Lecture 1: Introduction to Ecology/ Processes and Patterns in the Physical Environment

Outline:

A. Definition of ecology - relationships between organisms and their environments

B. Environmental factors

1. Physical - temperature, water, abiotic nutrients, atmosphere
2. Biological - competitors (intrspp. and interspp) predators, food (prey), parasites, mutualists, mates

C. Definition of population

1. Proximity
2. Potential for intermating
3. Shared gene pool
4. Difficulties

    a. Defining edges - Open vs closed populations, BIDE model.
    b. Study populations
    c. Asexual reproduction

D. Data from individuals to answer questions about populations

E. Physical Environment

1. Climate - broad patterns
    a. Hadley Cells
    b. Coriolis Force
2. Seasonality.
    a. Earth-Sun distance
    b. Annual orbit and axis tilt
3. Microclimate
    a. topography
    b. geography
4. Climate and vegetation communities

Lecture 1: Introduction to Ecology/ Processes and Patterns in the Physical Environment

Ecology 1. Andrewartha & Birch in 1950's defined ecology as "study of distribution and abundance of organisms"

- focused, *goal-oriented* definition of what ecology tries to explain: what determines how many of an animal will be found, and where will they be found.

2. Pianka in 1994 defined ecology as "study of the inter-relationships between organisms and their environments"

- broad, *process-oriented* definition. The relationships between individuals and their environment will determine the distribution and abundance of species, but there is an explicit goal of understanding *how and why* the observed distribution of a species is determined

Environment - In Pianka's definition of ecology, the *environment* includes

physical factors (temperature, water, light, nutrients)

biological factors (competitors, predators, prey, parasites, mutualists, mates)

Physical and biological factors affect

- *survival* and *reproduction* of *individuals*, and therefore affect
- the *distribution* of and *abundance* of *species*

Raises an important point about 'population biology', which is the core of this course. Data is collected and analyzed at the level of ***individuals***, even though the questions are at the level of ***populations***.

Population - a group of individuals of the *same species* (cf. guild, community, ecosystem), *living sufficiently close* together than *intermating is possible*, and therefore *sharing a common gene pool*.

Difficulties w/definition:

-in practice, can be hard to identify a population; often a study area is defined and this defines a 'study population'. Care is needed when a population is defined in this way, b/c immigration and emigration can affect estimates of survival and reproduction. (Open vs. closed populations, BIDE model). Especially a problem for animals that live at low density, large ranges.

- population size and geographic extent vary through time
- definition does not apply directly to asexual organisms - for these, the focus is on proximity

Reasons for focusing data collection on individuals, to address questions about populations:

1. Population-level variables depend on the demography and behavior of individuals that compose the population:

a. Population growth (increasing, decreasing, or stable in numbers) depends on reproductive rate and annual survival of individuals in population.
b. Geographic range depends on movements of individuals (both one-way dispersal, and two-way migration)
c. Patterns of dispersion w/i population depend on behavior of individuals (e.g. discussed later is territoriality --> overdispersion or 'regular distribution', while sociality --> underdispersion or clumping

2. Natural selection acts primarily at the level of individuals to shape physiology and behavior. Population parameters like 'the birth rate of 6 year olds' or 'the probability of surviving from birth to reproduction' are not directly under selection. It is the physiology and behavior of individuals (which *are* under selection) that set the values of population parameters. This will be discussed at length in lectures 5 & 6.

Patterns in the Physical Environment

Most of this course will focus on relations of animals with their biological environment (from lecture 8 onwards), b/c that side of ecology is theoretically more complex. First few lectures will focus on interactions with the physical environment.

Large Scale Physical Patterns

Climate **-** patterns of sun, wind & water

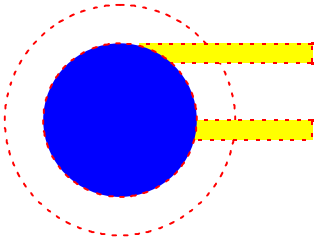
Varies spatially (tropical - temperate- polar regions) and temporally (hot - cold or wet - dry seasons)

Main effects on animals are by determining *temperature* and *availability of water*.

Temperature - low at poles and high at equator, because:

1. Angle of incidence --> area over which energy of light beam is dissipated.

2. angle of incidence --> depth of atmosphere penetrated (deeper at acute angles) --> amount of light energy that is reflected by airborne particles w/o reaching surface



Beam A = deep atmosphere; acute angle, large area, little energy/sq. km

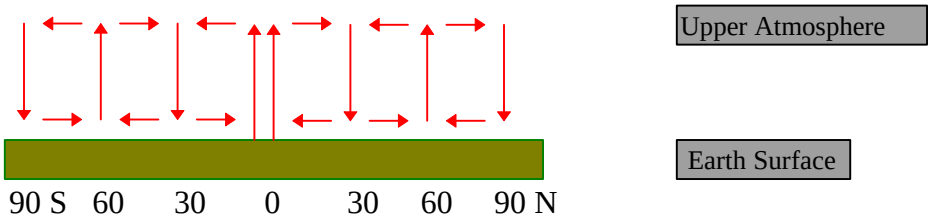
Beam B = perpendicular, small area, more energy/sq. km

Hot at equator --> rising air.

1. Cools as it rises (***adiabatic cooling*** = no loss of total heat, but b/c P ~ T, as P decreases, T decreases).
   Lower capacity to hold water.
   Rain heavy at equator.

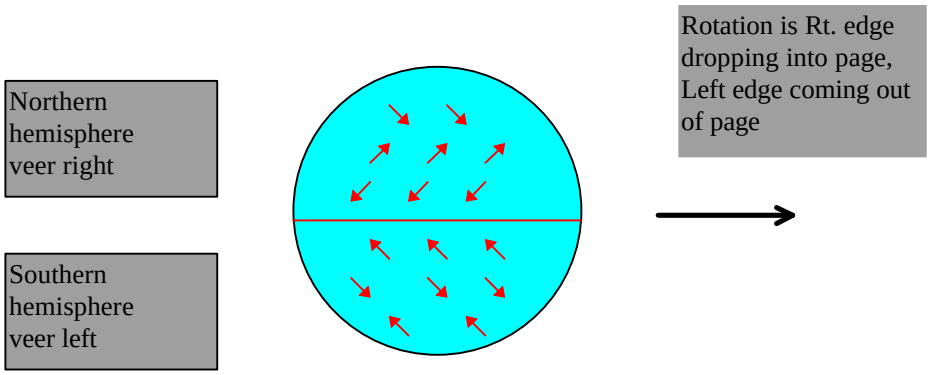
2. Causes circulation pattern of ***Hadley cells***. Closed system, so rising air spreads in upper atmosphere, cools and eventually drops back to surface at ca. 30° N & 30°S. Water-depleted, and gaining capacity to hold water as it drops (***adiabatic heating***) and warms, therefore *desiccating* air. --> Dry at this latitude (many deserts).

(Overhead)



3. Conservation of momentum - ***Coriolis force.*** Superimposes major easterly and westerly patterns in winds blowing N & S within Hadley Cells.

(Overhead & draw arrows by hand)



4. Patterns of air movement described (rising/sinking, N/S, E/W) combine with patterns in ***oceanic currents*** to explain major global climate patterns. Oceanic currents driven by wind & Coriolis force.

Seasonality. Due to position of earth relative to sun

Earth-Sun Distance varies on very long time scales (22,000 yrs) producing glacial and pluvial periods.

Orbit (annual), together with 23.5^{o} tilt in axis of daily rotation, produces seasons due to effect on hours of daylight. Also causes N-S shift in Hadley cells as *thermal equator* moves from 23.5 S (T of Capricorn) to 23.5 N (T of Cancer). E.g. One v. two rainy seasons depending on latitude within the tropics.

Microclimate. Local patterns superimposed on global pattern by *topography* and *geography*.

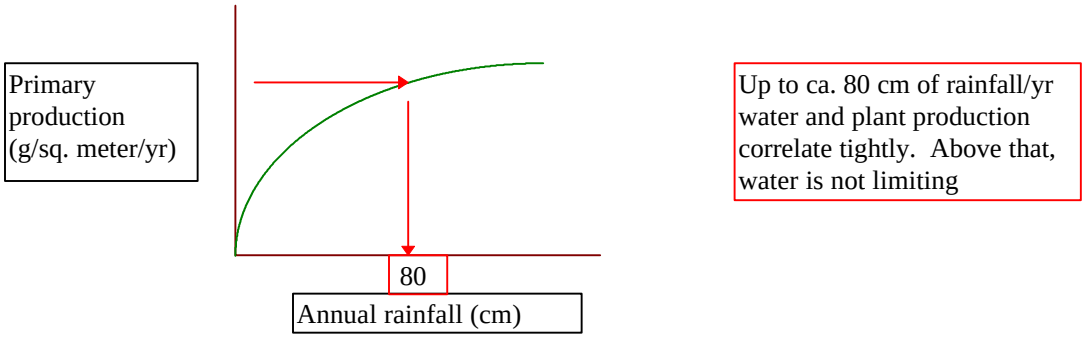
Topographic - rainshadow of mountains affects water availability. Altitude also affects temperature

Geographic - proximity to water bodies, which modulate temperature due to high heat capacity of water relative to air. Also affects precipitation e.g lake effect snow, summer storms in continent centers, winter rain on coasts w/onshore wind

Climate and Vegetation Together with topography and soils, climate determines vegetation type. (Pianka Fig.4.1)

Water and solar energy limit plant *primary production* = energy con verted from solar radiation to chemical energy via photosynthesis.

Photosynthesis requires CO_2, H_20 and solar energy. CO_2 in atmosphere is rarely limiting, so H20 and sunlight are normal limits for plant growth. (Nutrients also can be limiting.)



Evapotranspiration = H_20 from evaporation + H_20 from plant transpiration + H_20 from animal respiration. Gives *combined* measure of water and solar energy available. Correlates very well with primary production.

Under canopy or in aquatic ecosystems, light is often the limiting factor for plan productivity.

In turn, vegetation influences climate: vegetation dampens fluctuations in wind, humidity and temperature.

Consequence of these relationships is that one can (roughly) classify plant communities on a plot of precipitation vs. rainfall.

(Fig. 4.16 p.76 Pianka & Figs. from Krebs text)

Climate & plant community determine distribution of animals

(Figs from Krebs)