Lecture: Deserts

Desert characterized by:

- Low, unevenly distributed precipitation, less than 10 inches (25 cm) per year
- Temperature extremes
- Windy (increased evaporation rates)
- High light intensity (90% light reaches ground, vs. 40% in humid area)
- Nutrient-poor, salty, alkaline soil
- Low rates of primary production

Deserts of California

- All found on leeward side of mountain ranges
- From north to south:
  - **Great Basin**, east of the Cascades and the Sierra Nevada
  - **Mojave**, to the interior of the Transverse Ranges
  - **Colorado Desert**, lying east of the Peninsular Ranges.

Great Basin Desert

- Climate:
  - cooler than more southerrn deserts
  - most precipitation received as snow in winter
- Vegetation
  - most common plant is the Great Basin Sagebrush (found on well-drained sandy soil)
  - Upper fringe dominated by juniper or pinyon pine
  - Most growth delayed until spring, as opposed to southern deserts where in winter

Mojave Desert "high desert"

- Climate: hot desert with precipitation mostly in winter, but with an occasional summer thunderstorms
- Dominant vegetation:
  - Joshua Tree
  - Creosote Bush

Joshua Tree

- Found where:
  - winter snowfall
  - soil is coarse & non-alkaline

Creosote Bush

- Found:
  - below Joshua Tree zone
  - sandy soil, doesn't occur in the clay soils of dry lakes
- dark green resinous shrub with wand-like stems growing on flat desert slopes

Colorado Desert "low desert"

- California portion of the large Sonoran Desert
- Climate:
  - Majority of precipitation comes as summer thunderstorms (~7 inches)
  - More summer precipitation than other deserts, so washes are common
- California's "Low Desert" is the Colorado Desert.
- Dominant vegetation:
  - many small cacti
  - leaf-succulent plants (Agave)
  - drought-deciduous plants (Ocotillo)
  - legumes

Plant & Animal Adaptations to Deserts

Environmental Stress

- Long periods of drought
- Unpredictable precipitation
- High soil & leaf temperature
- Saline soils

- **Plants cope with these stresses**:
  - Physiologically
  - Anatomically
  - Life history strategies

Drought Tolerators

- **Xerophytes**
  - Evergreen shrubs
  - High root-to-shoot ratio:
    - take up lots of water
    - transpire less
    - low maximum growth rates

- xerophyte example: Creosote
  - Extensive rooting system
  - Sheds some leaves in extreme drought
  - Flowers opportunistically

- **Succulents**
  - Low surface-to-volume ratio
    - shallow roots to absorb water whenever possible
    - Water efficient
    - Spongy parenchyma to store water
  - Slow growing
  - Photosynthetic stems & CAM physiology
  - Adaptations to minimize herbivory
    - Spines
    - Camouflage (e.g. stone plants)
  - Examples: Cacti,"century" plants, euphorbias

Drought Avoiders

- **Drought deciduous**
  - Leaves not drought tolerant but inexpensive to produce
  - High maximum photosynthetic rates
  - Limited photosynthetic period
  - May have carbohydrate storage for rapid manufacture of new leaves when conditions become favorable

- **Phreatophytes**
  - Deep root systems tap into capillary fringe above water table
  - Seeds of many of these (legumes) require scarification (abrasion by sand and gravel in stream) for germination
  - Regeneration niche is critical

- **Ephemerals** ("annuals")
  - Grow only when water available
  - Life span: weeks to months
  - Rapid photosynthetic & growth rates
  - Cooled via transpiration (can't tolerate drought)
  - May not possess xerophytic features

Desert Plants Avoid Overheating by:

- decreasing heating by conduction
  - foliage far enough above ground
- increasing rates of convective cooling
  - very small leaves
  - open growth form
- reducing rates of radiative heating
  - reflective surfaces with dense coating of white hairs
  - orienting leaves parallel sun's rays
  - folding leaves at midday

Water Acquisition by Plants:

- root development often reflects water availability
- In dry climates, roots:
  - More grown
  - grow deeper (30 m)
  - greater proportion of plant biomass (90%)

Water Conservation by Plants:

- Waterproofing (thick, waxy cuticle)
- thick leaves (so less transpiring leaf surface area per unit volume of photosynthesizing tissue than thin leaves)
- less leaf surface area per area (length) of root; reduce leaf area by:
  - drop leaves in response to drought ("drought deciduous")
  - produce leaves only in response to soaking rains.
- Stomatal adaptations
  - few
  - sunken
- water-conserving photosynthetic pathways

DESERT ANIMALS

- Adaptations to stress of:
  - temperature extremes
  - sparse and unpredictable food supply
  - drought

Ectothermy Adaptive in Desert

- Body heat
  - Ectothermic animals gain most of their body heat from environment (low metabolic rate)
  - endothermic animals that gain most of their heat from metabolism (high metabolic rate)
- Ectothermic animals, with their low metabolic rates, have an advantage
  - heat in desert in large supply, but food scarce
  - Ectotherms don't waste valuable calories keeping their bodies warm

Sparse Food

- Desert is a food-poor ecosystem—total biomass of animals in desert is small
- Photosynthesis ➔ 890 pounds per acre per year (100 g/m2/yr) of edible biomass
- Acre of desert will support:
  - 89 pounds (36 kg) of herbivores
  - <9 pounds (3.6 kg) of carnivores

Adaptation to Food-poor Ecosystem

- In wet years, productivity may double
- Short-lived animals can respond to this abundance
- Long-lived animals respond by delaying reproduction until high productivity
- Common desert animals:
  - arthropods (insects, spiders, and scorpions)
  - reptiles

Water conservation:

- water storage, heat avoidance, dormancy, drought-tolerance, body orientation, waterproof integument
- behavior

Desert Tortoise

- Dormant often from summer-winter
- emerges from its burrow in spring to feed on moisture-rich leaves & flowers (especially on ephemerals); stores these as water & fat reserves
- Stores a quart of water in its body (mostly in the bladder)
- competes with cattle, sheep & donkeys for food
  - Lead to malnutirition & decreased reproductive rate
  - state threatened species (decreased 50% from 1980-1989)

Desert Lizards

- Niche partitioning based on food preference, size, & habitat
- Insectivorous sand dwellers
  - fringe-toed lizards (sand dunes)
  - Zebra-tailed Lizard (washes)
  - horned lizards (other sandy areas where ants present)
- Insectivorous tree dwellers
  - Desert Spiny Lizard (Joshua trees)
  - Long-tailed Brush Lizard
  - Desert Night Lizard (feeds on termites under fallen yuccas)
- Insectivorous rock dwellers
  - Banded Rock Lizard, Leaf-toed Geckos,
- Herbivorous--Desert iguana, chuckwalla

Rattlesnakes

- Venomous ("pit vipers")
- Excellent at locate prey
  - temperature-sensitive pit next to each nostril that gives them "stereo" heat perception to locate warm-blooded prey
- Protection
  - Use rattle as threat
  - Uses venom only as a last resort
  - Most bites occur by accident

Roadrunners

- predators of insects, lizards, snakes, mice, snakes; also eat berries
- prefer running (up to 15 mph) to flying
- Bask in the sun
  - Absorbs heat from the sun in morning (black skin enhances this)
  - Enables them to lower body temperature at night and use sun to warm up, instead of metabolic energy (energy conservation device—up to 551 calories/hour)
- Balance population against food supply
  - number of eggs in a nest is correlated to available food supply
  - adults eat weak or lethargic nestling

Jack Rabbits

- use radiative cooling
  - Dissipate heat through surfaces of long limbs & ears
  - Typically, they remain in shade on north side of a bush facing the clear northern sky
- use convective heat loss too, by wiggling their ears

Kangaroo Rats

- Feed primarily on seeds that have gathered at night (store in their burrows)
- Water conservation
  - concentrated urine, reduces urinary water loss
  - Plug burrow during the day & sleep; humidity in sleeping chamber rises; water vapor reclaimed
    - absorbed through the rat's nasal membranes
    - absorbed by seeds, which later get eaten
- go entire lives without drinking liquid water
  - good at water conservation
  - get enough water from their metabolism & food

Tarantula hawk

- adult tarantula hawk feeds on flower nectar
- Also attack tarantulas or trap-door spiders
  - At night, searches for spider burrows
  - When it finds one, it disturbs the web to incite a fight
  - the spider rears back into its attack position, then the wasp stings it on a vulnerable spot on its underside, paralyzing it
  - Then the wasp drags the spider down into its burrow, lays an egg on it, which hatches into a white larva in a few days
  - for ~30 days, the larva eats the paralyzed spider, then pupates with an adult wasp emerging the next year