

## Lecture 2: Ecology

- ***The study of the interactions that living organisms have with each other and their environment.***
- These interactions determine the distribution & abundance of organisms

## Environment

- Abiotic--nonliving components
- Biotic--“biota”, living components

## Population Ecology

- Population: group of individuals of a single species living in the same general area
- Including environmental influences on:
  - population density & distribution
  - age structure
  - variations in population size

## Population Dynamics

## Types of Dispersion—patterns of spacing within a population

- clumped dispersion :
  - individuals aggregate in patches
  - influenced by resource availability & behavior
- uniform dispersion
  - individuals evenly distributed
  - influenced by social interactions
- random dispersion
  - position of individual is independent of others

Growth often NOT unlimited, because resources are limited

- Carrying Capacity ( $K$ )
- maximum population size environment can support
- Effected by: competition for resources, dynamic

## Community

- assemblage of populations of various species living close enough for potential interaction

## Community Ecology

- Study of the interactions of species in a community
- Each species has a role—"ecological niche"
- Types of interactions:
  - Competition
  - Predatory-prey
  - Symbiotic

### Competition

- When species are competing for a particular resource in short supply
- Major influence on community dynamics
- 2 types:
  - intraspecific
  - interspecific

### Interspecific Competition

- 2+ species competing for a particular resource in short supply
- Competitive exclusion:
  - two species competing for the same limiting resources cannot coexist in the same place
  - local elimination of one of the competing species
- Resource partitioning → coexistence

- Fundamental niche

- physical conditions under which a species might live if no competitive interactions with other species

- Realized niche

- Restricted fundamental niche
- Restricted due to:
  - Competition
  - Predation
  - Disease
  - Parasitism

- Niche overlap: 2+ species use similar resources, so leads to interspecific competition

### Competitive Exclusion

### Predation

- Interaction where a species (predator) kills & eats the other species (prey)
- Predator adaptations
  - Claws
  - Teeth
  - Stingers
  - Poison
- Defensive adaptations
  - camouflage
  - mimicry
    - non-harmful sp. mimics harmful sp.
    - resemblance of unpalatable sp.

### Facilitation

- Positive interactions between species
- Affect survival & reproduction of other species

### Resource Partitioning

#### Dominant Species “Ecological Dominants”

- Most abundant species (number or biomass)
- Affect the occurrence & distribution of other species
- Why is a species an ecological dominant?
  - best at exploiting limited resources
  - best at avoiding predators

#### Keystone Species

- Although not abundant, exert strong control on a community

#### Ecosystem “Engineers” (Foundation Species)

- Cause physical changes in the environment that affect community structure

### Biodiversity

- Encompasses many biotic scales
- Described in terms of:
  - Richness (number of entities of genotypes, species, ecosystems...)
  - Evenness (relative abundance of species)
  - Functional traits (response, effect)
  - Local vs. Regional vs. Differentiation

## Species Richness vs. Evenness (relative abundance)

### Trophic Relationships “who eats whom”

- Producers--autotrophic
- Consumers--heterotrophic
  - Herbivore, omnivore, carnivore (predator), detritivore
- Often modeled as linear, but usually more complex (web)
  - Producer → herbivore → predator
  - Organisms may switch trophic role during life as part of development or in response to environment

### Disturbance

- influences species diversity & composition
- moderate disturbance → higher species diversity (“intermediate disturbance hypothesis”)
- Disturbance:
  - event that changes a community
  - removes organisms from a community
  - alters resource availability
- Examples:
  - Fire
  - Disease
  - Humans

### Biogeographic factors affect community diversity

- Two key factors correlated with a community’s species diversity
  - Latitudinal gradient (sun & water)
  - Size (species-area curves)

### Habitat heterogeneity : diversity

### Island Biogeography Theory

- number of species on an island:
  - immigration of new species
  - extinction of previous species
- **Island area**—larger the island, the more niches, greater diversity

### Communities Change → Succession

- Replacement of community members over time
  - Disturbance

- Changing resources
  - Negative interactions (e.g. competition)
  - Positive interactions (e.g. facilitation)
- Primary
  - Starting of community on area with no vegetation/soil
- Secondary
  - Start on area that did have vegetation/soil

#### Changes during Succession

- soil
  - development & depth increases
  - organic content increases
  - soil moisture holding capacity increases
  - overall nitrogen increases
  - phosphorus decreases
  - nutrient retention increases
- Biomass & community complexity increases
- life history characteristics change (r→K)
- example: Succession in Glacier Bay, Alaska

#### Organisms Interact with their Environment

##### Adaptation

- genetically determined characteristic that improves an organism's ability to survive & reproduce under current environmental conditions

##### Geographic Variation

- Cline—graded change in a trait along a geographic axis

##### Natural Selection

- Accumulates & maintains favorable genotypes in population
- Requires
  - heritable variation for some trait
  - differential survival and reproduction associated with possession of trait.

#### The Smallest Unit of Evolution

- Populations = Smallest Unit of Evolution
- Natural selection acts on individuals, but populations evolve
- Genetic variations in populations → evolution

## Types of natural selection

### Sexual Selection

- “Natural selection for mating success”
- Intrasexual Selection
  - direct competition among individuals of one sex for mates of opposite sex
- Intersexual selection
  - Individuals with traits that attract mates favored

### Adaptive Radiation

- Evolution of diversely adapted species from a common ancestor upon introduction to new environmental opportunities
- Examples: Hawaiian archipelago “Silversword Alliance”, *Ensatina escholtzii*
- Subspecies descended from common ancestor
- Each subspecies adapted to local environment
- Black zones = distinct species (can no longer interbreed)

Ecosystem Ecology--Study of interaction of organisms (biotic) & physical environment (abiotic)

Four basic processes at work in all ecosystems

- **Energy flow**
- **Mineral cycle**
- **Water cycle**
- **Community dynamics**

### Main Ecosystem Processes

- Energy Flow
  - Flows through an ecosystem
  - “transformation” (some lost as heat)
- Chemical Cycling
  - Matter cycles (nutrients) within ecosystem
  - “processing”

PHOTOSYNTHESIS= LIGHT + CO<sub>2</sub> = FOOD

### Primary Production

- amount of light energy converted to chemical energy by autotrophs during a given time period
- Limited by physical & chemical factors
- Gross primary production (GPP)
  - total primary production in an ecosystem
- Net primary production (NPP)
  - GPP- energy (used by primary producer for respiration)
  - Only NPP is available to consumers

### Factors Affecting NPP

- Light Limitation
  - Filtered by above vegetation
  - depth of light penetration (“photic zone”) in aquatic environments
- Nutrient limitation
  - Marine production most limited by nitrogen & phosphorous, also iron
- climatic factors (temperature & moisture) affect primary production on a large geographic scale

### Trophic Efficiency

- % of production transferred from one trophic level to next
- Usually ranges from 5% to 20%

### Detritivores

- Decomposers
- recycle essential chemical elements (return organic material to inorganic reservoirs)
- mainly bacteria and fungi

### Biogeochemical Cycling

- Cycling of water & nutrients between biotic and abiotic components
- Resources
  - water
  - nutrients
- Conditions (e.g. temperature) affect biogeochemistry

### Nutrient Cycling Rates

- Decomposers play a key role in chemical cycling
- Rates vary among ecosystems, mostly as a result of differences in rates of decomposition

## Carbon Cycle, Nitrogen Cycle, Phosphorous Cycle, Water cycle

### Turnover Time of Water

- time required for entire volume of a particular “reservoir” to be renewed
  - Atmospheric water: 9 days
  - Rivers: 12-20 days
  - Lakes depend on size, depth & drainage: days-centuries
  - Oceans 1,300 years

### Climate: “prevailing weather conditions”

#### Global Circulation Patterns, Global Wind Patterns, Ocean Currents

### El Nino Conditions

#### Local Topography affects Climate

##### Rain Shadow

- A dry region on the leeward side of a mountain range resulting from a reduction in rainfall. California's deserts are all the product of **rain-shadow** effect.

##### Mediterranean Climate

- Occur between ~30°-40° latitude on west coasts of continents, where cold ocean currents.
- wet season in winter, dry season in summer
- Total annual precipitation: ~ 10-40 inches/year

##### Fog Formation

- Forms when humid warm, air moves over cold California Current
- hugs the ground/water because warm, moist air condenses as moves over cooler water
- fog diminishes as air warms and condensation decreases
- Local pressure & wind bring fog inland late in the day and through the night

#### Human Disruption of Chemical Cycles

- As the human population has grown in size, especially coupled with the industrial revolution, we have impacted:
  - trophic structure, energy flow, chemical cycling
  - Global Warming: Rising Atmospheric CO<sub>2</sub>
  - Too many nutrients → eutrophication