

Introduction to Biology Study Guide – Exam 3: Ecology

1. Impact of predators & parasites on prey abundance & behavior

- Removal/exclusion experiments show that predators have a major impact on prey abundance
- Removal of skunks from duck nesting areas dramatically improved hatchling survival (less predators – skunks – means more prey – duck hatchling – survival)
- Abundance of red kangaroos in southern Australia was 10-30 times higher when dingo predators were excluded
- Charles Elton, a British ecologist, analyzed lynx/hare predator-prey cycle and tried to understand the forces behind the cycle
- Lynx = predator; Hare = prey
- Lotka-Volterra (L-V) predator prey equations developed to show relationship between predators and prey
- Parasites decrease prey (host) abundance
- Ticks increased mortality of cattle egret nestlings by 300-500% compared to tick-free chicks (they were treated with insecticide to kill off ticks)
- Mange (parasite) in Sweden reduced fox population abundance 5x (causing hare population to increase 6x)
- Parasites affect prey (host) behavior as well
- Flat worm parasite causes amphipods to swim near surface during day
- Trematode causes periwinkles to move out of water onto rocks where they're more visible and easily eaten by seagulls
- An interesting example of a parasite's effect on its host's behavior is the example of the spider (host) and wasp (parasite)
- The wasp injects a virus into the host
- The virus alters the spider's genes
- As a result, the spider produces proteins that cause immune cells to die and proteins that halt development
- Additionally, neuropeptides are prevented from being manufactured in the brain
- The spider starts making retarded webs as a result
- **Parasitoids** = parasites that always kill their hosts

2. Effects of predators on ecosystem structure and diversity (e.g. the wolves of Yellowstone)

- Wolves at Yellowstone National Park were killed off
- Elk are preferred prey of wolves
- With wolves killed off, there was overpopulation of elks
- With overpopulation of elks, there was too much consumption of vegetation (willows, aspen and cottonwood trees)
- With excess consumption of vegetation, animals such as songbirds and beavers were losing habitats, and their numbers declined as a result
- Re-introduction of wolves significantly reduced elk numbers
- As a result, willow, aspen and cottonwood trees thrived (less elk were available to consume the vegetation)
- Additionally, due to increased vegetation, organisms such as songbirds and beavers gained their habitats back, and their numbers went up

- Now beavers could create dams and ponds, and the dams provided water to help even more vegetation grow, while the ponds provided habitats for other organisms such as otters and muskrats
 - Besides elk, coyote were also preyed upon by wolves, and loss of wolves led to more coyote
 - Re-introduction of wolves led to reduction of coyote and thus an increase in prey of coyote: pronghorn fawns, voles, mice, etc.
 - Competitors of coyote benefitted from coyote population being controlled by wolves
 - Additionally, wolves often consume only half their victim, providing scavengers (such as magpies, ravens, grizzly bears, etc.) a food source
 - Wolf kills were an especially important food source for ravens, which benefitted greatly from re-introduction of wolves
 - To summarize: Predators may affect not only their own prey (elk/coyote), but the prey of their prey (pronghorn fawns, voles, mice, etc.), vegetation (willow, aspen, cottonwood trees) and seemingly unrelated organisms (beavers, songbirds, ravens, etc.)
 - Predators clearly affect ecosystem structure tremendously; Removal of predators decreases diversity (decreased vegetation and dying out of many species such as beavers, ravens, etc.)
3. Types of mutualism & benefits that mutualistic associations provide to the partners.

- Both partners in mutualistic relationship benefit from one another

Types of Mutualism

1. **Obligate** = Each species benefits but can't survive without partner
2. **Facultative** = Each species benefits but is capable of surviving without partner

Types of Benefits

1. **Trophic** = 1 or more partners gains water, energy, nutrients, refuge
2. **Defensive** = Partner defends against predators/parasites/competitors
3. **Dispersive** = Seeds or pollen of 1 partner transported by other

4. The importance of mutualistic associations to entire communities (see Mutualism article)

- Originally, mutualistic relationships weren't thought of as very important, but they are
- Without mutualism, reef-building corals, which rely on mutualism with various algae, would cease to exist
- Without mutualism, many insect-pollinated plants would disappear from communities
- The loss of such plants would cause a cascade of extinctions
- Herbivores and predators of the herbivores would die out
- Digestion of cellulose by herbivores is enabled by mutualistic bacteria and protozoa
- Most plants can't fix atmospheric nitrogen – they rely on mutualistic associations with rhizobial bacteria
- Many organisms wouldn't exist without mutualism, and the world would be impoverished without mutualism

Tobacco Plant-Bug Mutualism

- Hawk moth lays egg on tobacco plant's leaves
- Caterpillar emerges from eggs and starts eating plant's leaves
- Plant releases chemical signaling big-eyed bug
- Plant benefits from bug because bug kills caterpillar, and bug benefits because it gets food

Plant-Wasp Mutualism

- Injured plant sends out signal to wasp, which lays eggs on caterpillars eating plant's leaves, and the wasp's eggs eat the caterpillars from the inside out
- Plant benefits because caterpillar is killed, and wasp benefits because its larvae get food source

Wasp-Virus Mutualism

- When wasp attacks caterpillar it injects virus in caterpillar that prevents caterpillar's immune system from attacking wasp's eggs
- This virus can only reproduce within ovaries of wasp, and the wasp's eggs die in the absence of the virus
- Thus, virus benefits from wasp (can reproduce in wasp's ovaries), and wasp benefits from virus (virus presence allows wasp eggs to live)

Leaf Cutter Ant-Fungus Mutualism

- Leaf cutter ants cultivate fungus (provide it food)
- Fungus then eaten by ant larvae

Leaf Cutter Ant-Bacteria Mutualism

- Special bacteria grows on ant's body
- Bacteria produce antibiotics that kill parasitic fungi infecting the ant's garden
- In return, the bacteria are provided food by the ant

Fish-Cleaner Fish Mutualism

- Cleaner fish remove parasites, bacteria and dead tissue from "client" fish visiting certain areas of coral reef

Fungi-Plant Root Mutualism

- Very important and ancient mutualism
- In some species, fungal mycelia form fuzzy sheath around roots of plant
- In other cases, mycelia live within interior of roots
- Either way, the connection between fungi and roots is so strong that we now think of roots as mycorrhizae (fungus-roots)
- Fungi benefit from association by receiving supply of carbon from sugars
- Plant roots benefit by obtaining enhanced ability to absorb phosphorous, nitrate and water, allowing many plants to reach higher abundances and inhabit more diverse range of habitats
- Plants also benefit by gaining resistance to herbivores/pathogens/parasites and by gaining ability to withstand greater temperature range
- With an increasing number of fungal species, biomass and species diversity increase
- Roots of different plant species may merge into one large mycorrhizal system, allowing plants to share water, sugars and nutrients (thus, the mutualism affects not only individuals but community as well)
- The more diverse the community, the greater the resistance to drought, low nutrient levels, etc.

5. The latitudinal gradient in species diversity & possible causes

- Latitude = distance north or south of equator
- Increasing latitude means you're getting further from the equator
- Higher latitudes = less birds
- Higher latitudes = less mammals
- Many hypotheses for reason that latitudinal gradients exist (all difficult to test; there's no consensus; there's no single reasons for the pattern seen; many diverse factors are involved)

Hypotheses explaining existence of latitudinal gradients include

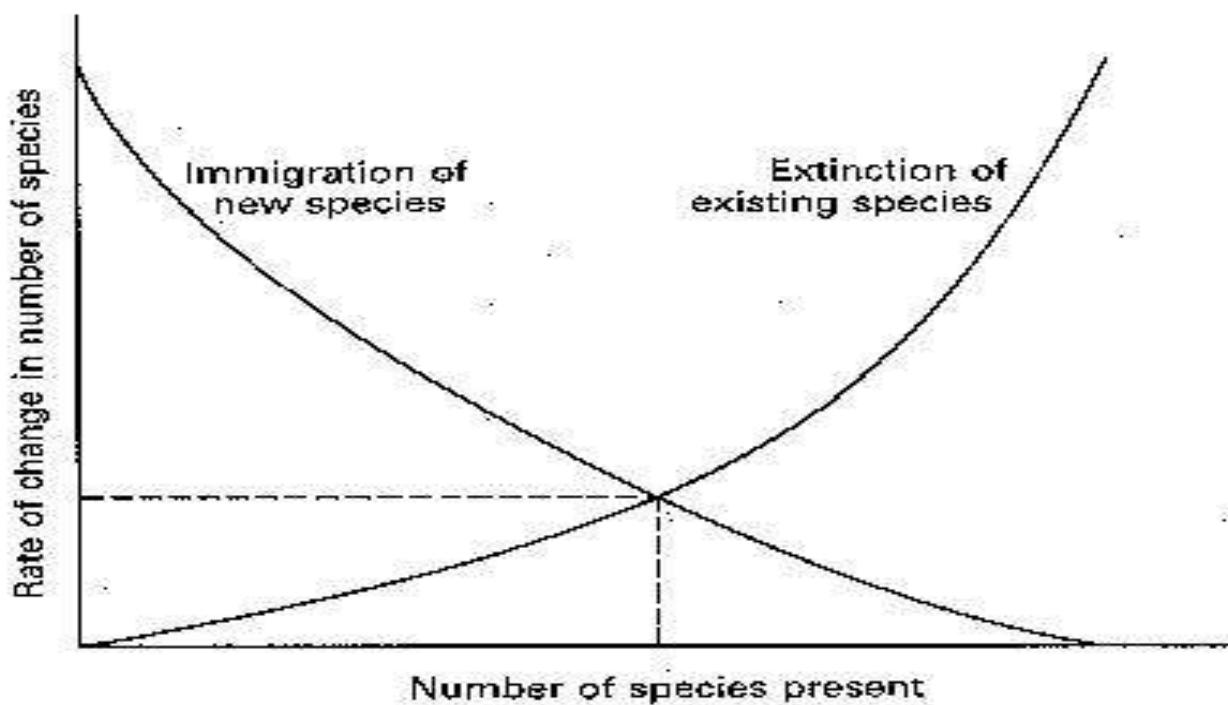
1. **Productivity Hypothesis** = more light and heat in tropics (low latitude), longer growing seasons; greater productivity results and promotes higher population sizes, higher speciation rates, lower extinction rates, etc.
2. **Stability Hypothesis** = tropical climates are less variable; greater stability promotes higher speciation rates, lower extinction rates, etc.

6. The species-areas relationship

- $S = cA^z$, where S = species, c = constant, A = island area, $z = \sim 0.2$
- Larger area = more species
- Relative to a smaller island, a large island will have lower extinction rates since there are more resources due to the greater area of the large island, reducing competition for resources

7. The MacArthur-Wilson equilibrium model

- As there are more species, extinction rates increase (due to increased competition), and immigration rates decrease (less room for species on island)
- Equilibrium # of species occurs when extinction rate = immigration rate



8. The Intermediate Disturbance Hypothesis & the mechanism that promote greater or lesser levels of diversity under different degrees of disturbance

- **Intermediate Disturbance Hypothesis** = Local species diversity is maximized when ecological disturbance is neither too rare nor too frequent
- At low levels of disturbance, more competitive organisms will push subordinate species to extinction and dominate the ecosystem
- At high levels of disturbance, due to frequent forest fires or human impacts like deforestation, all species are at risk of going extinct

- According to the hypothesis, at intermediate levels of disturbance, diversity is maximized because both competitive K-selected and opportunistic r-selected species can coexist

9. Lessons learned from LIDs concerning the recovery of ecosystems from disturbance and ecosystem resilience

- **LID** = Large, Infrequent Disturbance
- LIDs, such as the volcano eruption at Mount St. Helens, are especially important b/c their effects occur over large areas and may persist for 1000s of years
- Other LIDs include the fires at Yellowstone that burned 36% of the forest
- The abundance and distribution of leftovers from pre-disturbance community greatly influence speed of successional change as well as structure, composition and diversity of recovered communities
- Ecologists view LIDs as “vast editing processes” in which some biotic elements are deleted, others transformed and still others left unaffected
- What we’ve learned from LIDs is that ecosystems have a remarkable ability to return to their previous structure, diversity and functioning after almost total annihilation (this property is called resilience)

10. The concepts and examples of tipping points, phase space, basins of attraction, alternative stable states, hysteresis, resilience, stability and catastrophic shifts in ecosystems (see Resilience article)

- **Stability** = Relatively constant state variables; keep in mind that even highly resilient systems can have fluctuations in state variables due to changes in biotic/physical environment; stability is measured by variance and magnitude of changes in such state variables
- **Phase Space** = All possible states of a system through time; we can call the set of all points in this space A
- **Basin of attraction** = Set of points obtained if all points entering A converge on a subset of points in A as $t \rightarrow \infty$ (in other words, the state that will ultimately be reached over time)
- **Alternative Stable State** = Theory that predicts that ecosystem can exist under multiple stable “states” (set of biotic/abiotic conditions); Alternative stable states are the multiple basins of attraction
 1. Collapse of coral reefs (Transition from state of coral domination of coral reefs to state of algae domination of coral reefs)
 2. Wolves of Yellowstone (Removal of wolves and re-introduction of wolves both changed ecosystem significantly)
 3. Orcas and Otters (Fishing pressure in the North Pacific increased, changing ecosystem – specifically, numbers of most organisms, such as otters, decreased; the number of orcas, or killer whales, wasn’t really affected)
 4. Eutrophication (Increasing plant biomass of an aquatic system by the addition of artificial or natural substances to the aquatic system, as is the case when shallow waters undergo catastrophic shifts and obtain a large increase in phytoplankton numbers)
 5. Lake Guri (Dam constructed in Venezuela, creating Lake Guri; Additionally, flooding of the valley behind the dam turned former hilltops into islands; The islands were all missing top predators that previously existed)
 6. Pisaster and Intertidal (Pisaster are starfish that were removed from the intertidal zone of the Muccaw Bay, resulting in change in ecosystem – specifically, the number of species fell from 15 to 8)
- **Hysteresis** = Occurs when ecosystem can exist in different states under same environmental conditions
- **Resilience** = measure of magnitude of disturbance a system can absorb before it fails to return to its previous state and instead enters another state
 1. Mount St. Helens volcano eruption – environment eventually bounced back

- **Catastrophic Shift** = new state of a system that represents a seriously degraded ecosystem with fewer species and impaired functioning; can be caused when 2 disturbances occur, with the 2nd occurring before full recovery from 1st
 1. Coral reef community near Discovery Bay, Jamaica shifted from coral dominated state to algae dominated state due to 2 major hurricanes and the dying off of sea urchins (major algae predator)
 2. Shallow lakes – normally have clear water and lots of submerged vegetation; catastrophic shift results in turbid (cloudy) water, loss of submerged plant community and increase in phytoplankton (phytoplankton reduce light levels at bottom, which is the reason for the loss of the submerged plant community); the shift is caused by an increase in nutrients (primarily phosphorus); the natural, pristine state is highly resilient to increased nutrient levels, but nutrient runoff from farms, etc. may exceed threshold eventually
- **Tipping Point** = Point at which system rapidly undergoes a catastrophic shift to an alternative stable state

***Most important cause of ecological changes is disturbances caused by humans

11. The idea and importance of Keystone Species

- **Keystone species** = species whose effects on other species in a community are much greater than would be predicted from its abundance
- Importance = keystone species control community structure (abundance, diversity and interactions of other species)

12. Factors contributing to the complexity of ecosystems

- Complexity depends upon species diversity and species interactions

13. Importance of positive & negative feedbacks in food web dynamics

- Positive Feedback = Change that results in products promoting that change
- Negative Feedback = Change that results in products promoting an opposite change
- Ex: Snakes consume mice; If you increase the number of snakes (change), the number of mice decrease (product), and the smaller amount of mice results in less food for snakes, resulting in a decrease in the number of snakes (opposite change)
- Ex: Snowshoe Hare – Lynx cycle

14. Control of food web structure & Trophic Cascades

- Food web structure can be affected by various organisms
- Predators and keystone species play an especially important role in food web structure
- **Trophic cascades** = Predators reduce amount of their prey, resulting in less predation upon the prey of the prey
- **Top Down Cascade** = Trophic cascade where the food chain or food web is disrupted by the removal of a top predator (as was the case with construction of large dam in Venezuela, creating Lake Guri)
- The result was a major change in the ecosystem – ex: prey of top predators flourished

15. The small world, hub-dominated nature of food web architecture (see Food Web article)

- Hub species = Species that are central to a web of interactions with various predators, prey, competitors, parasites, and pathogens
- In food webs, hub species have a stabilizing effect on web stability and dynamics

16. The greatest threats to biodiversity

- Impact of humans (we caused global warming, ecological overshoot, etc., which are defined below)

17. Understanding of the causes and ecological consequences of global warming

- Global warming caused by increasing CO₂ levels in atmosphere
- “Anthropogenic warming will lead to ecological impacts that are abrupt and irreversible, depending on rate & magnitude of climate change” –IPCC
- Already ~70% of Earth’s species affected
- Distribution shifts, abundance declines, smaller ranges; new parasites, diseases, competitors & predators
- Extinction rates will be elevated world-wide

18. Basic ideas behind the Rivet Popper, Redundancy, and Tapestry Hypotheses for the effects of species loss on ecosystem functioning

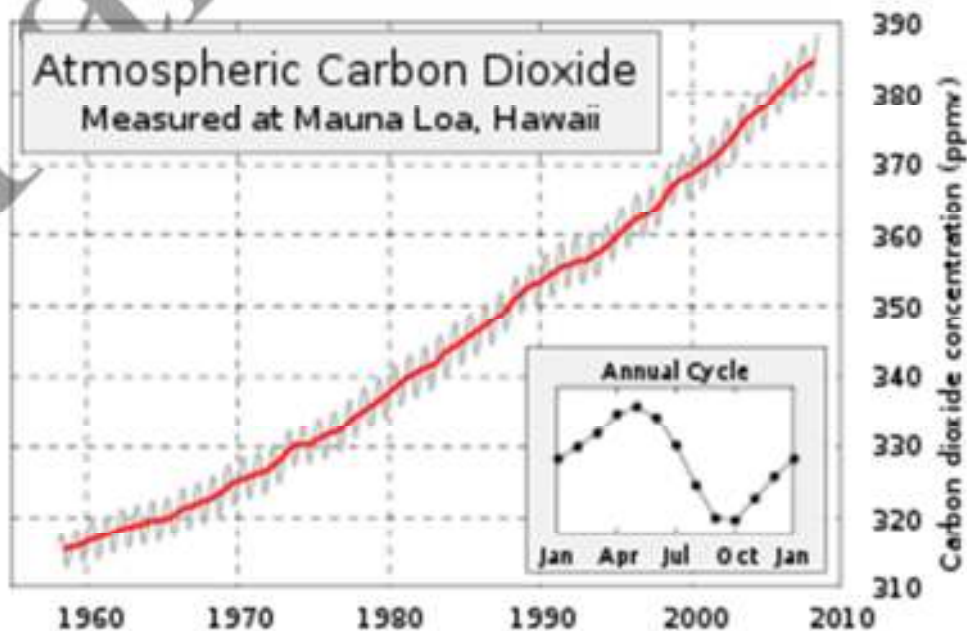
- **Redundancy Hypothesis** = most species superfluous; only a few key species are needed; losing most species is inconsequential
- **Rivet Popper Hypothesis** = each species has small, important role; losing any 1 species weakens system, causing system to crash

19. The ideas and examples of ecological footprint and ecological overshoot

- **Ecological footprint** = measure of our cumulative impact on the planet
- Definition: The area of productive land and water ecosystems required to produce the resources that the population consumes and assimilate the wastes that the population produces
- Accounts for flow of energy/matter to and from collections of individuals (towns, cities, etc.)
- Compares throughput of renewable resources relative to what is annually renewed (how fast we’re using resources relative to how fast Earth can renew those resources)
- Ecological footprint measured in global hectares
- If ecological footprint = 1 global hectare, we’re using resources as fast as Earth can renew them; If ecological footprint < 1 global hectare, Earth is renewing resources faster than we’re using them; If ecological footprint > 1 global hectare, we’re using resources faster than Earth can renew them (which is currently the case)
- **Ecological overshoot** = how much more of the planet we’re using than we should be
- While each person should only be using 1.8 hectares on average, people are using 2.2 hectares on average
- The ecological overshoot is 20%
- Such an overshoot is unsustainable
- The human population has been in overshoot for about 30 years, and the overshoot is increasing

20. The Keeling curve

- Graph which plots the ongoing change in concentration of carbon dioxide in Earth's atmosphere since 1958



21. The concept of Ecosystem Services and examples of these services

- **Ecosystem services** = Benefits to the human race derived from a multitude of resources and processes that are supplied by natural ecosystems

Examples

1. Purification of air and water
2. Seed dispersal
3. Protection from ultraviolet rays
4. Control of agricultural pests
5. Prevention of erosion