Distribution Limits

- Physical environment limits geographic distribution of a species.
  - Organisms can only compensate so much for environmental variation

Kangaroo Distributions and Climate

- Caughley found a close relationship between climate and distribution of the three largest kangaroos in Australia
  - *Macropus giganteus* - Eastern Grey
    - Eastern 1/3 of continent
  - *Macropus fuliginosus* - Western Grey
    - Southern and western regions
  - *Macropus rufus* - Red
    - Arid / semiarid interior
Kangaroo Distributions and Climate
• Limited distributions may not be directly determined by climate
  – Climate often influences species distributions via:
    • Food production
    • Water supply
    • Habitat
    • Incidence of parasites, pathogens and competitors

Distributions of Plants along a Moisture-Temperature Gradient
• *Encelia* species distributions correspond to variations in temperature and precipitation

Distributions of Plants along a Moisture-Temperature Gradient
• *Encelia* species distributions correspond to variations in temperature and precipitation
Distribution of Individuals on Small Scales

- Random:
  - Uniform distribution of resources
- Regular:
  - Exclusive use of areas
  - Individuals avoid one another
- Clumped:
  - Mutual attraction between individuals
  - Patchy resource distribution

Distributions of Individuals on Large Scales

- Bird Populations Across North America
  - Root found at continental scale, bird populations showed clumped distributions in Christmas Bird Counts
  - Clumped patterns occur in species with widespread distributions
  - Brown found a relatively small proportion of study sites yielded most of records for each bird species in Breeding Bird Survey

27 November 2001 by NASA satellites

Notice the clumped distribution
What is the dispersion pattern?

- 5 sample plots = n
- What is the mean # tiger beetles?
- What is the variance \( \sigma^2 \) in # of tiger beetles?
- What is the null hypothesis?

<table>
<thead>
<tr>
<th>Plot #</th>
<th># of tiger beetles</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
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<tr>
<td>2</td>
<td>5</td>
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<td>3</td>
<td>3</td>
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<tr>
<td>4</td>
<td>1</td>
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<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Calculation:
- \( \text{Mean} = \frac{2 + 5 + 3 + 1 + 3}{5} = 2.8 \)
- \( \text{Var} = \frac{\text{sum of the squared differences}}{n-1} \)
  - Sum of squares = 8.8
  - Var = 8.8/4 = 2.2
- Ratio = 2.8/2.2 = 1.27
- \( \chi^2_{\text{critical}} = \frac{(4*2.2)/2.8}{2.2} = 3.14 \)

Chi Square Table

<table>
<thead>
<tr>
<th>Plot #</th>
<th># of tiger beetles</th>
<th>SS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>((2-2.8)^2 = 0.64)</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>((5-2.8)^2 = 4.84)</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>((3-2.8)^2 = 0.04)</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>((1-2.8)^2 = 3.24)</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>((3-2.8)^2 = 0.04)</td>
</tr>
</tbody>
</table>
Terrestrial Biomes

- Biomes - distinguished primarily by their predominant plants and associated with particular climates.
  - Geographic and seasonal variations in temperature and precipitation are fundamental components.

Temperature, Atmospheric Circulation, and Precipitation

- Spherical shape and tilt of earth’s axis cause uneven heating of earth’s surface.
  - Drives air circulation patterns & consequently precipitation patterns.
    - Warm, moist air rises
    - Cools, condenses, and falls as rain
    - Cooler, dry air falls back to surface

Solar-Driven Air Circulation

- Moisture in ascending air cools, forming clouds.
- Some ascending air flows to the north.
- Dry air flowing over land absorbs moisture.
Temperature, Atmospheric Circulation, & Precipitation

- **Coriolis effect** causes apparent deflection of winds clockwise in the N hemisphere and counterclockwise in the S hemisphere.

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Climate Diagrams

- Summarize climatic information using a standardized structure.
  - Temperature plotted on left y-axis.
  - Precipitation plotted on right y-axis.
  - 10° C equivalent to 20 mm precipitation.
  - Relative position of lines reflect water availability.
  - Adequate moisture for plant growth when precipitation above temperature.

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Soil : Foundation of Terrestrial Biomes

- Soil is a complex mixture of living and non-living material.
  - Classification based on vertical layering (soil horizons)
    - Soil Profile = snapshot of soil structure in a constant state of flux
Soil Horizons

- O horizon: Organic Layer freshly fallen organic material - most superficial layer
- A horizon: Mixture of minerals, clay, silt and sand
- B horizon: Clay, humus, and other materials leached from A horizon - often contains plant roots
- C horizon: Weathered parent material

Tropical Rainforests

- Most occur within 10° latitude of equator.
- Little temperature variation between months
- Annual rainfall of 2,000 - 4,000 mm relatively evenly distributed
  - Quickly leaches soil nutrients.
  - Mycorrhizae help gather nutrients.
- Organisms add vertical dimension
- Harbor staple foods and medicines for world’s human populations - increasingly exploited
Tropical Dry Forest

- Usually located between $10^\circ - 25^\circ$ latitude
- Climate more seasonal than tropical rainforest
- Soils generally richer in nutrients, but vulnerable to erosion
- Shares many animal and plant species with tropical rainforests
- Heavily settled by humans with extensive clearing for agriculture

Tropical Savanna

- Most occur north and south of tropical dry forests within $10^\circ - 20^\circ$ of the equator
- Climate alternates wet / dry seasons
  - Fire dependent
- Soils have low water permeability
  - Saturated soils keeps trees out
- Landscape is more 2-dimensional with increasing pressure to produce livestock
Tropical Savanna

- Major bands at 30° N and 30° S latitude
- ~ 20% of earth’s land surface
- Water loss usually exceeds precipitation
- Soil usually extremely low in organic matter
- Plant cover ranges from sparse to absent
- Animal abundance low, but biodiversity may be high
  - Strong behavioral adaptations
- Human intrusion increasing

Desert

- Major bands at 30° N and 30° S latitude
- ~ 20% of earth’s land surface
- Water loss usually exceeds precipitation
- Soil usually extremely low in organic matter
- Plant cover ranges from sparse to absent
- Animal abundance low, but biodiversity may be high
  - Strong behavioral adaptations
- Human intrusion increasing
Mediterranean Woodland & Shrubland (Chaparral)
- All continents except Antarctica
- Climate cool & moist in fall, winter, and spring; hot & dry in summer
- Fragile soils with moderate fertility
- Trees and shrubs typically evergreen
- Fire-resistant plants due to fire regime
- Long history of human intrusion
  - Cleared for agriculture

Temperate Grassland
- Widespread distribution
- Annual rainfall 300 - 1,000 mm
- Periodic droughts
- Soils tend extremely nutrient rich and deep
- Dominated by herbaceous vegetation
- Large roaming ungulates
  - Bison vs. cattle
Temperate Grassland

Temperate Forest

• Majority lie between 40° and 50° latitude
• Rainfall averages 650 - 3,000 mm
• Fertile soils
  – Long growing seasons dominated by deciduous plants
  – Short growing seasons dominated by conifers
• Biomass production can be very high
• Many major human population centers
Boreal Forest (Taiga)

• Confined to Northern Hemisphere
  – ~ 11% of earth’s land area
• Thin, acidic soils low in fertility
• Generally dominated by evergreen conifers
• Relatively high animal density
• Historically, low levels of human intrusion

Tundra

• Covers most of lands north of Arctic Circle
  – Climate typically cool & dry; short summers
  • 200 - 600 mm precipitation
• Low decomposition rates
• Supports substantial numbers of native mammals
• Human intrusion historically low, but increasing as resources become scarce
  – What type of increased use?
Mountains

- Built by geological processes and thus concentrated in belts of geological activity
- Climate changes with elevation and latitude
- Soils are generally well-drained and thin
- Flora and fauna change with elevation
- Historically used as a source of raw materials for human settlements
The Hydrologic Cycle

- Over 71% of the earth’s surface is covered by water:
  - Oceans contain 97%
  - Polar ice caps and glaciers contain 2%
  - Freshwater in lakes, streams, and ground water make up less than 1%

Replacement period – time to complete cycle (9 days to 30,000+ years)

The Hydrologic Cycle

- Turnover time is the time required for the entire volume of a reservoir to be renewed.
  - Atmosphere 9 days
  - Rivers 12-20 days
  - Oceans 3,100 years
Oceanic Circulation

Ocean - Structure

- Littoral Zone (intertidal zone): Shallow shoreline – rise/fall of tides
- Neritic Zone: Coast to margin of continental shelf

Intertidal Zonation
Ocean - Structure

• Oceanic Zone: Beyond continental shelf
  – Epipelagic 0 - 200 m
  – Mesopelagic 200 - 1,000 m
  – Bathypelagic 1,000 - 4,000 m
  – Abyssal 4,000 - 6,000 m
  – Hadal 6,000 + m

• Benthic: Habitat on bottom of ocean
• Pelagic: Habitat off the bottom of the ocean

Ocean Zones

Ocean Biology

• Photosynthetic organisms are limited to upper epipelagic zone (euphotic zone).
  – Phytoplankton and zooplankton
  – Due to size, oceans contribute ¼ of total photosynthesis in the biosphere.
• Chemosynthesis occurs near undersea hot springs.