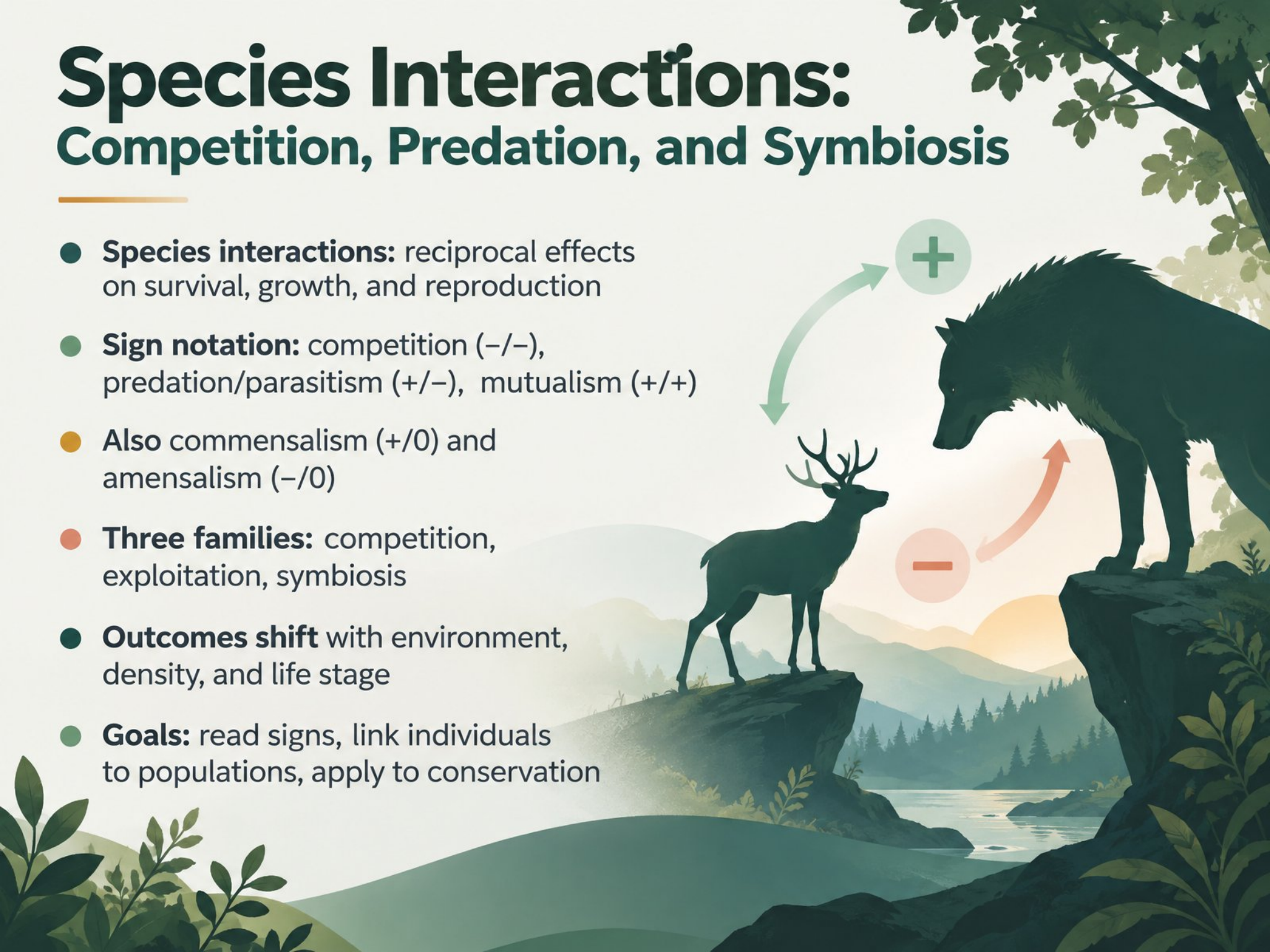
Species Interactions:
Competition, Predation, and Symbiosis

- **Species interactions:** reciprocal effects on survival, growth, and reproduction
- **Sign notation:** competition (–/–), predation/parasitism (+/–), mutualism (+/+)
- **Also** commensalism (+/0) and amensalism (–/0)
- **Three families:** competition, exploitation, symbiosis
- **Outcomes shift** with environment, density, and life stage
- **Goals:** read signs, link individuals to populations, apply to conservation

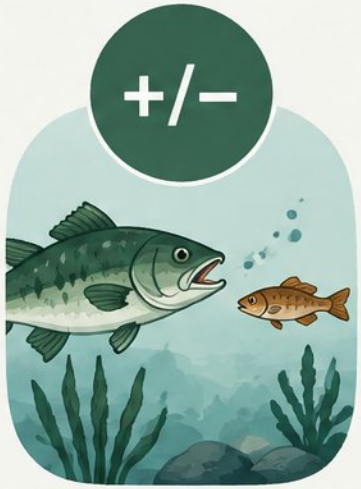


Why Sign Notation Matters: Reading Interactions Correctly

CONNECTED SPECIES
THRIVING SYSTEMS

- Symbols describe direction of effect, not its strength
- Signs summarize survival and reproduction: +, −, 0
- Individual effects differ from population and community outcomes
- Symbiosis is an umbrella term, not just mutualism
- Predation kills prey; parasites exploit hosts over time
- Sort examples: plants, fish, insects, fungi







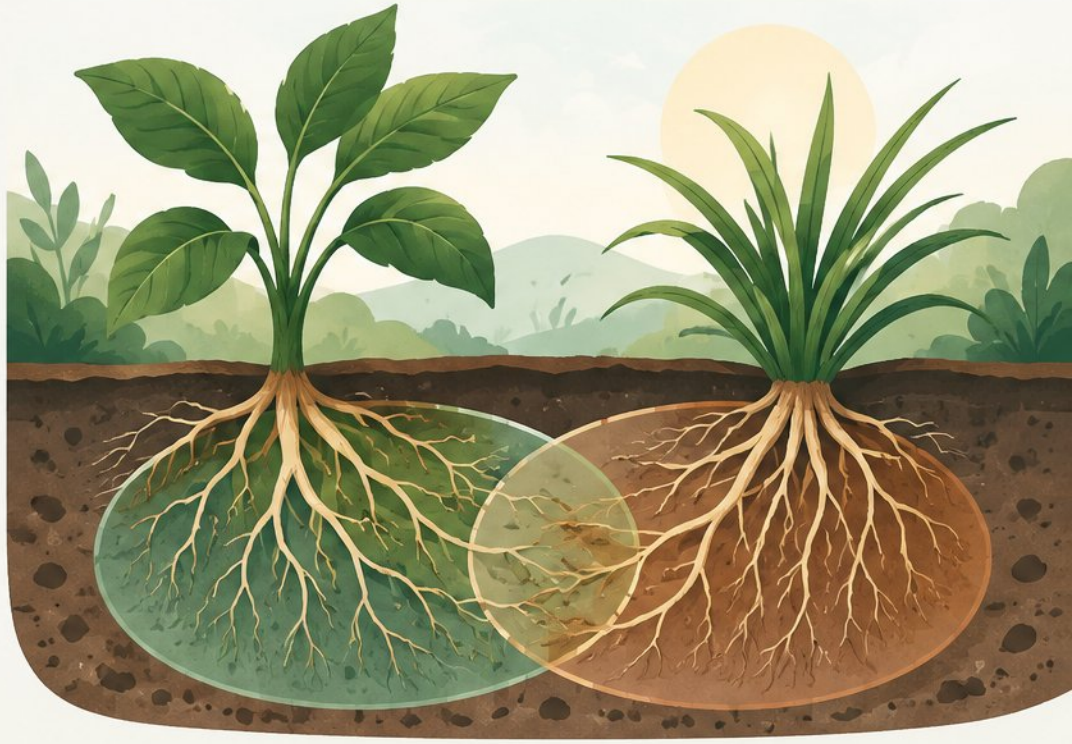


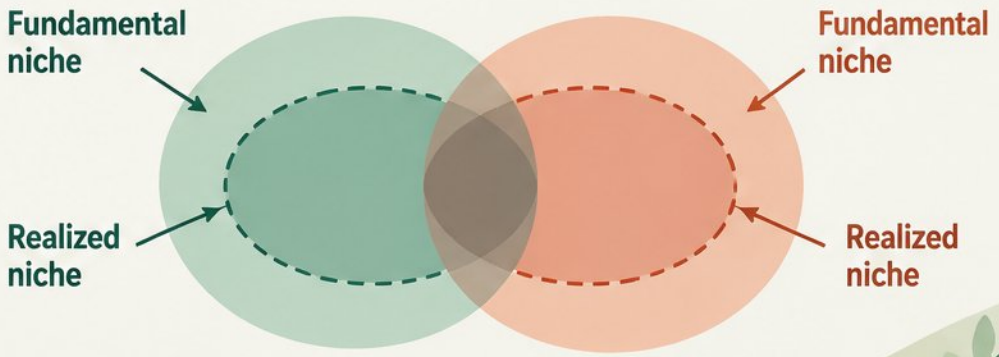


DIFFERENT SPECIES
A BRIGHTER TOMORROW

Competition Basics: Intraspecific, Interspecific, and Resource Limits

- **Competition:** shared limited resource, reduced availability, both participants harmed (−/−)
- **Intraspecific competition:** same species; can drive density dependence and adaptation
- **Interspecific competition:** different species; shaped by niche overlap and resource limits
- **Fundamental niche:** full range of usable conditions without competitors
- **Realized niche:** narrower, restricted by competition; selection favors traits that reduce overlap





Exploitation, Interference, and Apparent Competition

Exploitation competition:
indirect loss of shared resources (e.g., plant roots)

Interference competition:
direct exclusion by behavior or chemicals

Allelopathy:
plants release toxins that suppress neighbors

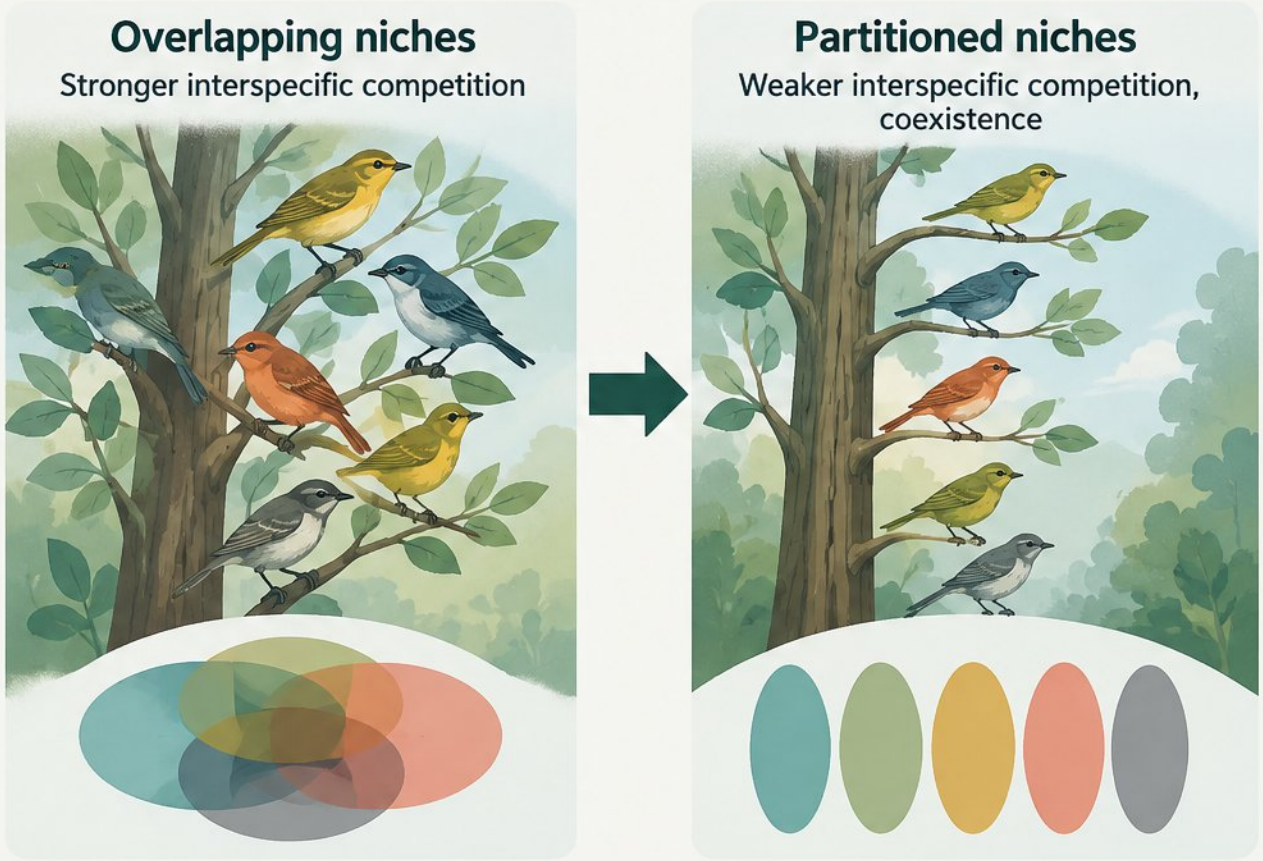
Apparent competition:
shared enemy drives both species down

Mechanism shapes how we measure and manage competition



Coexistence or Exclusion: Niche Overlap and Character Displacement

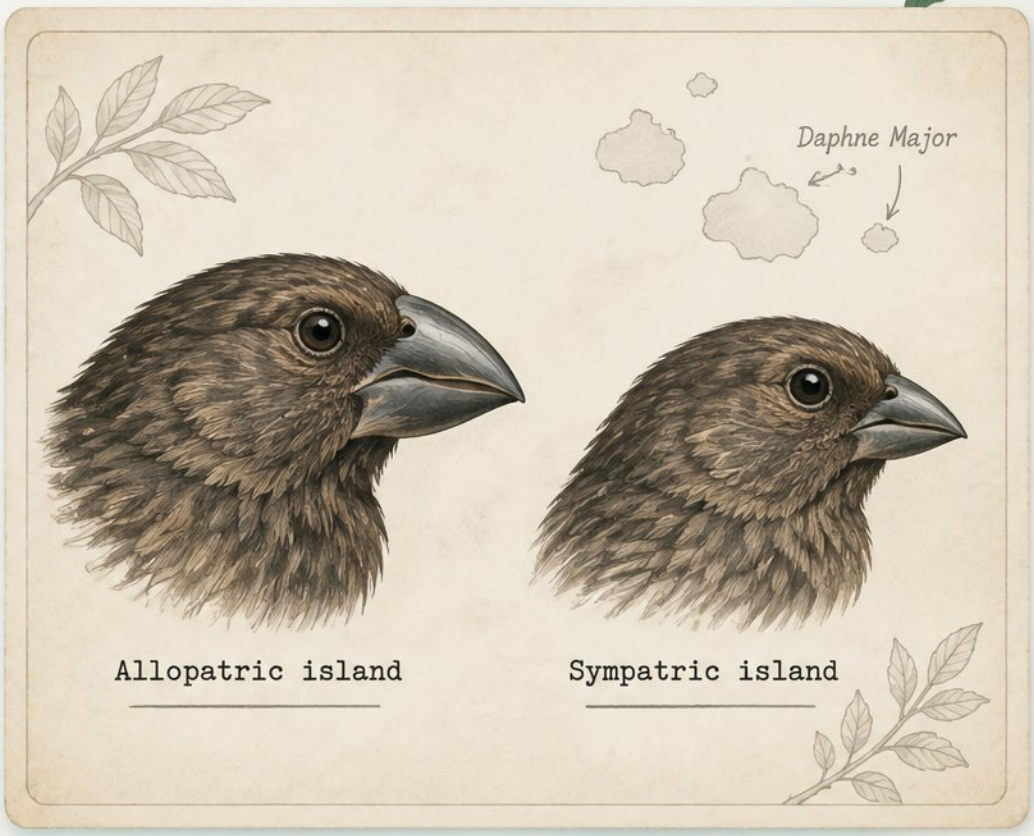
- Competitive exclusion **principle:** species sharing all resources cannot stably coexist
- **Resource partitioning:** different niches, weaker interspecific competition, coexistence
- **MacArthur's warblers:** five species divide tree zones and feeding times
- Puerto Rican anoles: 11 species partition habitat by location and height
- Darwin's finches: beak size diverges in sympatry, a classic case of character displacement





Character Displacement in Action

- **Character displacement:** trait evolution driven by selection to lessen competition
- **Sympatry–allopatry comparison** is the standard evidence pattern
- **Grant studies:** Geospiza finches on Daphne Major
- Medium ground finch evolved smaller beaks after large ground finch invasion
- **Alternative outcome:** competitive exclusion when heritable variation or time is insufficient



DIFFERENT PLACES. BRIGHTER ANSWERS IN NATURE.

Predation Broadly Defined:
Herbivory, Carnivory, and Parasitoidism



Herbivory



Carnivory



Parasitoidism

- Predation (+/−): one organism captures and consumes another
- Extends to herbivory (eating plant parts) and parasitoidism (consuming a host)
- Parasitism is also (+/−), but hosts are exploited over time, not killed outright
- Predator and prey are roles, not fixed categories
- Cannibalism is intraspecific predation, common when food is scarce
- Examples span terrestrial, freshwater, and marine systems

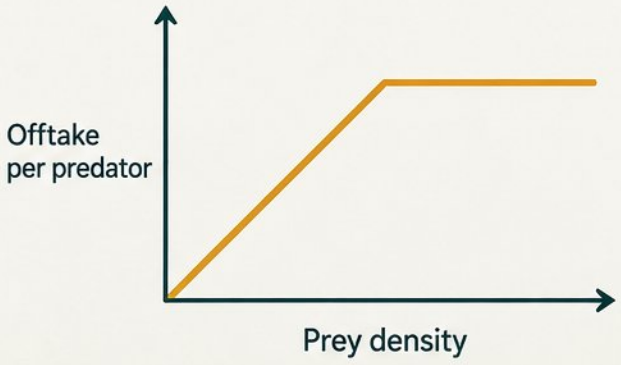
Functional and Numerical Responses

- **Functional response:** a predator's intake rate versus prey density
- **Type I:** linear rise, then abrupt saturation; rare in nature
- **Type II:** decelerating curve limited by handling time
- **Type III:** sigmoid curve with learning and prey switching
- Total offtake = functional response × numerical response
- Types I–III form a continuum, not separate boxes



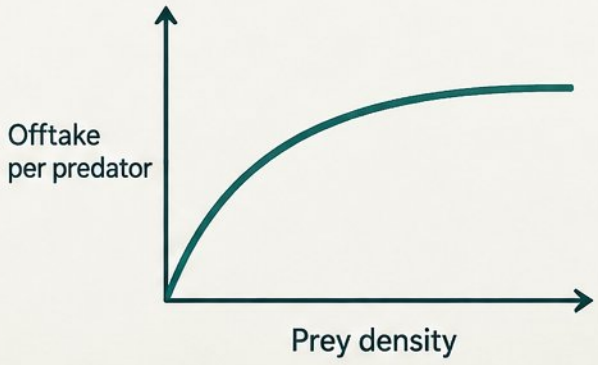
Type I

linear rise, then abrupt saturation; rare in nature



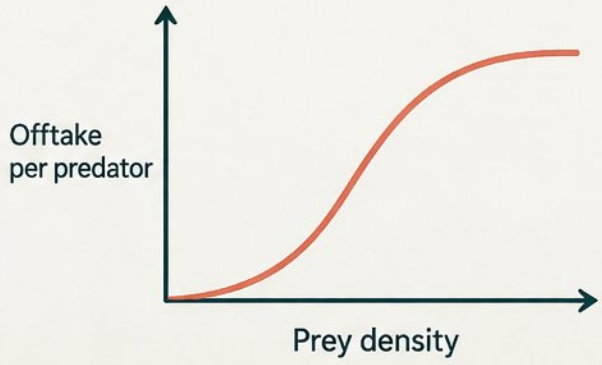
Type II

decelerating curve limited by handling time



Type III

sigmoid curve with learning and prey switching

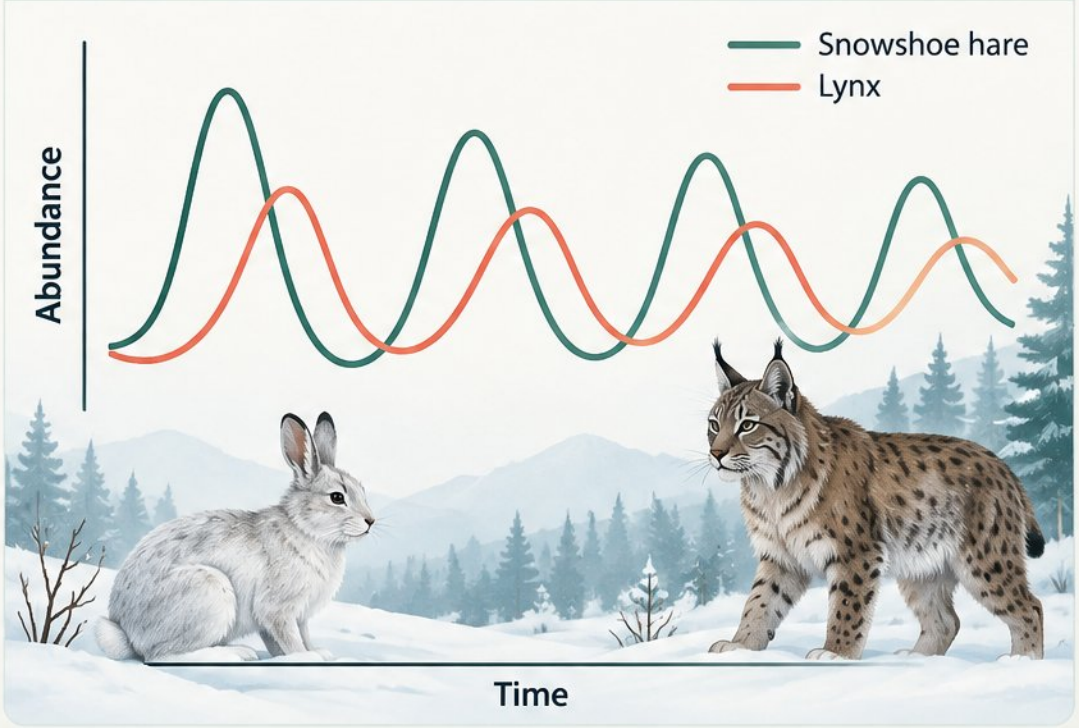


Total offtake = functional response × numerical response
Types I–III form a continuum, not separate boxes

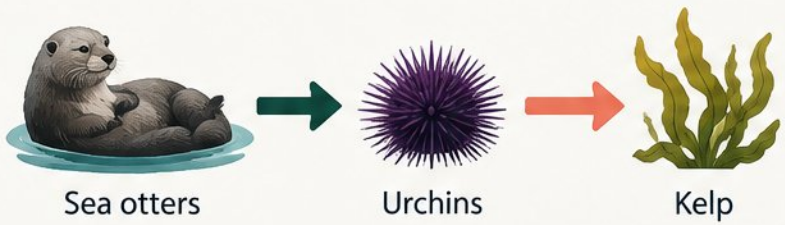
Predator–Prey Cycles and Trophic Cascades

- **Lynx and snowshoe hare:** ~10-year cycle, predator lagging 1–2 years
- **Cycles are rare in nature:** generalist predators and alternative prey stabilize dynamics
- **Top-down trophic cascade:** predators suppress consumers, releasing producers
- **Classic cascades:** sea otters–urchins–kelp; piscivorous fish–plankton
- **Risk effects:** prey alter behavior and traits without being eaten

Lynx and Snowshoe Hare Population Cycles



Top-Down Trophic Cascades



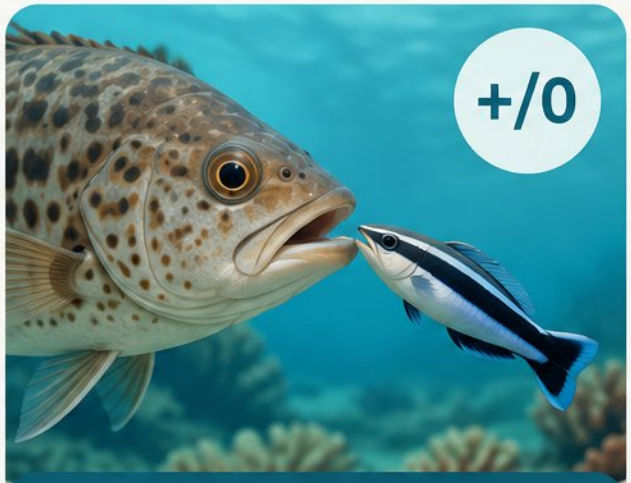
INTERCONNECTED LIFE
HEALTHY ECOSYSTEMS THRIVE

Symbiosis: Mutualism, Commensalism, and Parasitism

Different lives.
A more connected world.



Mycorrhizae (plant–fungus)



Cleaner fish and client



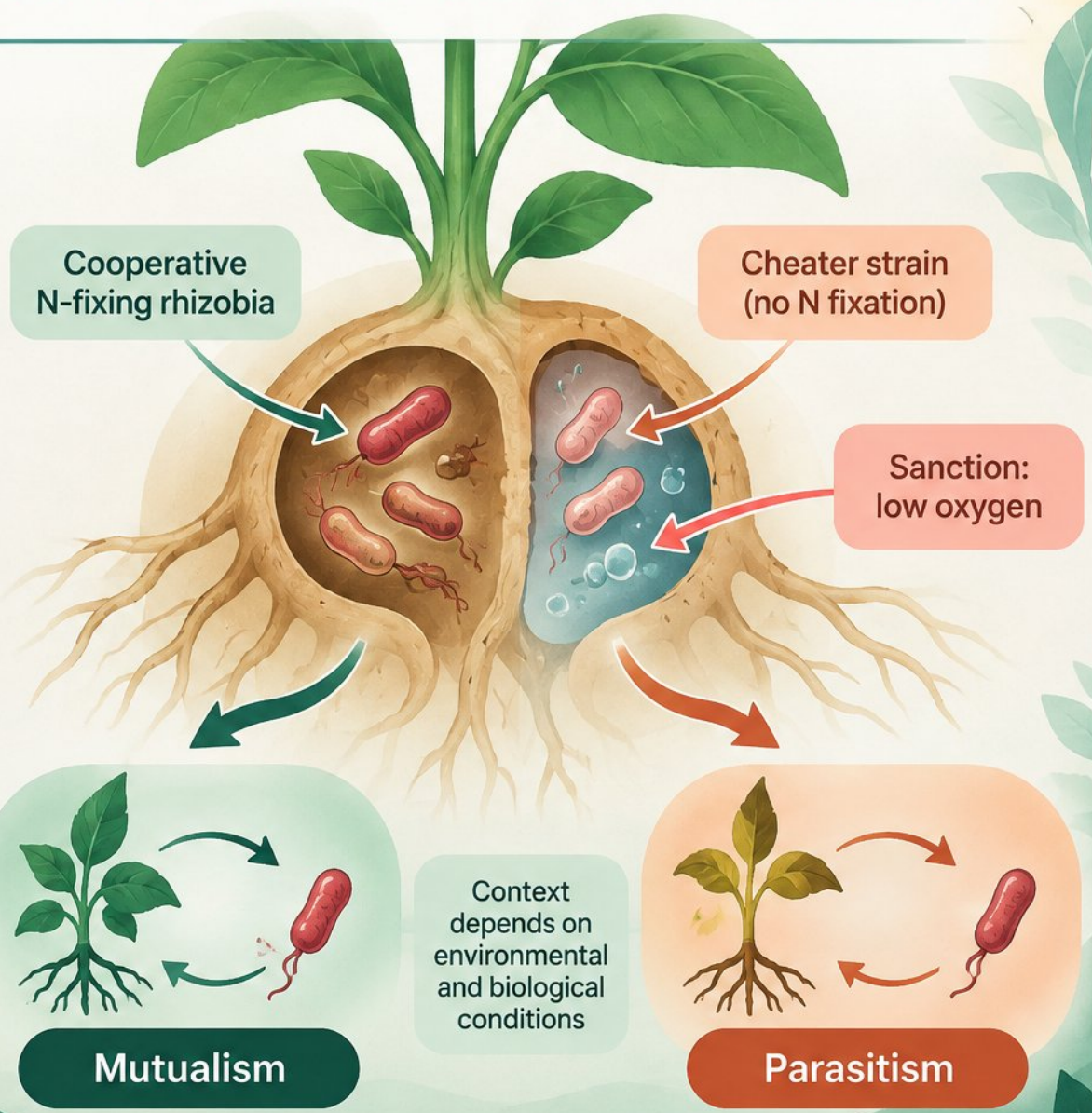
Brood parasitism

- **Symbiosis:** close, ongoing contact between species; includes all three types.
- Some biologists use "symbiosis" narrowly as a synonym for mutualism.
- **Mutualism (+/+):** both partners benefit from the association.
- **Commensalism (+/0):** one benefits; the other is neither helped nor harmed.
- **Parasitism (+/−):** parasite benefits; host is harmed but usually not killed.
- **Obligate** = cannot survive without the partner; **facultative** = can, but often less well.
- **Examples:** mycorrhizae, rhizobia–legumes, cleaner fish, brood parasitism.

SPECIES TOGETHER
STRONGER TOMORROW

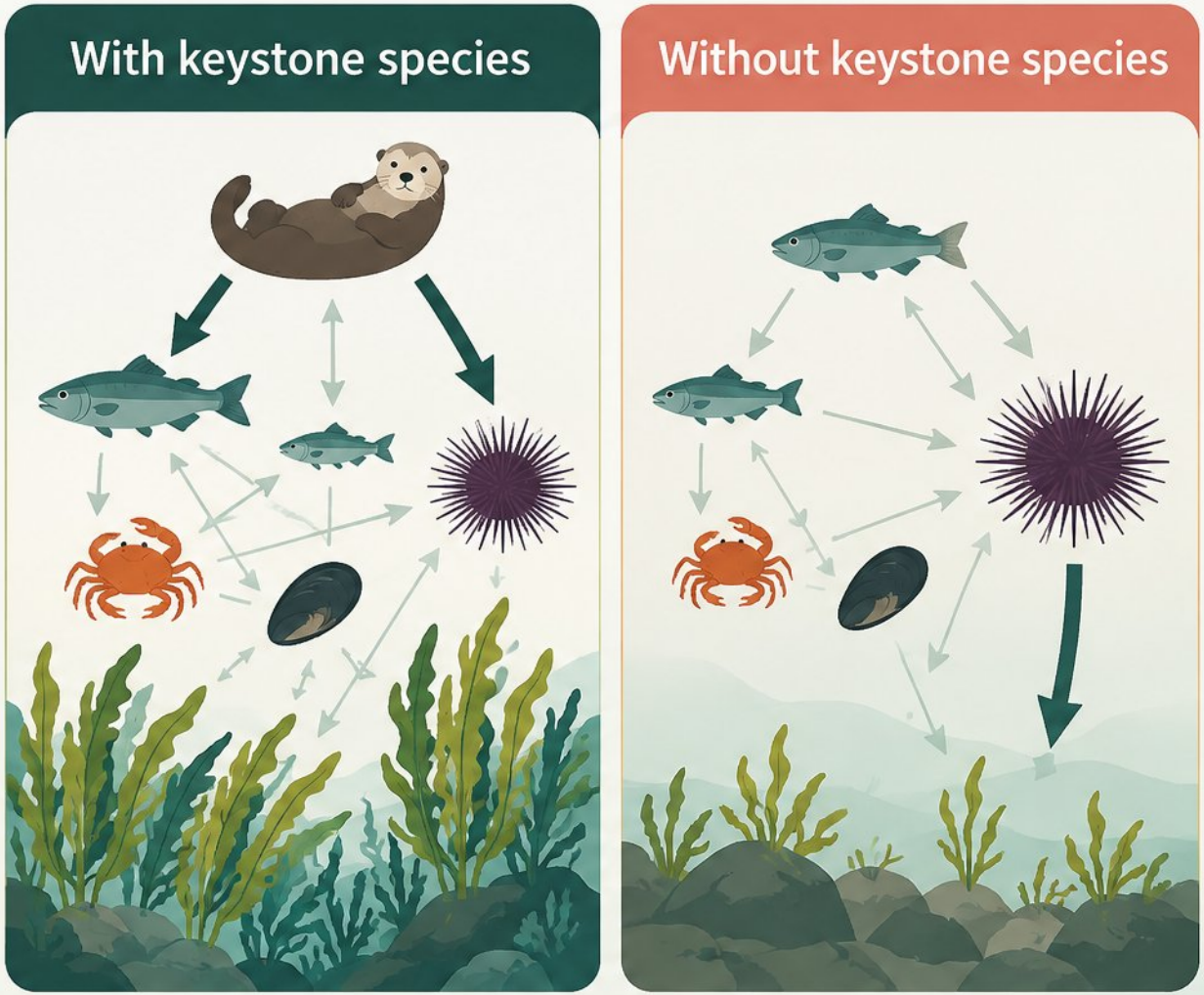
Cheating, Sanctions, and the Parasite–Mutualist Continuum

- Mutualisms are vulnerable to cheaters that take benefits without paying costs
- Sanctions punish cheaters: low oxygen to N-fixing rhizobia, fig fruit abortion, chased cleaners
- Context shifts outcomes: nutrients, ectoparasite abundance, density, life stage
- Same pair can flip between mutualism and parasitism within a generation
- Treat the continuum as an arms race, not a fixed label



Interaction Strength, Keystone Species, and Indirect Effects

- Interaction strength = magnitude of one species' effect on another
- Net effect = direct effects plus indirect effects combined
- Food webs show many weak links and few strong links, promoting stability
- Keystone species: disproportionate influence, as in Paine's starfish and sea otters
- Indirect effects include apparent competition and trait-mediated interactions



Applied Ecology:
Conservation, Agriculture, and Invasion



- Gorongosa rewilding: ungulates ate invasive Mimosa pigra; invasion fell in a decade
- Native pine martens suppress invasive grey squirrels across European landscapes
- Recovering sea otters suppress invasive green crabs in Elkhorn Slough
- Competition and predation guide biocontrol, pest management, and removal
- One Health: disease ecology as symbiosis–predation interface



Teaching, Synthesis, and Assessment

Common misconceptions:
symbiosis means mutualism;
effects are fixed; only individuals matter

Activities:
sign-diagram sorting, string food-web demos, concept-map redrawing

Conceptual change stories
contrast individuals vs. populations and direct vs. indirect effects

Integrated case study
plus transfer-oriented self-check and assessment prompts

Frontiers:
microbiome ecology and global-change interaction research



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