1 ☐ Ecology Overview

2 ☐ Field of Ecology

- Studies the distribution and abundance of organisms, interrelationships of organisms and relationship between organisms and their environment
- Both field and laboratory studies explore parameters from biosphere level to organism level

3 ☐ Levels of Ecological Studies

- Biosphere-Global scale; zone of life from Earth's deep crust to lower trophosphere
- Biomes-areas determined by climate-decades of patterns of temperature and precipitation
- Ecosystem-the biotic community, interrelationships of populations, and relationship between the populations and environment
- Community-the populations within an area
- Population-all the organisms of a species within an area
- Organism- a member of a population

4 ☐ Major biomes

- Tundra
- Forest
- Grassland
- Desert
- Aquatic

5 ☐ Tundra

- Arctic; low precipitation
- severe winds, all light summers and all dark winters, permafrost
- low nutrients
- Plants grow flat on ground, hairs, flowers parabola shaped, heliotrophic, pollination wind driven
- Animals glycerol in body tissues for antifreeze, white fur, fat insulation, hibernation, insects live in H2O in winter-fox, hare, polar bear, mice

6 ☐ Forests

- Temperate: 75-150 cm even precip throughout year, temperatures -30 to 30 C, oak, hickory, beech, hemlock, maple, elm are plants; animals: squirrels, rabbits, birds, deer, bobcats, foxes
- Tropical: >200 cm/yr precip even throughout year, 20-25 C, plants: trees like mahogany, orchids, bromeliads, vines, palms, buttressed trunks shallow roots; animals: birds, bats, sm. Mammals, insects
- Taiga: 40-100 cm precip mostly as snow, very cold temperatures, plants: Evergreen conifers, pine, fir, and spruce, animals: woodpeckers, hawks, moose, bear, weasel, lynx, fox wolf, hares, shrews

7 ☐ Grasslands

- Savannah: 51-127 cm/ yr, rainfall conc. in 6-8 mos. followed by drought, high temps/close to equator, plants: grasses/trees-acacias, animals: elephants, giraffes, dik-dik, bush back
- Prairies: 51-88 cm/yr precip in spring, hot summers, cool-cold winters, plants: dense, tall grass;

herding animals

- Steppes: 24-51 cm/yr precip, hot summers, cool-cold winters, plants: short (25 cm) grass; herding animals

8 Desert

- Deserts: hot & dry -arid<50 cm/yr H2O evap. before hit groundcover 20% land, 20-25C extremes -18 to 50; plants: shrubs, sm trees, spines, thorns; animals: nocturnal, few mammals, mostly reptiles, amphibians have accelerated life cycles, many animals burrow

9 Aquatic

- Freshwater lakes: spring, fall overturn; lakes 3 main layers-epilimnion, warm, thermocline-rapidly changing, hypolimnion-cool, light determines plants-phytoplankton to SAV; animals: insect larvae, insects, fish
- Streams:headwaters cool-cold,mouth warmer speed water flow determines plants: mosses-rooted w phytoplankton according to current; insects: shredders, grazers, fish, crayfish, snails
- oceans/seas: light levels determine primary productivity and somewhat secondary biomass above thermocline; varies by latitude and season, below isotherm, 2-4 C ;phytoplankton and SAV in euphotic zones have great diversity of fauna - all phyla represented adaptations for cold, lack of light, and viscosity of medium

10 Population Ecology

- Study of population growth and regulation
- Influenced by density dependent factors (competition, predation, r vs K selected species) and density independent factors (climate, habitat disruptions offering opportunities for r selected species

11 demography

- Study of vital statistics that affect population growth (birth rate, death rate, age structure and gender distribution by age)
- Age structure is the relative number of individuals of each age
- Young and old members of population mostly likely to die; generation time birth to fertility age)

12 Life table

- Summarize mortality rates for each age group
- Contructed by cohorts
- Cohort is a group of organisms followed from birth to death
- Survivorship curve shows number of members of a cohort that are still alive at each age interval

13 Survivorship Curves

- Type 1: modern human populations mortality low during early and middle age and increases rapidly w old age
- Type 2: K selected populations that produce relatively few offspring and provide parental care
- Type 3: r selected populations that produce numerous offspring, most of which die young, few will survive to adults

14 Logistic models of population growth

- Mathematical modeling compares rates of growth, variables affecting growth, and predict population size
- dN/dt = rN describes instantaneous change in population number where N is population, t is time, and r is reproductive rate; equation describes an exponential curve
- dN/dt = rN (K-N)/K iw logistic growth where K is the carrying capacity within that environment; the curve begins exponential then varies around an equilibrium point

15 Models

- Any increase in populations numbers could have a negative effect on population growth
- Oscillation around an equilibrium point is overshooting by population because there is a lag time before the negative effects of population size impact population

16 Density dependent factors

- Nutritional resources, increasing predation
- May act to slow population growth

17 Density Independent factors

- Weather or habitat disruption
- Reduce population by the same proportion whether the population is large or small

18 Life histories: r and K selected

- Life history is the birth, reproduction and death of organisms
- 3 factors affect the rate of increase (r): # or reproductive periods, clutch size; maturation age
- R selected: opportunistic, early maturation, large clutches of small, independent individuals, no parental care
- K selected: equilibrium (K), few offspring, mature late, larger bodied, parental care

19 Human Population Growth

- Exponential growth; haven't reached equilibrium point
- Doubling time decreasing; projected to reach over 8 billion in 2017
- Drop in death rate, especially infant mortality

20 communities

- Collection of populations and their interactions within a given area
- Biogeography: distribution of species on planet
- Succession: change in community structure over time
- 2 points of view on succession:
- Gleasonian: change groupings of species found in same area because of same requirements for environmental factors
- Clementsian: community is superorganism that develops in predictable sequence over time towards the climax community in which the species best fit the environmental factors (inhibition-prevent other species from colonizing; facilitation-set up stage for colonization by next species)

21 Community properties

- Diversity: number of species found in a community
- Abundance: number of organisms within a population
- Dominant vegetation-physiognomy
- Trophic structure: feeding pyramid
- stability

22 Adaptations to biotic factors

- Coevolution: reciprocal adaptations where one species acts as a selective agent on another species who acts on first species as a selective agent (flowers and their pollinators)

23 Competition between and within populations

- Interspecific competition: competition between species for food and habitat
- Intraspecific competition: competition within members of a population for food, habitat, and mates
- Competitive exclusion principle: two species that compete for the same limiting resource cannot occupy the same habitat
- Resource partitioning: feed in same area but on different food sources (various bird species on beach all have different beak lengths and feed on different food sources)
- Habitat: address; niche: job (function)
- Fundamental niche: resources an organisms could theoretically use
- Realized niche is resources that is actually can use as determined by biological competition and predation

24 Predation

- Trophic pyramids and predator/prey relationships
- Adaptations to increase success include development of senses, morphological changes including defenses such as claws or coloration or chemical defenses-bitter or poisonous
- Behavioral adaptations: hide, flee, or fight
- Key stone predators switch sources of prey as prey becomes less plentiful resulting in a balanced community

25 Coloration

- Cryptic coloration: deceptive markings to discourage or confuse predators
- Aposematic coloration: bright colors to help predators not to eat them as they are poisonous or distasteful
- Mimicry: one species resembles another
- Batesian mimicry: harmless species resembles a poisonous species
- Mullerian mimcry: mutual imitation by two distasteful species possibly to lure other species as prey

26 Other interactions

- Mutualism: both species benefit from the relationship (corals and zooxanthellae)
- Commensalism: one species benefits from the other, the second species is neither harmed nor benefited (Spanish moss hanging in trees)
- Parasitism: one species benefits at the expense of another (lampreys feeding on other fish)

27 Community stability

- Resilience is the ability of the community to retain its structure when stressed by abiotic or biotic factors
- Usually diverse communities are most resilience
- If there is a limiting factor, then communities with abundant populations are more successful

28 Distribution of species: biogeography

- Species may be limited to a range because it has insufficient population to colonize or climate factors or geographical features prevent colonization or indigenous species outcompete the colonizing species
- 2 major clines: from northern or southern latitudes towards the equator and from shallow to deep water

29 Island Biogeography

- MacArthur and E. O. Wilson
- Closer to mainland, more species
- Larger island, more species
- Initial species numerous, fewer new species can become extablished
- Extinction rate of present species increase
- When immigration and extinction rates are equal an equilibrium in species diversity exists

30 Ecosystems

- An ecosystem is the relationships between and among the populations and the abiotic (environmental) factors
- Ecosystems are characterized by their structure and function
- Structure is the abiotic features like topography, and the plants and animals that make up the ecosystem
- Function is the relationship between them-trophic structure, nutrient cycling, flow of energy through the ecosystem

31 Trophic structure

- Troph means to feed
- Trophic structure determines the flow of energy through the ecosystem
- There are two main trophic pyramids
- The classic pyramid begins with autotrophs (plants) then primary consumers, secondary consumers,….
- The other pyramid begins with detritus and then saprophytes and scavengers in the primary consumer level, then secondary consumers…
- There usually are not many levels in a feeding pyramid because at each level, most of the energy is lost and little is transferred to the upper levels
- The upper levels will be top predators who must have a large range to find sufficient food

32 Food Chains and Webs

- Food chains are the transfers of food between trophic levels
- Food webs are the interactions within a food chains
- There may be many different species within each level of a trophic pyramid, and their predators may also be varied leading to complex food webs

33 Energy Flow

- The source of most energy in trophic pyramids is ultimately the sun; in webs that are not photosynthetic or have detritus that is photosynthetically based, the source of energy may be elements and compounds, like those that form the basis of the food webs of hydrothermal vents and seeps

34 Primary productivity

- Primary productivity is the rate of conversion of light to chemical energy
- This is accomplished by photosynthetic organisms
- Net primary productivity (NPP) is the gross primary productivity (GPP) minus the energy consumed by respiration to drive cellular processes
- 50-90% of GPP is used by the organism leaving only a small portion as NPP

35 Determining primary productivity

- Production and consumption of oxygen can be used to determine productivity of aquatic ecosystems
- PP can be expressed as energy per unit area per unit time (kcal m^{-2} yr^{-1})
- Biomass is mass of dry organic material per unit area per unit time (usually expressed as live biomass, dead biomass, total biomass, and may be only aboveground biomass but usually includes roots
- Standing crop is total biomass of plants per unit area per unit time
- The most productive ecosystems are tropical forests, estuaries, and coral reefs

36 Limiting nutrient

- One that is not present in adequate amounts limiting primary productivity
- P, due to its slow, sedimentary cycle and N, because it is entirely bacterially mediated and is found only as a diatomic gas without bacteria are the most common limiting nutrient
- Pollution, over fertilization by N and P and run off from feed lots, leads to primary productivity blooms in aquatic ecosystems
- As the primary producers die and decompose, the bacterial decomposition uses all the dissolved oxygen, creating "dead zones" in the water
- This combination of extensive growth at the surface preventing growth of submerged aquatic vegetation (SAV) and subsequent anoxic zones in the water is called eutrophication

37 Energy pyramids

- Energy flow through the ecosystem is also represented as a pyramid
- Most gross productivity is used by the autotrophs, leaving little energy for the primary consumers
- The primary consumers are only able to convert a small percentage (4-10%) of the energy that remains
- Subsequent levels of the pyramid have less energy available and consequently, there is less biomass at each level

38 Chemical cycling

- Biogeochemical cycles look at the transformations of nutrients within ecosystems or biomes
- Autochthonous sources move within an ecosystem and allochthonous sources move between and within ecosystems

39 Carbon cycle

- Photosynthesis converts carbon dioxide to small hydrocarbons-sugars
- Metabolism of these sugars by mitochondria as a function of cell respiration results in the production of carbon dioxide
- Burning of hydrocarbons releases carbon dioxide and water as products of combustion
- Excess carbon dioxide may be sequestered by oceans where carbon dioxide reacts with salts to form bicarbonate

40 Nitrogen cycle

- Every step of the nitrogen cycle is bacterially mediated
- Nitrogen fixing bacteria remove nitrogen from the atmosphere by making compounds that can be used by plants in a process called ammonification
- Plants use the nitrogen in amino acids, nucleic acids, and other organic molecules
- As plants or animals decompose, some bacteria release nitrogen back to the atmosphere (denitrification) or convert ammonia to nitrates (nitrification)

41 Phosphorus cycle

- This is the slowest cycle because it has no gaseous component
- Weather of rock adds P to soil or water usually in the form of phosphate ions which plants can absorb
- Humus and oil particles can bind P keeping it available for cycling within an ecosystem
- If the ecosystem is aquatic or if the P flows into an aquatic ecosystem, some P will be adsorbed in sediments and trapped
- These sediments will become sedimentary rocks and the process begins with weathering of these rocks

42 Nutrient cycling in ecosystems

- The rate of cycling of nutrients depends on climate and precipitation and availability of the nutrients
- Some ecosystems cycle C rapidly, as in deciduous forests, come cycle slowly as in fens, bogs or salt marshes
- Tropical rain forests all of the C is tied up in the biomass, there is little reservoir of C in the soil or in litter; the litter cycles rapidly

43 Anthropogenic effects on nutrient availability and nutrient cycling

- Agriculture adds N and P, but removes much of the biomass which incorporates that N & P; some of the fertilizers may be lost if applied where there are no buffers between fields and water sources or if applied before rainfall
- Logging removes biomass and nutrients and alters the amount of light that enters the forest; Hubbard Brook Forest study demonstrated that logging leads to more nutrients lost in run off since there is low biomass to slow water flow and to cycle the nutrients
- Eutrophication was discussed earlier

44 Biomagnification and Bioaccumulation

- Substances that are synthetic or not biodegradable (e.g. pesticides, herbicides, radioactive substances) may biomagnify in an organism; DDT, a pesticide, has been found in nearly every organism tested
- Biomagnification is the accumulation of the substance in the tissues of an organism over its lifetime (often lipid soluble, these substances sometimes accumulate in the brain)
- As these organisms are consumed as part of the food chain, the toxic substances bioaccumulate; each level of the food chain has more of the substance; DDT bioaccumulated in birds of prey and prevented egg shell formation resulting in large loss of populations-endangered species

45 Increased levels of gases due to anthropogenic activities

- Increases in some gases, such as carbon dioxide from burning of biomass and fossil fuels, contribute to changes in atmospheric chemistry
- These increase the “Greenhouse effect” which leads to an increase in global temperature
- Increases in global temperature alter the pattern of precipitation and winds which changes biomes and food availability

46 Ethology

- Behavior is not just psychological and usually isn’t!
- Behavior is affected by biochemistry, genetics, physiology, evolutionary theory, and ecology
- Behavior is any observable movement or action of an animal in response to a stimulus
- Ethology is the study of animal behavior in their natural environment and includes feeding, courtship, mating and communication

47 Causes of Behavior

- Proximate causes of behavior occur within ecological time and explain behavior in terms of present

cues and responses

- Ultimate causes of behavior relate to the evolutionary basis of a behavior, such as the evolutionary roles of males or females

48 Instinct or Learned?

- Much of behavior is determined genetically-instincts, some is behavior is predisposed
- Even human personality is about 60% inherited factors which affect expression of behavior
- Some behaviors are learned and result from complex interaction between physiology and external cues-you are interpreting these symbols; that interpretation is a complex interaction between the symbols and perception and then what response will occur due to those perceptions

49 Fixed Action Patterns

- A stimulus leads to a behavior which is initiated and carried through completion
- Attack behavior in red stickleback fish is the red belly of the intruder and may extend to any red object that enters its territory
- Behavior is stereotypic

50 Internal stimuli

- Innate releasing mechanisms are networks of neurons or cells which produce chemical stimuli
- Feeding or reproductive behaviors are not continuous, they are stimulated- "drives"

51 learning

- Learning is the modification of behavior as a result of experience
- Habituation refers to the loss of sensitivity to unimportant or repeated stimuli
- Imprinting is the learning that is associated with innate behaviors; species recognition and reproductive behavior are tied to this
- Chicks or ducks following the first moving object, usually their mother is an example of imprinting
- Salmon or turtles returning to the exact location of their birth is an example of imprinting
- Imprinting has a critical period in which these associations are made and then remain for life of the organism

52 Trial and error learning

- Associative learning refers to the ability to associate one stimulus with another
- Good or bad tastes with food is probably a form of trial and error learning (operant conditioning)
- Animals may be able to learn by observing other animals (foraging in garbage cans)

53 Insight learning or reasoning

- Ability to perform a behavior correctly in a novel situation
- The capacity to learn confers a survival and reproductive advantage and can be acted on by natural selection

54 Behavioral rhythms

- feeding, sleeping, reproducing, and migrating are all repeated behavioral patterns that have a temporal rhythm
- Most animals and plants have a circadian rhythm of 24 hours
- Some rhythms are based on exogenous or external cues such as length of time of sunlight and some rhythms are based on endogenous cues- feeding and glucose levels in the blood

55 Orientation and navigation

- Animals use cues to orient themselves and navigate through their environments
- A taxis is a automatic movement directed toward or away from a stimulus
- A kinesis is a change in activity rate in response to a stimulus
- Long distance migration may depend on position of stars or magnetic fields

56 Feeding behaviors

- Generalist concentrate on an abundant food item, developing a search image for the favored item; if that item is scarce, a new image forms
- Specialists have morphological and behavioral adaptations that are specific for their food item and make them more efficient at foraging
- Optimal foraging-natural selection favors animals that make efficient choices that maximize energy intake over expenditure
- Sharks don't chase and kill, they make the most of opportunities, bite and allow their victim to run and die, once the victim is dead or weak, they feed-minimizing energy required to feed

57 Social behaviors

- Involve the interaction between two or more animals, usually of the same species
- Agonistic behavior: contests-males competing for mates
- Dominance hierarchies: determines which animals gain access to resources and prevent continual combat wasting energy
- Territoriality: area defended from other members of same species established for feeding , mating, and rearing young
- Courtship: most animals programmed to view other animals, even of their own species, as competitors; courtship behaviors allows this aversion to be overcome

58 Communication

- Main methods of communication include visual cues, vocalization, and scents (pheromones)

59 Altruistic behavior

- Difficult to explain as animals regard all others as competitiors
- Usually ensures the success of directly related kin