LOSS OF BIODIVERSITY
This note set aligns with this concept.
What Is Biodiversity?

• Biodiversity is a measure of the biological diversity in an area.
• Scientists measure biodiversity at 3 levels:
  – Genetic Biodiversity – measuring the diversity of genes and alleles in the population of an organism
  – Species Biodiversity – counting how many different species are in an area
  – Ecosystem Biodiversity – measuring the diversity of ecosystems in a region
Why is Biodiversity Important?

- More biodiversity = more stability in ecosystems
- More biodiversity = more ecosystem services and natural resources
- More biological diversity = more resilience to disturbance and catastrophe
  - Example – Disease
    - Low genetic diversity = uniform and catastrophic response to emerging disease outbreak
    - Example: Tasmanian Devils low genetic diversity in response to outbreak of facial cancers
How To Measure Biodiversity?

• 1) Genetic Biodiversity – analyze the amount and types of DNA and alleles in populations

• 2) Species Biodiversity – 2 measurement methods exist:
  • Count Species Richness – simply count the number of different types of species seen in an area
  • Count Species Evenness – count the number of species seen AND the numbers of individuals for each species, to see if one species is dominant or if diversity is “evened” out between species

• 3) Ecosystem Biodiversity – quantify number of ecosystems over large region or Earth
Measuring Species Biodiversity

1) **Species Richness** – Just count the number of different species seen in an area

2) **Species Evenness** – the most common way to measure evenness is using the Shannon-Weiner Index (a mathematical formula)
   
   – The higher the absolute value of the Shannon Index = the higher the biodiversity

\[
H' = \sum_{i=1}^{s} (p_i)(\ln p_i)
\]
Species Richness vs Species Evenness

Community 1 and Community 2 have the **same species richness**, but they have **different species evenness**.
## Shannon-Wiener Index

**Plot A**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Number</th>
<th>( p_i )</th>
<th>( \ln(p_i) )</th>
<th>( p_i(\ln(p_i)) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coyote</td>
<td>2</td>
<td>2/25 = 0.08</td>
<td>( \ln 0.08 = -2.53 )</td>
<td>-0.202</td>
</tr>
<tr>
<td>Red Fox</td>
<td>11</td>
<td>11/25 = 0.44</td>
<td>( \ln 0.44 = -0.82 )</td>
<td>-0.361</td>
</tr>
<tr>
<td>Gray Fox</td>
<td>5</td>
<td>5/25 = 0.20</td>
<td>( \ln 0.20 = -1.61 )</td>
<td>-0.322</td>
</tr>
<tr>
<td>Wolf</td>
<td>6</td>
<td>6/25 = 0.24</td>
<td>( \ln 0.24 = -1.43 )</td>
<td>-0.343</td>
</tr>
<tr>
<td>Kit Fox</td>
<td>1</td>
<td>1/25 = 0.04</td>
<td>( \ln 0.04 = -3.22 )</td>
<td>-0.129</td>
</tr>
</tbody>
</table>

\[ N = 25 \quad \text{TOTAL} = -1.357 \]

**Plot B**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>Number</th>
<th>( p_i )</th>
<th>( \ln(p_i) )</th>
<th>( p_i(\ln(p_i)) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coyote</td>
<td>12</td>
<td>12/20 = 0.60</td>
<td>( \ln 0.60 = -0.51 )</td>
<td>-0.306</td>
</tr>
<tr>
<td>Red Fox</td>
<td>7</td>
<td>7/20 = 0.35</td>
<td>( \ln 0.35 = -1.05 )</td>
<td>-0.368</td>
</tr>
<tr>
<td>Gray Fox</td>
<td>1</td>
<td>1/20 = 0.05</td>
<td>( \ln 0.05 = -2.99 )</td>
<td>-0.150</td>
</tr>
</tbody>
</table>

\[ N = 20 \quad \text{TOTAL} = -0.824 \]

Plot A is more biodiverse. 1.357 is greater than 0.824
Biodiversity Loss

- Experts agree that Earth is in its 6th mass extinction
  - Background rates of extinction is 1-5 species/yr
  - Current rate is 1,000 times this

- Organismal taxa at threat
  - Amphibians – group that has the high levels of endangerment – very sensitive to environmental changes
  - Primates – most primates show major population declines
  - Corals – losses from coral bleaching

- All organismal taxa are showing large-scale biodiversity declines
Species At Risk Labels

• For species at risk of population declines, there are classifications given:

  • Extinct – no living member of the species exists any more on Earth
  • Extirpated – species is extinct to a local area (will still occur somewhere in larger range)
  • Endangered Species – in danger of becoming extinct
  • Threatened Species—in danger of becoming endangered
Common Traits of Endangered/Threatened Species

- K-selected – low reproductive rate
- Large
- Top Carnivore
- Large Home Range/Habitat Requirements
- Specialist – narrow niche
- Low genetic diversity or genetically isolated or bottlenecked (ex: cheetahs)
- In competition with hardier species (humans!)
- Sensitivity to pollution
Reasons for Species Endangerment

• The primary reason for loss of species is habitat loss
  • Conversion/destruction of habitats for other land purposes.
• Another negative effect of habitat loss is habitat fragmentation
  • Fragmentation is when remaining habitat areas are in smaller pieces than before.
  • Habitat fragments act as “islands” in a “sea” of other land, with species often unable to move between them.
  • Fragmented habitats experience the “edge effect”, in which there is a loss in “interior” habitat and an increase in “edge” habitat.
  • This causes more edge to occur in the habitat than if it was larger and undisturbed.
Reasons for Species Endangerment

• Edge Effect makes edge habitats, leading to:
  • More predation – many aggressive predators typically use edge to hunt
  • More parasitism and nest parasitism (laying eggs in nests of other species)
    • Nest Parasite: Brown-headed Cowbird
  • More chance of invasive species
• Species impacted by fragmentation often have large homeranges, prefer interior habitats, like low to no disturbances, and may be prone to predation or parasitism.
• Example: North American Songbird Decline
  • A majority of migratory birds in US have shown at least 40% population declines in the last 70 years due to habitat loss and fragmentation.
Reasons for Species Endangerment

• Poaching – illegally killing and taking organisms. Examples:
  – Rhinos for horns
  – Gorillas for bushmeat
  – Sharks for fins in sharkfish soup
  – Herons/cranes for feathers for fashion of 1900s
  – Bears for gall bladders (thought to be medicinal in Asian cultures)
  – Tigers for skin and organs (used in Asian medicine)
  – Monkeys/Lemurs for bushmeat
  – Antelopes for trophy hunting
  – Bluefin tuna for meat
Reasons for Species Endangerment

• Climate Change
  – Cold adapted species at risk as their habitats change
  – Droughts harm aquatic species
  – Sea level rise destroys coastal habitat
  – Increase in disease/pest transmission – warmer weather enhances survival and transmission of disease vectors
    – White Nose Syndrome – fungus killing many bat populations by disturbing bats in hibernation, leading to loss of energy reserves and death before the end of hibernation
Reasons for Species Endangerment

Pollution
- Pesticide, fertilizer, fossil fuel pollution can impact species directly or create other environmental problems

Pet Trade
- Taken straight out of wild for pets – a problem with exotic, fish, reptiles, amphibians
- Pet trade spreads disease
  - Chytrid Fungus – widespread and deadly fungus that attacks skin of amphibians causing hardening and flaking of skin; causes death in most amphibian species
Reasons for Species Endangerment

- Invasive Species
  - Exotic species - not native to area
  - Invasive species – species that have negative environmental and/or economic consequences
    - Invasive species usually:
      - Very high reproductive rate
      - Are generalist
      - Aggressive
      - Disperse quickly and widely over areas
  - Impacts of Invasives:
    - Outcompete native species, overuse environmental resources, predate native species, disrupt food web
Actions To Stop Species Loss

- Conserve habitats
- Connect habitat fragments with corridors
- Creation & enforcement of anti-poaching laws
- Ban trade in wildlife products or live wildlife
- Prevent spread of invasive species
- Prevent pollution of habitats
- Prevent climate change pollution
- Expand wildlife refuge areas
- Create captive breeding programs for reintroduction of animals into the wild
Actions To Stop Species Loss

- Law - Endangered Species Act (1973)
  - US Law that created a list of endangered & threatened species, including subspecies
  - Requires protection of species habitat
  - Must develop population recovery plan
  - Benefits of the Act
    - Many species have recovered and been delisted as a result (ex: Bald Eagles)
    - Habitat conservation is a by-product of enforcing this law
    - Not expensive (yearly budget equal about 20 cents per US citizen)
  - Negatives of the Act
    - ~ 1% of species have been delisted.
    - Private lands cannot be developed at will if there is evidence of a listed species on the property.
Actions To Stop Species Loss

• International Action - IUCN Red List
  – A global list of species and their ranking of endangerment, created by the IUCN research group
  – This helps in ranking species in terms of conservation priority and gives understanding to global population trends

• International Treaty - CITES Treaty (Convention on International Trade in Endangered Species)
  – International treaty signed by 170+ nations that agrees nations won’t commercially trade wildlife products from listed species
Famous Endangered Species

• Black-footed Ferret
  – Carnivore
  – Once considered most endangered mammal in the U.S.
  – About 750 in the world
  – Found in prairies – eat prairie dogs
  – Killed frequently when prairie dogs were poisoned by farmers
  – Also threatened by an outbreak of distemper – a disease that ran through the small population
  – Saved by captive breeding of ferrets, habitat protection, elimination of poisoning
Famous Endangered Species

- **Whooping Crane**
  - Tallest North American bird
  - Nests in Canadian taiga (only few places) and winters on Texas Gulf Coast
  - Endangered due to habitat loss and killing for feathers (fashion)
  - Helped by captive rearing of chicks; eggs of crane would be reared by sandhill cranes or by humans using puppets and the planes to train birds for migration.
Famous Endangered Species

• California Condor
  – Largest land bird in N.America
  – Losses in population due to habitat loss, egg stealing, poaching, accidental poisonings (DDT)
  – At one point, only 22 birds left – all were taken into captivity and bred
  – Condors were then released into the environment and tracked. Currently over 300 condors
  – Condors had problems with lead poisoning from digesting bullets and contact with power lines
    • All captive birds trained to avoid humans and power lines
Reasons for Species Endangerment

• Current Issue: Palm Oil Use
  • Palm oil is the most popular vegetable oil used in cooking that is derived from fruits of oil palm trees
  • Most palm oil is grown in Asia (Indonesia and Malaysia)
  • To meet demand for palm oil, native forests cut and burned down native rainforest to plant palm plantations
  • Rainforest loss & fragmentation harms many species, including orangutans, tigers, and elephants.
  • Other problems from palm oil: Burning trees releases CO₂ and PM, animals are poached by workers, soil erosion, soil and water pollution from pesticides and fertilizers