacArthur (1958) demonstrated how multiple warbler species share the same spruce tree by isolating their feeding zones.

¶ 4.7







The Lotka-Volterra differential equations $\frac{dH}{dt} = rH - aHL$, $\frac{dL}{dt} = bHL - mL$

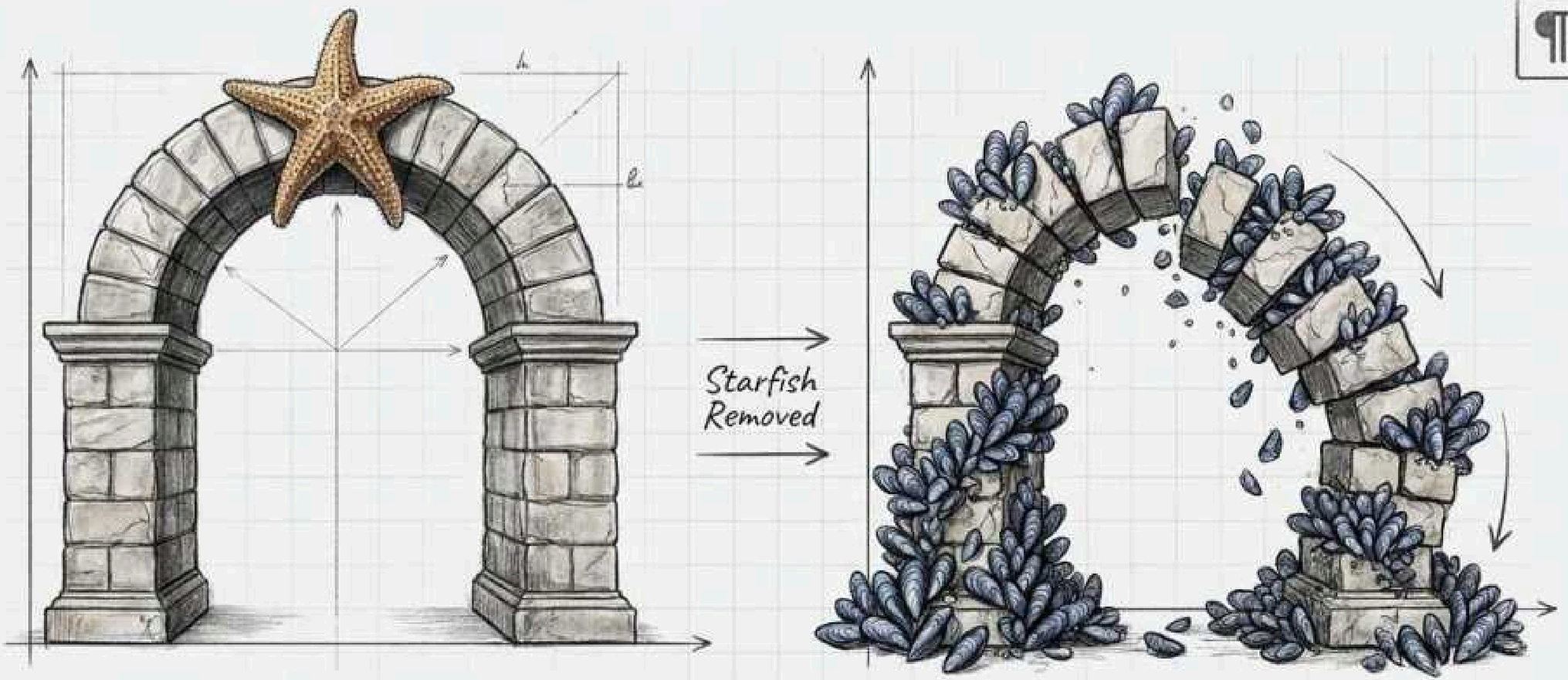
Phase 1:
Hares plentiful → Lynx thrive.

Phase 2:
Lynx increase → Hares decline.

Phase 3:
Lynx starve/decline → Hares recover.

Based on 10-year cycle records from the Hudson's Bay Company fur trade.

¶ 4.8



The Concept: Some species have effects far larger than their raw numbers suggest, holding the entire community structure together.

The Experiment (Robert Paine, 1960s): Removed predatory Pisaster starfish from Washington State rocky shores.

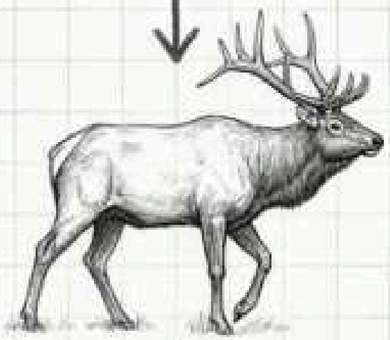
The Result: Without the keystone predator, mussels took over, crowding out other species and causing diversity to plummet.

The Return of the Yellowstone Wolves

¶ 4.9

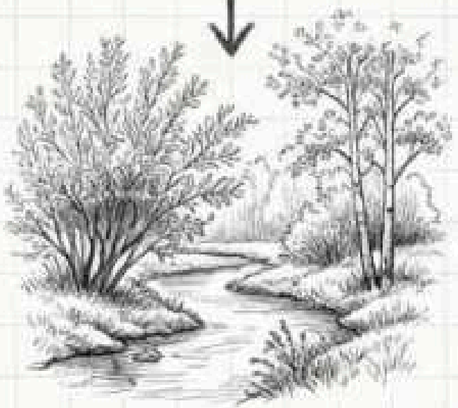


Introduced 1995
after 70-year absence



Decreased numbers /
Changed grazing behavior

Streamside Willows
and Aspens



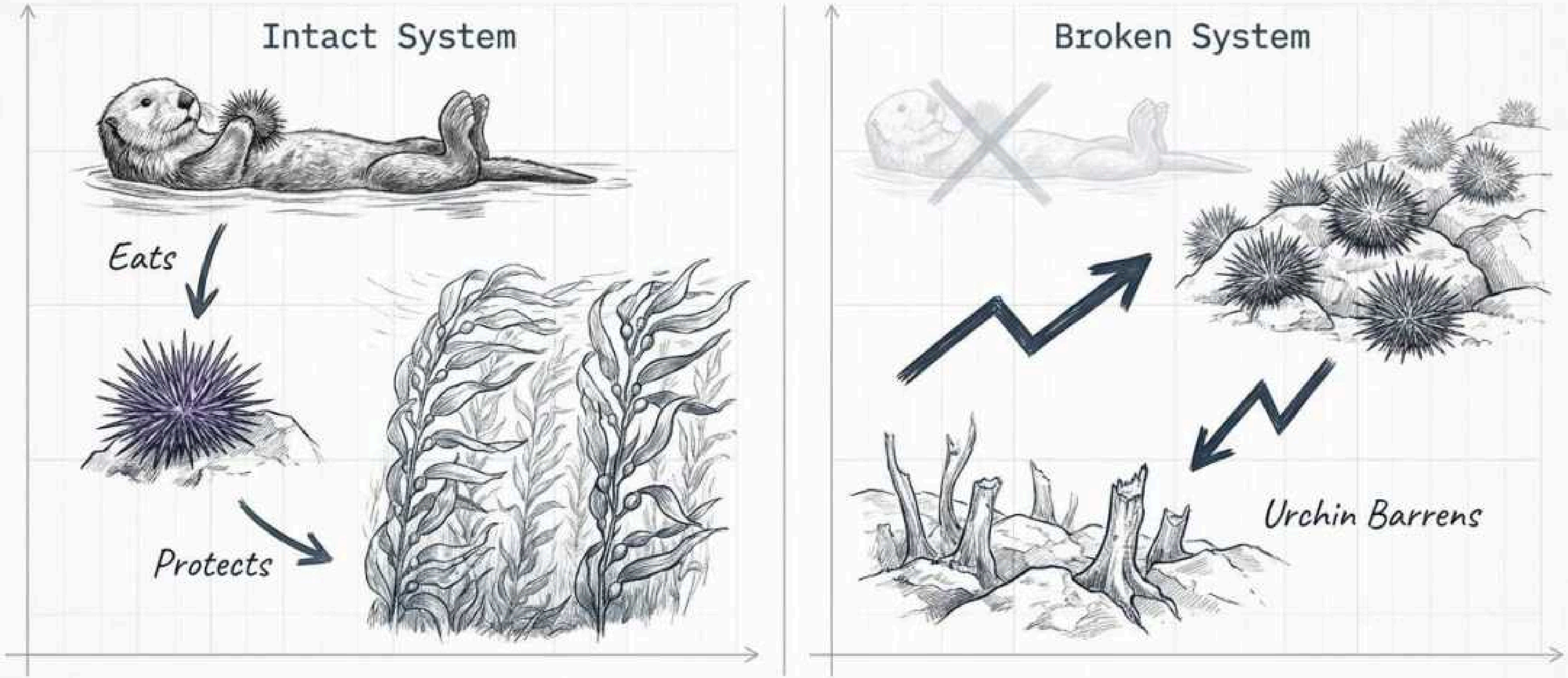
Recovered from overgrazing



Benefited from
habitat recovery

Caveat Note: Ecologists continue to debate the exact scale and widespread nature of these specific effects.

Definition: Trophic Cascades are chains of effects passing down a food web.



The presence of the apex predator dictates the survival of the foundational flora.

Symbiosis Part I: Mutualism

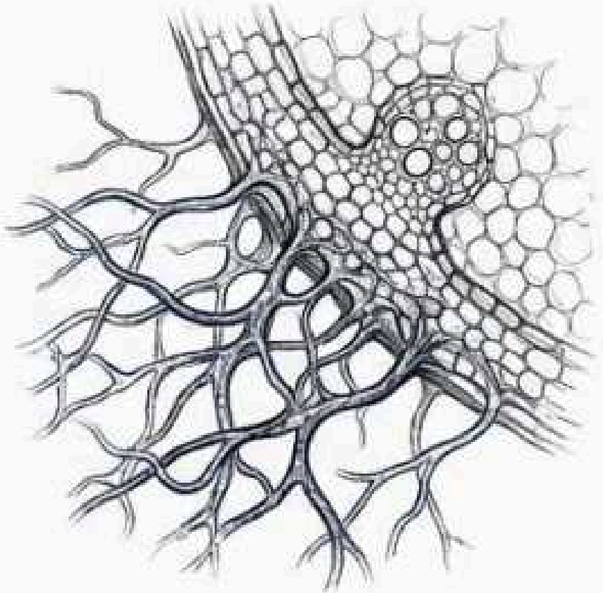
¶ 4.11

Interactions where both species actively benefit.

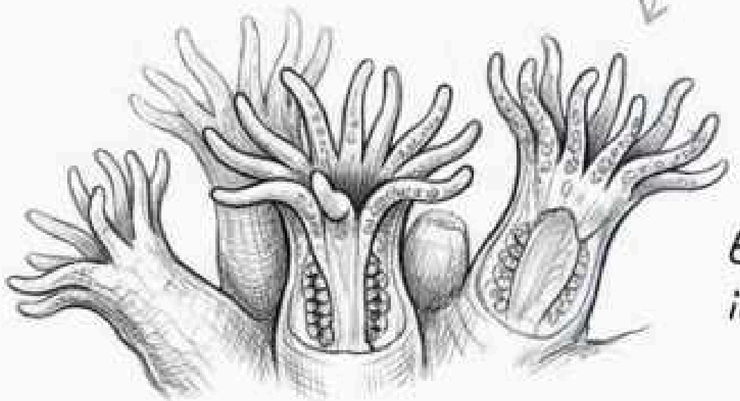


Exchange: Food for Pollen transport

[+/+]



Exchange: Nutrients for Sugars



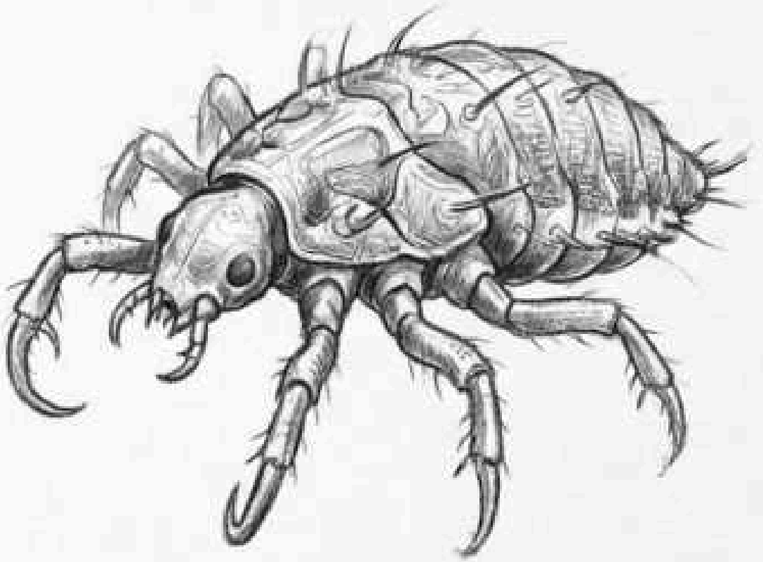
Exchange: Algae living inside tissues provide food

Commensalism
[+ / 0]



One species benefits; the other is completely unaffected.

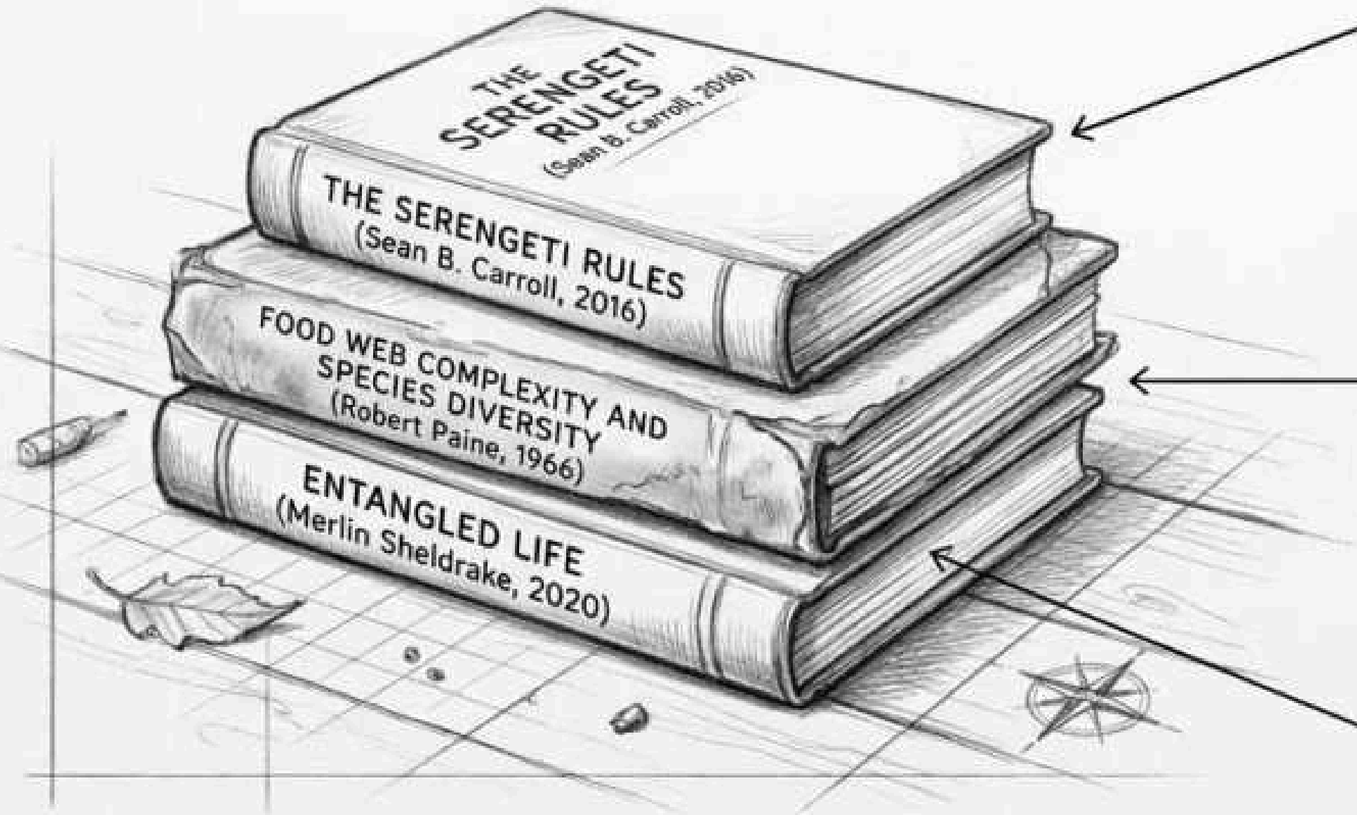
Parasitism
[+ / -]



One species benefits at the other's direct expense.

Key Stat: Parasites are so common they likely outnumber all free-living species on Earth.

Further Reading



The Serengeti Rules (Sean B. Carroll, 2016) — *The definitive modern story of keystone species and trophic cascades.*

Food Web Complexity and Species Diversity (Robert Paine, 1966) — *The short, famous, foundational original paper.*

Entangled Life
(Merlin Sheldrake, 2020) —
A deep dive into the hidden world of fungal partnerships and mycorrhizae.

Field Exercise: Apply the Framework

Choose a local habitat *(a nearby garden, park, or forest).*

- ☐ Identify 1 example of *Competition.*
- ☐ Identify 1 example of *Predation.*
- ☐ Identify 1 example of *Mutualism.*

Hypothesis: *Name one species whose removal would cause a community cascade.*



In Lecture 5, we expand our view from communities to complete Ecosystems.