"Here is your country. Cherish these natural wonders, cherish the natural resources, cherish the history and romance as a sacred heritage, for your children and your children's children. Do not let selfish men or greedy interests skin your country of its beauty, its riches or its romance."
— Theodore Roosevelt

"Only when the last tree has died and the last river been poisoned and the last fish been caught will we realize we cannot eat money"
-Cree Indian Proverb

Biogeography and Human Impacts

History of Life on Earth

Prokaryotes ~3.5 bya
- Stromatalites for 1.5 billion years

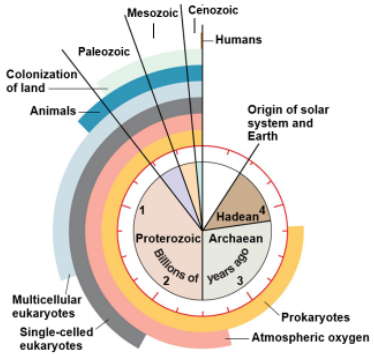
Atmospheric Oxygen ~2.7 bya
- Photosynthetic bacteria5

Multicellular eukaryotes ~2.0 bya
- Endosymbiosis of prokaryotes
- Soft bodied animals

Animals ~550 mya
- Cambrian explosion
- First predators

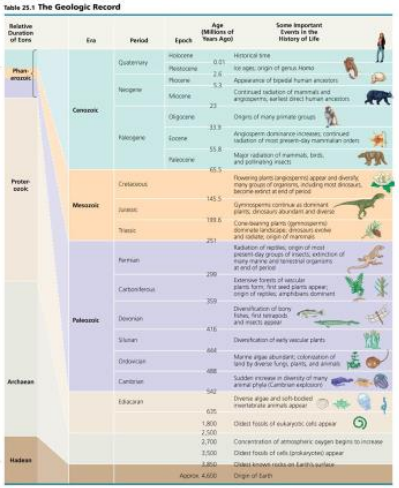
Colonization of land ~500 mya
- Plants with mycorrhizae
- Arthropods ~450 mya

Humans ~6-7 mya



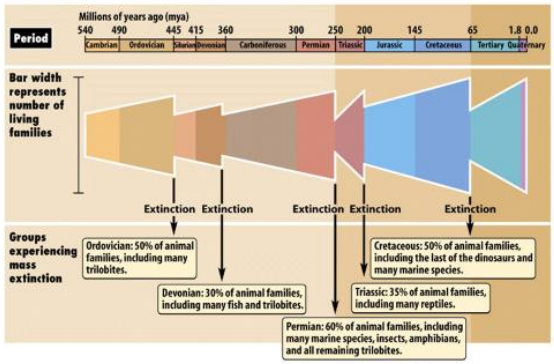
Geologic Timescale

- Geologic record divided into Eons, Eras, Periods, and Epochs
- Divisions between eras correspond to mass extinction events

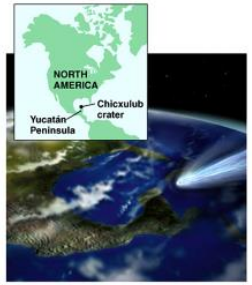


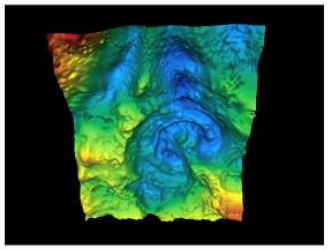
History of Mass Extinction Events

- _____ mass extinction events on earth
  - _____ are currently causing the sixth mass extinction event
- Permian extinction event was the largest with a loss of 96% of all species
- Cretaceous extinction led to the loss of the _____ 65 mya



K-T Boundary (Cretaceous-Tertiary)





Chicxulub Crater - Caribbean Sea near the Yucatan Peninsula of Mexico

Geologic Timescale

Precambrian Era (4.6 bya – 542 mya)
- 90% of all time on Earth
- First prokaryotes and eukaryotes
- Soft bodies animals and algae at end of era

Paleozoic Era (251 mya – 542 mya)
- Most animal phyla during Cambrian Period
  - Cambrian explosion ~500mya
- Vascular plants dominant terrestrial environments
- Fish diversity and first tetrapods in Devonian Period
- Amphibians and reptiles dominate

		251mya	
Paleozoic	Permian	299	Radiation of reptiles; origin of most present-day groups of insects; extinction of many marine and terrestrial organisms at end of period
	Carboniferous	359	Extensive forests of vascular plants form; first seed plants appear; origin of reptiles; amphibians dominant
	Devonian	416	Diversification of bony fishes; first tetrapods and insects appear
	Silurian	444	Diversification of early vascular plants
	Ordovician	488	Marine algae abundant; colonization of land by diverse fungi, plants, and animals
	Cambrian	542	Sudden increase in diversity of many animal phyla (Cambrian explosion)
	Ediacaran	635	Diverse algae and soft-bodied invertebrate animals appear
		1,800	Oldest fossils of eukaryotic cells appear
		2,500	
		2,700	Concentration of atmospheric oxygen begins to increase
		3,500	Oldest fossils of cells (prokaryotes) appear
		3,850	Oldest known rocks on Earth's surface
		Approx. 4,600	Origin of Earth

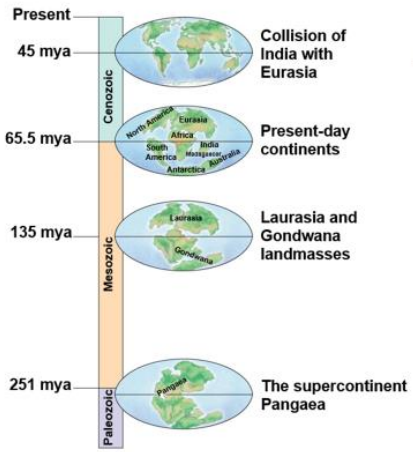
Geologic Timescale

Mesozoic Era (251 mya – 65 mya)
- Gymnosperms dominate
- Dinosaurs dominant
- Angiosperms begin to diversify

Cenozoic Era (65 mya – Present)
- Mammals radiate with loss of dinosaurs
- Angiosperms dominate
- Human ancestors diverge

Cenozoic	Quaternary	Holocene	0.01
		Pleistocene	2.6
	Neogene	Pliocene	5.3
		Miocene	23
	Paleogene	Oligocene	33.9
		Eocene	55.8
		Paleocene	65.5
Mesozoic	Cretaceous		145.5
	Jurassic		199.6
	Triassic		251mya

Historical time	
Ice ages; origin of genus *Homo*	
Appearance of bipedal human ancestors	
Continued radiation of mammals and angiosperms; earliest direct human ancestors	
Origins of many primate groups	
Angiosperm dominance increases; continued radiation of most present-day mammalian orders	
Major radiation of mammals, birds, and pollinating insects	
Flowering plants (angiosperms) appear and diversify; many groups of organisms, including most dinosaurs, become extinct at end of period	
Gymnosperms continue as dominant plants; dinosaurs abundant and diverse	
Cone-bearing plants (gymnosperms) dominate landscape; dinosaurs evolve and radiate; origin of mammals	



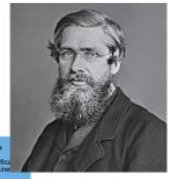
Earth's History

- Changes in climate and habitats on Earth
- Pangaea (245 mya)- supercontinent
  - Deep oceans drained shallow seas
- Pangaea began to break up (180 mya)
  - Laurasia
    - Europe, Asia and North America
  - Gondwana
    - Africa, Madagascar, South America, India, Australia, Antarctica

Biogeography

Biogeography: study of past and present geographic distributions of species through geologic time

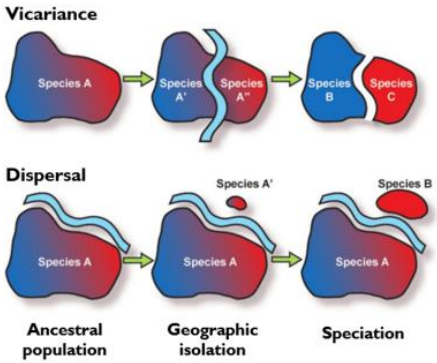
- Alfred Russel Wallace
  - Wallace's line: separation of biogeographic regions in Malayan Archipelago based on wildlife distributions



Vicariance vs. Dispersal

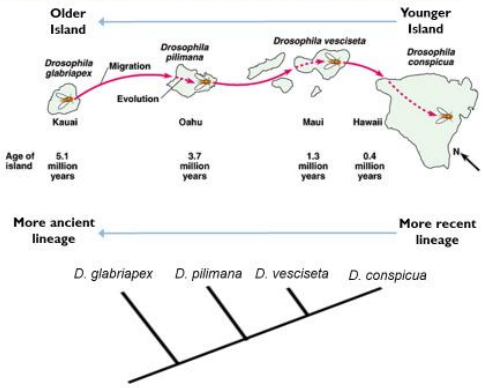
Vicariance: splitting of an organisms native range through the _____ to gene flow

Dispersal: movement of organisms to locations outside of their native range



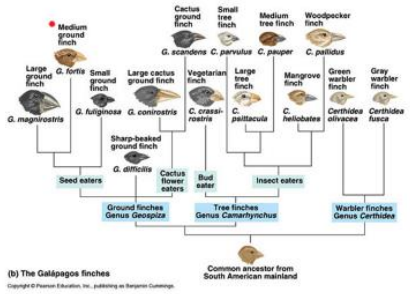
Biogeography: Dispersal

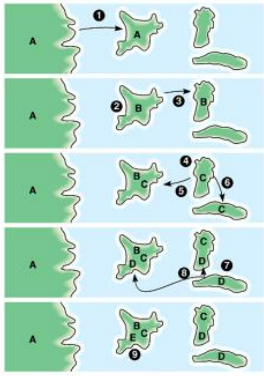
- *Drosophila* dispersed as islands formed in the Hawaiian Archipelago

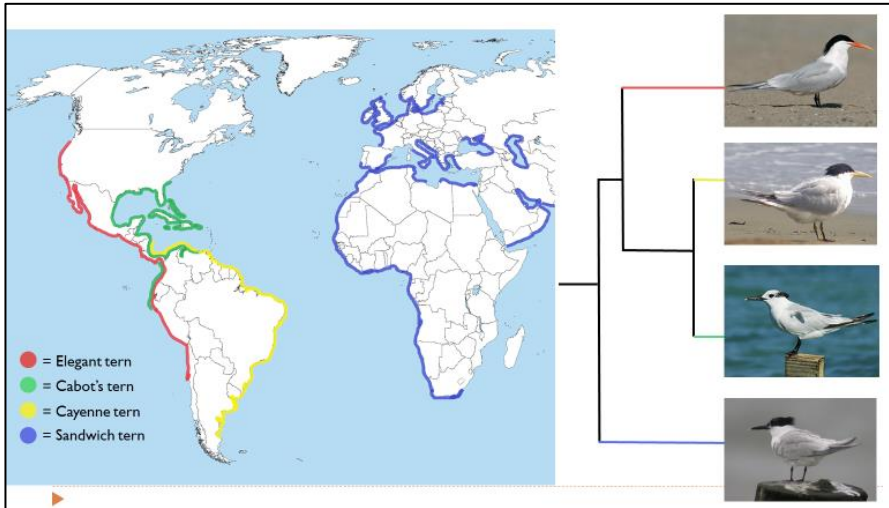


Biogeography: Dispersal on Islands

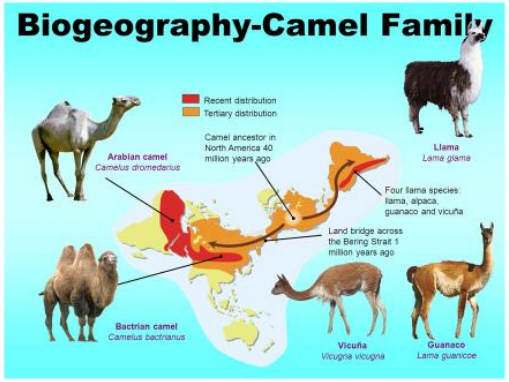
- Adaptive radiation of Galapagos finches likely due to dispersal between islands in Galapagos archipelago

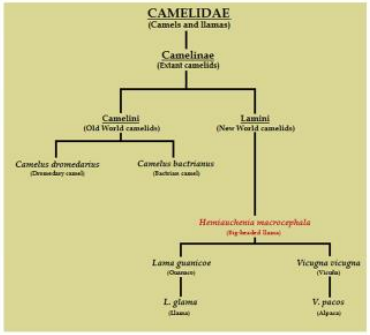






Biogeography of Camelidae: Dispersal



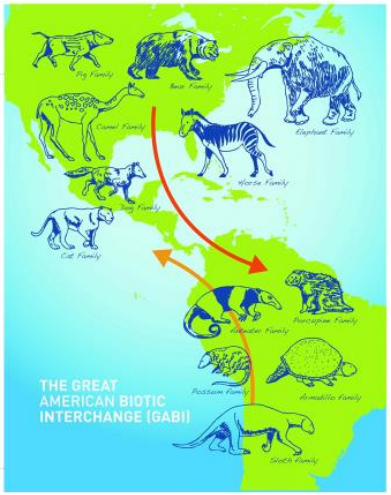


Biotic Interchange

Biotic interchange: when barrier between previously separated biotas breaks down, resulting in drastic changes to biodiversity

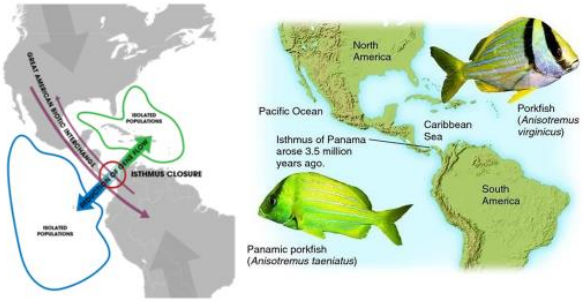
Great American Biotic Interchange

- Isthmus of Panama connected North and South America
  - Heading south: Bear, Cat, Camel, Horse, Elephant, Dog and Pig families
  - Heading north: Anteater, Porcupine, Armadillo, Sloth, and Possum families



Biogeography: Vicariance

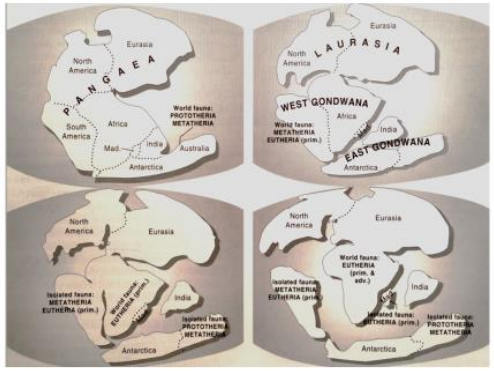
- Connection of North and South America at the Panama isthmus led to the vicariance of the pork fish populations.



Biogeography of Mammals: Vicariance

Early Jurassic
(~ 200 mya)
- Monotremes and marsupials in southern Pangaea

Early Cretaceous (~ 135 mya)
- Marsupials and monotremes isolated in "Australia"
- Marsupials isolated on "South America"

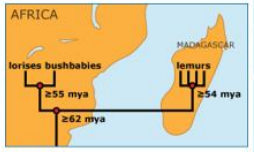


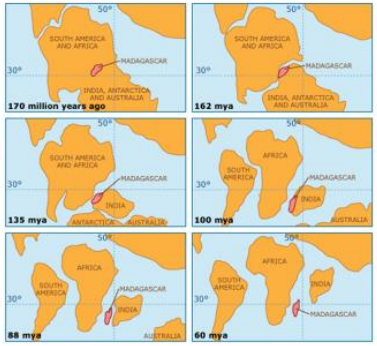
Late Jurassic (~ 180 mya)
- Eutheria diverge from Marsupials in "South America"

Early Paleocene (~ 65 mya)
- Dinosaurs extinct
- Mammal radiation
- Eutheria northern distribution

Biogeography: Vicariance

- Lemurs are only found on Madagascar
- Madagascar separated from Africa then India as Gondwana broke up
- Lemurs closet living relatives are on Africa





Biogeography or Gnatcatchers: Dispersal or Vicariance?

← California gnatcatcher

Black-tailed gnatcatcher →

Biogeography of Kapok Tree: Dispersal or Vicariance?

- African and Neotropic distribution
- Low level of genetic divergence between populations
- Long distance dispersal supported

Biodiversity

Biological diversity or biodiversity: the variety of plants and animals, or other living things, in a particular area or region

Why is it important?

- **Extrinsic value:** The value to humans, ecosystem services
  - Provisioning services: we need it for food, medicine or industrial uses
  - Cultural services: we like the way it looks, spiritual value
  - Regulating services: decomposition and pest control
  - Habitat services: produces oxygen (photosynthesis), nutrient cycling
- _____:The worth of an entity independent from external circumstances or its value to human
  - Value to biodiversity

Loss of Biodiversity

- Human caused mass extinction event
  - 1,000 to 10,000 times greater than natural extinction rates
  - Six mass extinction since evolution of life
  - Worst since extinction of dinosaurs
- _____ under the greatest threat
  - 40% at risk of extinction
  - Indicator species
    - Thin skin makes them susceptible to toxins
    - Live in both aquatic and terrestrial environments
- ___% of primates are endangered
  - Palm oil and orangutans
- Most _____ are threatened or endangered



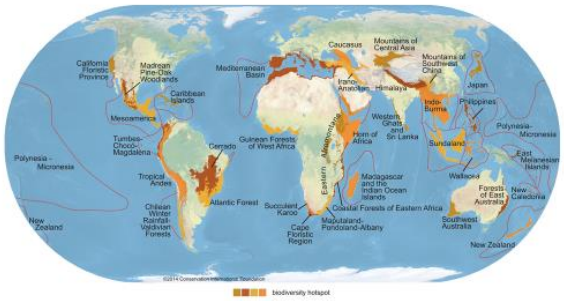

Biodiversity Hotspots

Requirements

- At least 1500 endemic plant species
  - _____:species found only in a distinct geographic area
- 70% loss of original habitat

35 areas around the world

- Support nearly 60% of all plant and animal species
- California Floristic Province



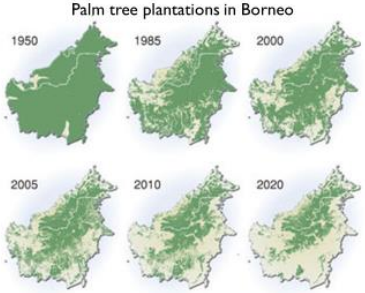
Conservation International (conservation.org) defines 35 biodiversity hotspots — extraordinary places that harbor vast numbers of plant and animal species found nowhere else. All are heavily threatened by habitat loss and degradation, making their conservation crucial to protecting nature for the benefit of all life on Earth.

Human Impacts on Biodiversity

Habitat loss: the conversion or transformation of a natural area into wholly human occupied area of little or no use to wild species

- _____ threat to biodiversity
- Mostly caused by expansion of agricultural land
- ___% of species listed threatened or endangered to habitat loss

Palm tree plantations in Borneo



Human Impacts on Biodiversity

_____ the clearing of forests and the conversion of the land for non-forests use

- Slash and burn

Causes:

- 48% due to subsistence farming
- 32% due to commercial agriculture
- 14% due to logging
- 5% used as wood for fuel

Consequences:

- Less oxygen
- Less water
- Land slides

Succession in Communities

Succession: a series of replacements of community members at a given location until a relatively stable final state is reached

Primary succession: succession in which the starting state is one of little or no life and a soil void of nutrients.

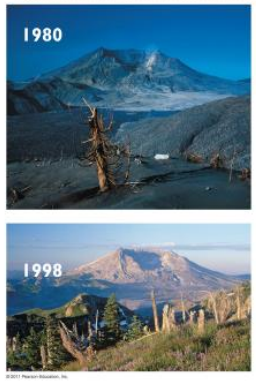
- Glaciers, floods, volcanic eruptions and landslides
- **Pioneering species**: hardy species that are the first to colonize disturbed ecosystems

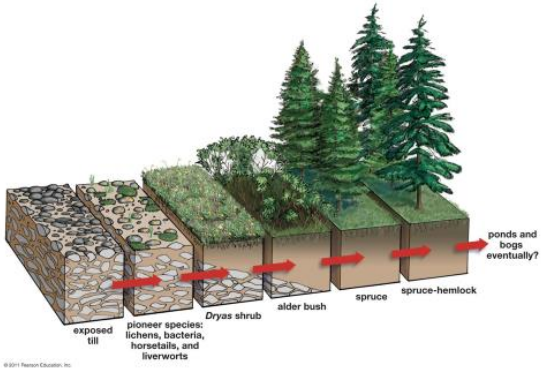
Secondary succession: succession in which the final stage of the habitat has been disturbed, but life remains and the soil has nutrients

- Fires or logging

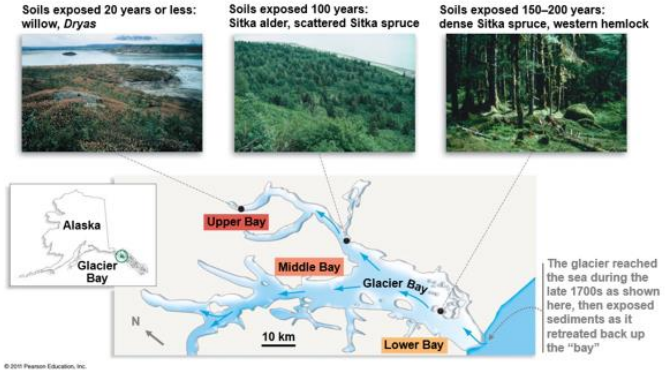
Climax community: an ecological community in the final stage of succession in which the species composition remains relatively stable

Habitat Succession





Habitat Succession



Human Impacts on Biodiversity

_____: the disruption of extensive habitats into isolated and small patches

- Smaller territories cannot sustain large carnivores

Urbanization: expansion of urban environments

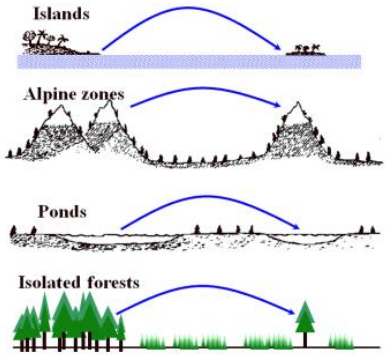
- Associated with habitat loss and fragmentation

Theory of Island Biogeography

Island: area of land isolated from mainland by a body of water

Habitat island: area of suitable habitat some distance from source population

Sky island: isolated mountains surrounded by radically different lowland environments

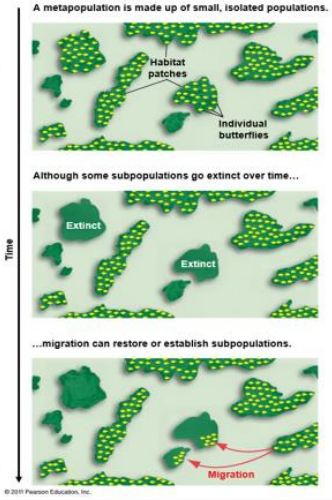


Metapopulations

Metapopulation: a population of populations

Source population: stable or growing population that produces offspring that disperse to other areas

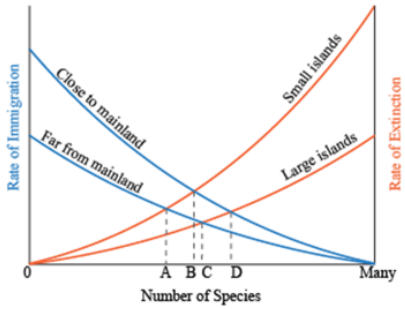
Sink population: a population with declining growth that must be sustained by immigration from other populations



Equilibrium Theory of Island Biogeography

Greatest number of species based on rates of immigration and extinction

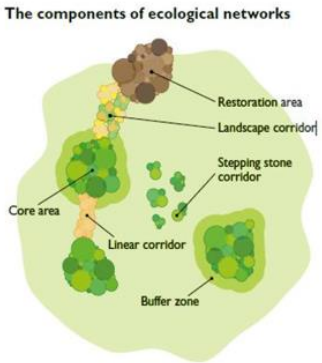
1. Large islands close to mainland/source
2. Large islands far from mainland/source
3. Small islands close to mainland/source
4. Small islands far from mainland/source



Corridors

Wildlife corridors: an area of habitat usually comprising native vegetation that links two separate fragments of similar habitat.

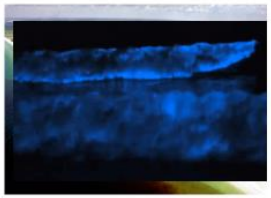
- Connects nearby plant and animal populations separated by an impassable barrier.

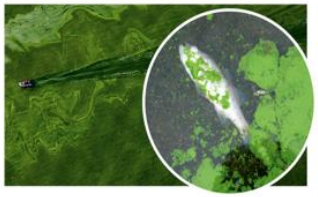


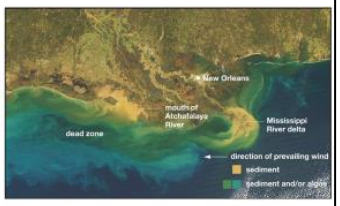
Human Impacts on Biodiversity

_____: excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of algae and bacteria resulting in the death of animal life from lack of oxygen.

- **Hypoxia**: the depletion of oxygen in the water often resulting in dead zones







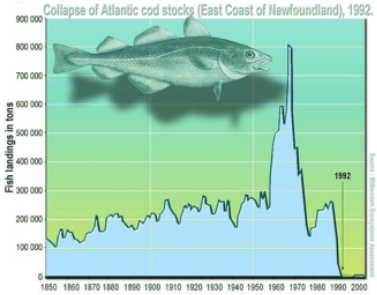
Overfishing

Overfishing: overexploitation of fish stocks in an unsustainable manner

- 30% of all commercial fish stocks are overfished

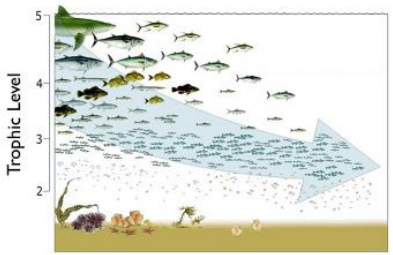
Factors that lead to overfishing:

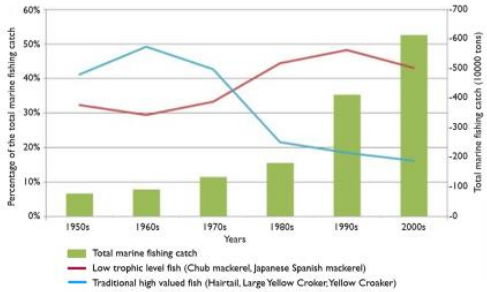
- International waters (>200 mi from shore) are unregulated resulting in open access fisheries
- Poor fisheries management
  - Fish are caught by multiple countries making data collection difficult to impossible
- Illegal fishing
  - Many catches are unreported
- Subsidized fishing fleets result in 2 times more fleets than necessary



Overfishing

Fishing down the food web: process by which fisheries deplete large predatory fish then begin to catch smaller and smaller species





World Commercial Catch of Marine Species

The total catch of marine species has been increasing since 1975

- Estimated at 109 million metric tons in 2016
- Approximately 30% of marine catch is unreported
- Amount of large predatory fish (tuna, billfish) has increased by 250% since 1975

Table 17.1 World Commercial Catches of Selected Fishes, Molluscs, and Crustaceans in Millions of Metric Tons

Catch	1975	1985	1995	2000	2005	2012
Herrings, sardines, etc.	13.43	21.10	22.01	24.90	22.27	17.55
Miscellaneous pelagic fishes	not listed	not listed	13.93	10.64	11.30	10.41
Cods, haddocks, hakes, pollocks	11.85	12.46	10.74	8.68	8.07	7.70
Tunas, bonitos, billfishes	2.06	3.18	4.89	5.82	6.51	7.18
Salmon, smelts	0.55	1.17	1.15	0.80	1.03	0.97
Flounders and other flatfishes	1.16	1.35	0.92	1.01	0.90	0.99
Sharks, rays	0.59	0.62	0.76	0.87	0.78	0.77
Total marine fishes	**51.93**	**64.40**	**72.00**	**71.84**	**69.60**	**65.49**
Fresh water fishes	**5.96**	**8.74**	**5.80**	**6.80**	**8.17**	**10.29**
Squids, octopuses	1.18	1.79	2.94	3.66	0.73	4.03
Scallops	0.29	0.60	0.54	0.66	0.73	0.75
Clams, cockles	0.94	1.51	0.96	0.80	0.65	0.61
Oysters	0.85	1.09	0.19	0.25	0.16	0.17
Mussels	0.53	0.97	0.24	0.26	0.13	0.10
Total marine molluscs	**4.03**	**6.18**	**6.38**	**7.25**	**6.49**	**6.55**
Shrimps	1.33	2.12	2.44	3.08	3.20	3.35
Crabs	0.75	0.89	0.95	1.09	1.23	1.50
Lobsters	0.10	0.20	0.22	0.23	0.23	0.29
Krill	0.04	0.19	0.12	0.11	0.13	0.19
Total marine crustaceans	**2.35**	**3.42**	**4.77**	**5.91**	**5.20**	**5.75**
World total catch in marine fishing areas	**61.22**	**75.68**	**85.04**	**86.80**	**92.49**	**91.3**

Note: Catches tabulated in groups defined by the Food and Agriculture Organization of the United Nations (FAO); only selected groups are listed and, when added, will not equal totals.

Human Impacts on Biodiversity

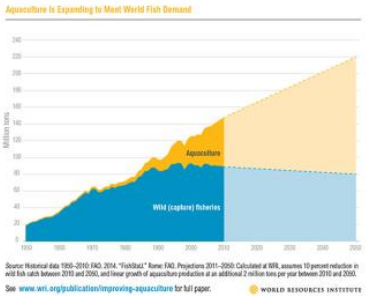
_____:a fish or other species that is caught unintentionally

- 38.5 million tones of bycatch caught world-wide

Aquaculture

Aquaculture: _____ of aquatic organisms including fish, molluscs, crabs and algae

- Accounts for more than half of all seafood consumed annually
- Expected to exceed wild capture fisheries by 2050



Marine Plastics

- Estimated that _____ metric tons of plastic are dumped into the ocean annually.
- Most of the plastic in the ocean consists to microplastics (< 5mm)
- Plastics are consumed by a variety of marine species
  - Plastics coated in algae mimic food items
  - Plastic chemicals can be transferred up the food chain
- Fishing nets and other plastics entangle marine life
  - Over 300 marine species have been recorded

https://youtu.be/AWgfOND2y68

Marine Plastics

Some of the 65 pounds of plastic found in the gut of a deceased sperm whale that washed on shore in Spain

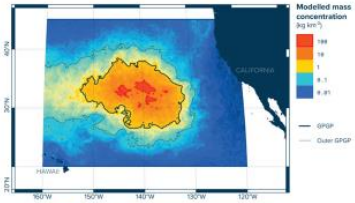
It is estimated that 90% of seabirds are ingesting some plastic. Plastics covered in algae take on the smell of seabird prey items. Many seabirds mistakenly feed plastic to their chicks

It is estimated that hundreds of sea turtles die every year from becoming entangled in plastics. More than half of all sea turtles are reported to have ingested some plastic

Marine Plastics

Giant Pacific Garbage Patch

- Covers 617,000 square miles of the northern Pacific Ocean
- Plastics make up 99.9 percent of the trash in the patch
- Discarded _____ made up almost 50% of all plastic discovered



Shark Finning

Shark finning: the removal of shark fins often while the shark is still alive

- Driven primarily for demand of shark fin soup
- Estimates of _____ sharks killed every year
  - Late maturity and k-selected life history strategy of sharks leads to drastic population declines
- Populations increasing in United States due to protections

Human Impacts on Biodiversity

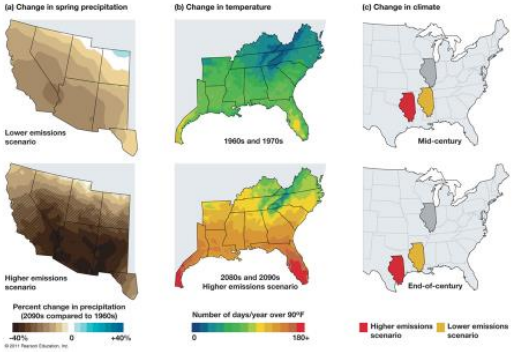
Hydroelectric dams alter natural water ways

- Reduce natural nutrient-rich runoff
- Impede fish _____
  - Fish ladders

Human Impacts on Biodiversity

Climate change

- 97% of climate scientists agree that climate trends over the last century are extremely likely to be due to human activity (NASA, 2016)
- Climate change predicted to cause widespread extinction, and migration, in plants and animals



Human Impacts on Biodiversity

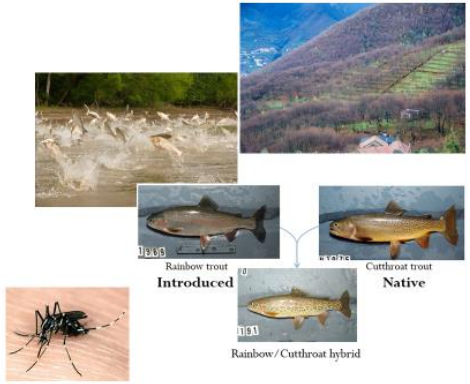
_____ **species**: a species that is non-native to and ecosystem and has caused or is likely to cause economic or environmental harm

Characteristics of Successful Invasive Species

- Fast growth
- Rapid _____
- Tolerance to wide range of environmental conditions
- High dispersal ability
- Lack of natural predators
  - Rapid evolution

Negative Impacts of Invasive species

- **Change an entire habitat**
  - Asian chestnut blight fungus nearly wiped out chestnut forests in Eastern U.S.
- **Alter ecosystem dynamics**
  - Asian carp in Mississippi river basin
- **Loss of _____ (genetic extinction)**
  - Hybridization between native and invasive species
- **Spread of disease**
  - Asian tiger mosquito



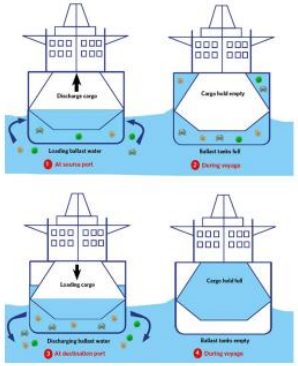
Invasive Species Introductions

- **Intentional introductions**
  - Feral pigs, European starling
- **Unintentional introductions**
  - Rats aboard ships, hitchhikers in cargo
- **Horticulture**
  - Ornamental or crop plants that later escape
- **Ballast water**
  - Many small marine organisms
- **Pet trade and aquarium release**
  - Lion fish, pythons

Invasive Species Introductions

Ballast water: water carried in the ballast tanks of cargo ships to level the load and provide stability during transit

- Many small marine organisms are transported in ballast water
  - American comb jelly in European Seas
  - Zebra mussel in North America
- Ballast exchange at sea to reduce introductions



Negative Impacts of Invasive species

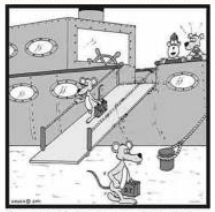
Zebra Mussel

- Can produce 5 million eggs in 5 years
- Dense growth blocks pipes and damage boats and other structures
- Consume majority of plankton leading to a collapse of the food web

Invasive Species Introductions

Unintentional introductions

- Rats have been introduced to most islands where they have caused the extinction of countless species including many seabirds
  - Eradication of rats from islands is on-going challenge
- The brown tree snake hitchhiked to Guam in military cargo and has led to the extinction of at least 12 bird species on Guam



I've got a bad feeling, the rats are leaving the ship...

Invasive Species Introductions

Pet trade and aquarium release

- Lionfish were released into the waters off Florida and are now found throughout the east coast of U.S, the Caribbean, and Gulf of Mexico
  - Large venomous spines and appearance likely deters predators
  - They breed year round and can produce young every 4 days
  - Reduce populations of juvenile and small fish on coral reefs by as much as 90%
- *Caulerpa taxifoila* is a popular aquarium algae that became established off southern California coast
  - *Caulerpa taxifolia* is now illegal in California

Negative Impacts of Invasive species

Black Mustard

- Allelopathic chemical
  - Prevents germination of native plants
  - Converts native habitats to grasslands
- Spreads quickly after fire
  - Dormant fire-stimulated seed banks

One week after 2008 complex fire

Five months after 2008 complex fire

Preservation of Species

Endangered Species Act of 1973: a U.S. environmental law designed to protect and recover imperiled species and the ecosystems upon which they depend

- Governed by U.S. Fish and Wildlife Service (FWS) and the Commerce Department's National Marine Fisheries Service (NMFS)
- Species designated as either threatened or endangered
- Designates _____
- Develops a recovery plan

Preservation of Species

Captive breeding programs

Protection of species and their habitats

Seed banks and frozen zoos

Preservation of Species

Protected Areas

- Protection of critical habitat
- National parks, preserves
- Marine protected areas

CEQA and NEPA

National Environmental Policy Act (1970): requires all federal agencies prepare environmental assessments (EAs) and environmental impact statements (EISs) to determine negative impacts associated with proposed projects

- **Environmental Impact Report (EIR)**: an assessment of all environmental impacts that a proposed project may incur

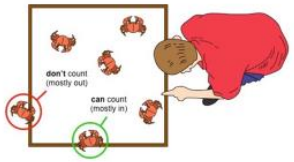
California Environmental Quality Act (1970): requires all state and local agencies analyze and disclose all potential environmental impacts of proposed projects, and adopt measures to mitigate any negative impacts to the environment.

	CEQA			
	Potentially significant impact	Less than significant impact with mitigation	Less than significant impact	No impact
AIR QUALITY - Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project				
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☑
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☐	☑
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?	☐	☐	☐	☑
d) Expose sensitive receptors to substantial pollutant concentration?	☐	☐	☐	☑
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☑
BIOLOGICAL RESOURCES - Would the project:				
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☑
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?	☐	☐	☐	☑
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means? **Less than 0.5 acres affected. Mitigation banking or on-site/in kind replacement of wetlands will compensate for impacts. (See Section 2.3.1)**	☐	☑	☐	☐

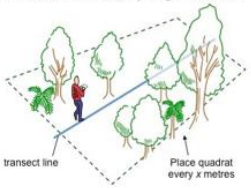
Biological Surveys

Biological surveys: use of various methods to quantify the abundance and distribution of various living organisms.

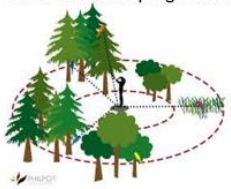
Quadrat Sampling Method



Line Transect Sampling Method



Point Count Sampling Method



Biological Surveys

Check Your Understanding

True of False: Humans are currently causing the sixth great mass extinction event on earth

True or False: The Permian extinction was the worst extinction event of all time.

True or False: Aquaculture is the greatest threat to marine species on earth

Check Your Understanding

Which of the following are <u>not</u> one of the ways that humans are trying to preserve species?

a. Seed banks
b. Pet trade
c. Captive breeding
d. Protected habitats
e. All of the above are ways that humans work preserve species

Check Your Understanding

What is an invasive species? What are the characteristics that make something a successful invader? Provide two ways that invasive species can be introduced to new environment.