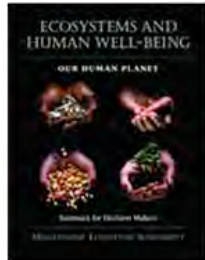


Millennium Ecosystem Assessment

<http://www.millenniumassessment.org>

- 2005 Landmark study by 1300 experts from 95 countries.
- Reports that humans have disrupted ~60% of earth's ecological systems to meet demands for food, water, timber and fuel.



Millennium Ecosystem Assessment

<http://www.millenniumassessment.org>

- “Any progress achieved in addressing . . . poverty and hunger, health and environmental protection is unlikely . . . if most of the ecosystem services on which humanity relies continue to be degraded.”
- “Human activity is putting such strain on the natural functions of earth that the ability of the planet’s ecosystems to sustain future generations can no longer be taken for granted.”
- Slowing this trend “will require radical changes in the way nature is treated at every level of decision-making.”

Real and potential human insults to the integrity of the biosphere

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Regional & global

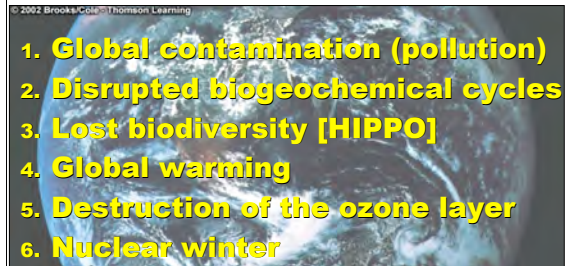
- ↳ Loss of biodiversity
- ↳ Loss of overall life support



Real and potential human insults to the integrity of the biosphere

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1. Global contamination (pollution)
2. Disrupted biogeochemical cycles
3. Lost biodiversity [HIPPO]
4. Global warming
5. Destruction of the ozone layer
6. Nuclear winter



Ecology and Environmentalism

- The precautionary principle



- Basically states that humans need to be concerned with how their actions affect the environment
- It is a lot more plausible to prevent environmental degradation than to try to remediate it

Disrupted biogeochemical cycles

- Water cycle
 - Desertification; contamination; saltwater intrusion
- Nitrogen cycle
 - Nutrient depletion; cultural eutrophication; nitrite contamination; acid rain
- Carbon cycle:
 - Excessive CO₂; depleted fossil pools
- Soils:
 - Erosion; nutrient depletion; fire suppression

Biodiversity Crisis

Birds

13% of known bird species worldwide are threatened with extinction.
Density of songbird populations has dropped by 50% in the US in the last 40 years.



Biodiversity Crisis

Plants

In the US, 200 species of plants have disappeared within the past 100 years. Another 730 species are endangered.



Biodiversity Crisis

Fish

About 20% of the known freshwater fishes in the world became extinct during historical times, or are now threatened.

About 200 of the 300 species of cichlids in lake Victoria are gone due to introduction of the exotic Nile perch.



Biodiversity Crisis

Since 1900,

123 freshwater vertebrate and invertebrate species have become extinct in North America, and hundreds more are threatened.

Extinction rates of aquatic species are five times that of terrestrial.

Biodiversity Crisis

Since 1900, the current rate of extinction is 100 to 1000 times "background" rates of prior centuries



This past century may represent the greatest extinction event of Earth's history!

TOP (BOTTOM?) TWENTYFIVE BIODIVERSITY HOTSPOTS



- Only 1.5% of Earth's landmass holds 33% of plant and vertebrate species
- Many of these hotspot species are endemic
- One third of these hotspots have already lost >90% of their area to human development

Biodiversity Crisis
HIPPO

Some local species at risk

- **Habitat destruction & fragmentation**
- **Invasive species**
- **Pollution**
- **Population (human)**
- **Overexploitation**



Bald eagle



Southern sea otter



Ohlone tiger beetle



Santa Cruz long-toed salamander

Habitat destruction & fragmentation


Reduction or loss of natural habitat by

- housing & industrial developments
- agriculture
- overgrazing
- urbanization
- deforestation
- mining
- oil drilling
- fire
- erosion etc.



Fragmented Habitats

- Partial destruction of habitat into patches isolates sub-populations
- Less than 10% old growth forest remains in the US Pacific NW




Fragmentation of forest by logging

Fragmented Habitats

Quality of Patches Determines Subpopulation Survival

- **Source habitat**
 - Reproduction exceeds deaths
 - High quality patch: old growth forest
- **Sink habitat**
 - Deaths exceed reproduction
- Number of source habitats decreasing



Northern spotted owl

LOCAL EXAMPLES OF HABITAT LOSS & FRAGMENTATION

SALT MARSH HARVEST MOUSE

- Found only in salt marshes ringing SF Bay
- Federally and state listed as endangered
- About 90%+ of salt marshes have been lost to development & salt ponds



LOCAL EXAMPLES OF HABITAT LOSS & FRAGMENTATION

PRESIDIO MANZANITA

- Shrub found today only on north end of S.F. peninsula
- Just ONE plant remains, in the Presidio
- Former range is now under S.F. itself
- Federally and state listed as endangered



LOCAL EXAMPLES OF HABITAT LOSS & FRAGMENTATION

BURROWING OWL

- Lives in burrows usually dug by ground squirrels
- Flat, open land around SF Bay is preferred territory
- Also preferred by developers!
- Owl was to be listed as threatened, but CA DF&G denied appeal



INVASIVE SPECIES CHARACTERISTICS

Invasive exotic species are bad news because they tend to be

- Competitive
- Quick reproducers
- Adapted to human disturbance
- Adapted to most domestic animal disturbance (grazing, trampling etc.)
- Rapid dispersers
- Without their native predators
- Just overall “weedy”



INVASIVE SPECIES

- Introduced species that gain a foothold in a new habitat
 - Usually disrupt their adopted community



(a) Brown tree snake, introduced accidentally to Guam in cargo

Figure 55.6



(b) Introduced kudzu thriving in South Carolina

LOCAL EXAMPLES OF INVASIVE SPECIES

WILD PIG

- Introduced to CA in 1930's for hunting
- Now found throughout lower elevation hills, from the coast to Sierra
- Will eat anything it finds--bulbs, fawns, acorns, snakes etc. etc.
- Considered one of California's most destructive exotics



LOCAL EXAMPLES OF INVASIVE SPECIES

YELLOW STAR THISTLE

- Originally from Europe, introduced accidentally
- Almost impossible to control or eradicate
- Out-competes all native grasses and forbs
- Now covers over 7 million acres in California



MORE EXAMPLES OF CALIFORNIA'S INVASIVES

- Eucalyptus (trees, Australia)
- French broom (shrub, Europe)
- Medusa-head grass (Europe)
- *Ailanthus* (“tree of heaven,” China)
- House mouse (Europe, Asia)
- Chinese mitten crab (Asia)
- Northern pike (fish, eastern US)
- Starling (Europe)
- English sparrow





Invaders of SF Bay

- The invasive **Asian clam**, *Corbula amurensis*, has changed the food web in San Francisco Bay estuary by severely restricting phytoplankton blooms in the northern embayment

LOCAL EXAMPLES OF POLLUTION PROBLEMS

CALIFORNIA CONDOR

- Captive breeding program is successful, but reintroduced birds now have high **lead** levels, likely from ingesting bullet fragments in scavenged food.
- Several reintroduced condors have died from drinking **ethylene glycol** (antifreeze) in contaminated puddles.

LOCAL EXAMPLES OF POLLUTION PROBLEMS

RED-LEGGED FROG

- Many male frogs are now **intersex** in some ponds polluted with **atrazine**.
- Atrazine is the most widely used, potent agricultural weed-killer in the US.

POPULATION (OURS)

- California's population is about 35 million.
- It's expected to double within 50 years.
- Human pressures are at the base of most of our conservation problems.

OVER-EXPLOITATION OF WILD "RESOURCES"

- Clear-cutting of forests

OVER-EXPLOITATION OF WILD "RESOURCES"



Figure 55.7

Fish

"Factory ships" with fleets of fishing boats cruise from area to area, moving on when nothing left worth catching

Stocks of large food fish (tuna, shark, grouper, swordfish etc.) have declined to just 10% of their numbers of 20 years ago due to over-fishing.

OVER-EXPLOITATION OF WILD "RESOURCES"

Sharks worldwide are threatened by the shark fin industry. Typically, only the fins are taken; the rest of the shark is discarded.

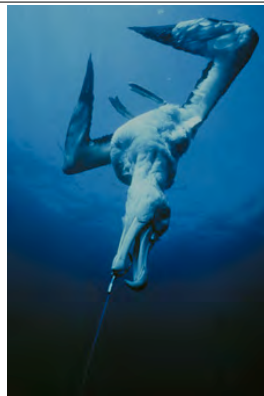
Sharks are slow to mature and produce few young

- All shark fisheries crash quickly



By-catch

Often, species other than those targeted by modern fishing fleets are caught too. This is called by-catch. These animals are discarded, and add to the depletion of marine species.



albatross caught on longline

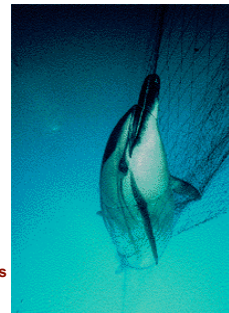
By-catch

- In some cases these by-catch species are already endangered.



❖ Sea turtle caught in a trawler netting. It may take a turtle an hour or more to drown.

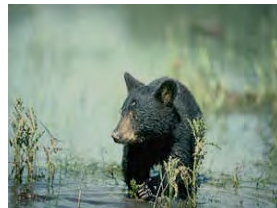
❖ Drift nets may be the leading cause of mortality today of marine mammals such as dolphins, whales and seals



OVER-HARVEST OF SPECIES IN CALIFORNIA

BLACK BEAR

- Legal hunting limit is ~1500 statewide per year.
- More than double that is estimated to be killed yearly, illegally, for their gall bladders and paws, which are exported to Asian markets as medicinals.



OVER-HARVEST OF SPECIES IN CALIFORNIA

ABALONE

- Despite strict regulation and monitoring, all species of abalone are in decline. Two are nearing extinction.
- Most taken illegally are exported to Asia.



California Red Abalone

OVER-HARVEST OF SPECIES IN CALIFORNIA

BLUE OAKS

- Blue oak woodlands are being devastated in the Sierra foothills by development and cutting for firewood.
- In many cases, woodcutters "poach" trees from private and public lands.

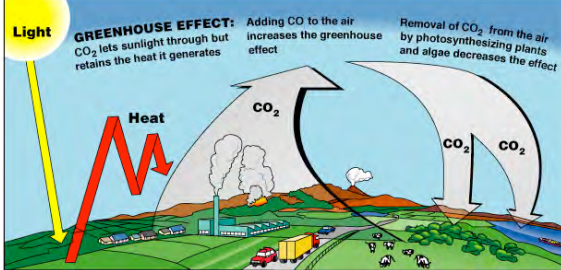


The Symbol of California

- A mammal hunted to extinction by 1922
 - California grizzly ("golden bear")



Global habitat impact: the Greenhouse effect

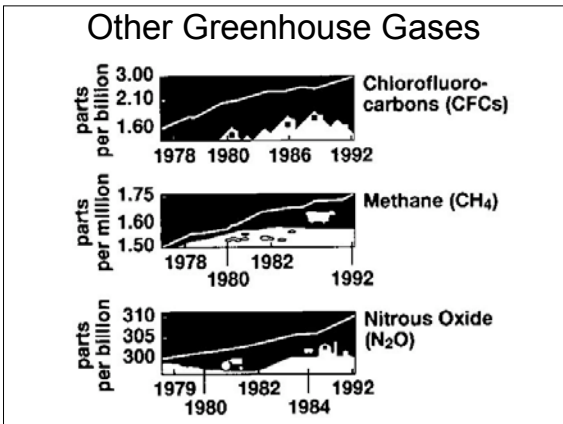
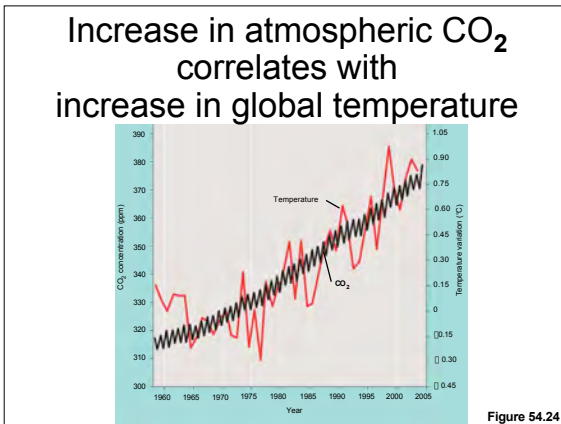
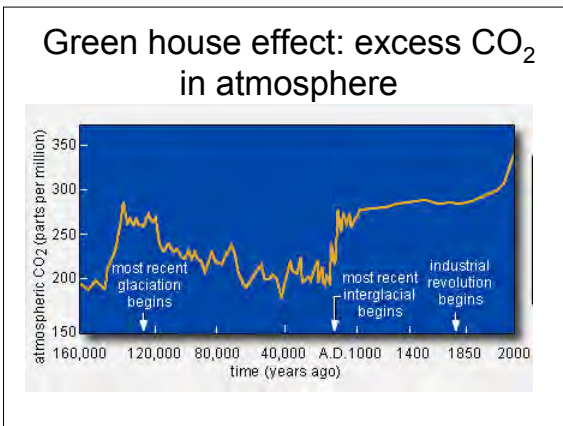


GREENHOUSE EFFECT: CO₂ lets sunlight through but retains the heat it generates

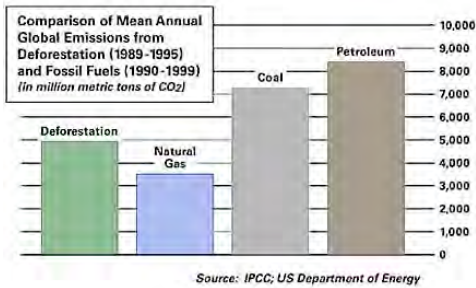
Adding CO₂ to the air increases the greenhouse effect

Removal of CO₂ from the air by photosynthesizing plants and algae decreases the effect

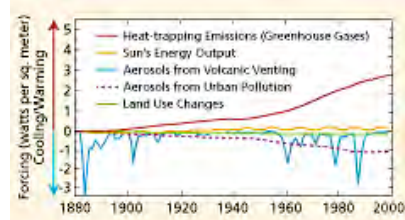
- "Greenhouse gases" (esp., CO₂) are transparent to sunlight but absorb infrared radiation trap heat within atmosphere



Sources of CO₂ Emissions



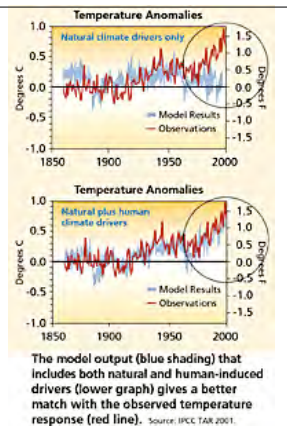
Global Climate Drivers



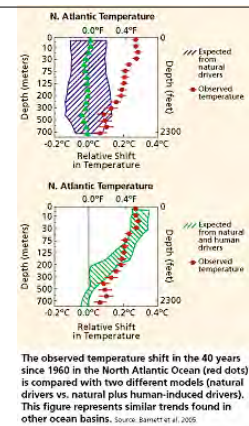
Heat-trapping emissions (greenhouse gases) far outweigh the effects of other drivers acting on Earth's climate.

Source: Hansen et al. 2005

Ecological Modeling the combined effects of climate drivers



Global warming & the ocean's thermal budget



Probable consequences of the greenhouse effect


- Melt polar ice caps, raise sea levels
 - Flood heavily populated coastal areas
- Alterations in global precipitation patterns
 - Desertification of agricultural areas
 - Deplete snow-pack water reserves
- Shift of great ocean current patterns
 - Decreased heat transfer away from tropics
 - More extreme climates between equator and poles
- Major changes in habitats leading to population shifts and loss of biodiversity

IMPACTS OF GLOBAL WARMING

- Change in sea level
 - Coastlines
 - Islands



IMPACTS OF GLOBAL WARMING



- Geographical shifts
 - Animals
 - Plants
- Sociological & political shifts
 - Food supply

Deterioration of the Ozone Layer

- Ozone (O₃) layer — region ~20km up in atmosphere
- Absorbs much of the UV radiation from the sun
- Chlorofluorocarbons (CFCs) from industrial processes (e.g., refrigerants, propellants, insulation) rise to upper atmosphere and degrade to release chlorine
- Chlorine catalyzes degradation of O₃ to O₂ □ decreases thickness of ozone layer

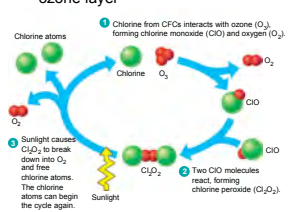
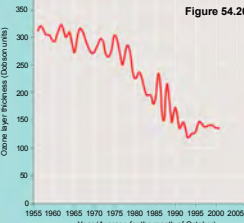
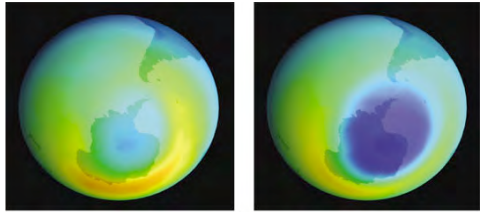



Figure 54.26

Figure 54.27

Deterioration of the Ozone Layer

- Upper atmospheric winds concentrate CFCs toward poles
- Thinning of ozone layer most severe over arctic/antarctic — “Ozone hole”
- But even temperate latitudes have thinned 2–10% over past 20 years




(a) October 1979 (b) October 2000

Deterioration of the Ozone Layer

Increased UV radiation exposure:

- Increased rate of skin burn and melanoma
 - “Tan today ... cancer tomorrow”
- Increased rate of cataracts
 - Argentinian cattle
- Possible destruction or inhibition of phytoplankton
 - Potential major disruption of global food webs and maybe even weather

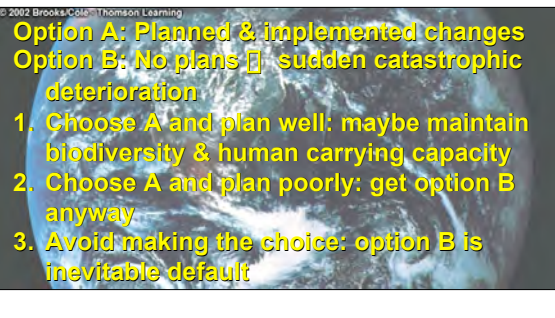


Human societies are changing the planet’s biosphere!

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Option A: Planned & implemented changes
Option B: No plans □ sudden catastrophic deterioration

1. Choose A and plan well: maybe maintain biodiversity & human carrying capacity
2. Choose A and plan poorly: get option B anyway
3. Avoid making the choice: option B is inevitable default



Ecology and Environmentalism

- **Ecology** — Provides the scientific understanding underlying environmental issues
- **Sustainable Development**
 - Long-term prosperity of both humans and ecosystems
 - Commitment to protect and preserve biodiversity
 - “Stewards of the land”
 - Decisions that benefit future generations




Figure 50.1

CONSERVATION STRATEGIES

- Research and more research
- Sound bio-reserve design
- Corridors
- Re-introduction
- Captive breeding
- Conservation of foundation species
- Conservation of umbrella species
- Habitat restoration
- Education and more education



RESEARCH!



In genetics, forensics, habitat quality assessment, home range analysis, systematics, rapid assessment in critical areas, cultural anthropology . . . All needed! Quick!

Understanding community dynamics

- allows biomanipulation to restore polluted ecosystem
- Restoration of Lake Vesijarvi, Finland
- Cultural eutrophication (sewage) allowed overgrowth of noxious alga and cyanobacteria
- 1. Sewage treatment alone did not restore lake ecosystem

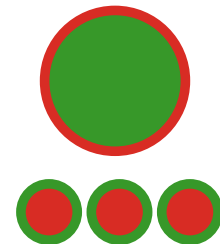
Food Chain	Polluted State	Restored State
Fish	Abundant	Rare
Zooplankton	Rare	Abundant
Algae	Abundant	Rare

- 2. the fish population allowed zooplankton population
- abundant zooplankton reduced alga & cyano populations

BIO-RESERVE DESIGN

Large reserves are better than small.

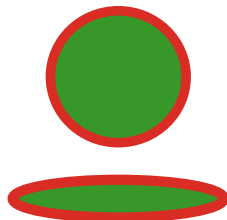
- large species
- large home range
- higher diversity
- less edge effect



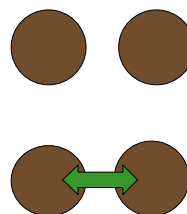
BIO-RESERVE DESIGN

Large, circular or square reserves are better than long, strip-like reserves.

- less edge effect
- less wind damage
- fewer opportunistic predators



BIO-RESERVE DESIGN



Corridors between reserves help

- maintain population contacts.
- allow dispersal of young.
- aid migrating species.

Movement corridors to connect habitat patches

- **Movement corridors** promote dispersal, help sustain populations
- Esp. to maintain contact from source habitats
- Multiple patches may be better than one big area
 - For *some* species
 - *Only* if connections are sufficient



Underpass serves as a movement corridor

REINTRODUCTION

Populations of recovered species are brought back to their native habitat (assuming it still exists).

Examples: tule elk, pronghorn, condor in CA.

(Right, tule elk photo by Stasia McGehee, De Anza ES 85A class)



CAPTIVE BREEDING



Animals/plants are held in captivity until enough are available for reintroduction. Examples: black-footed ferret, Przewalski horse, Pere David's deer, Arabian oryx.

PERE DAVID'S DEER



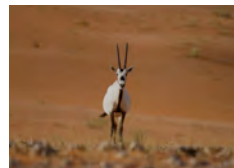
- Last individuals in native China were eaten by troops during the Boxer Rebellion, early 1900's.
- Fortunately, small captive herds existed in England, and provided the start of a new population.

PRZEWALSKI'S HORSE (TAKHI)

- Declared extinct in native Mongolia in 1960's
- Again, captive herds in the US, England & Europe became the nucleus of new groups.
- Horse reintroduced to Mongolia in mid-1990's.



THE ARABIAN ORYX



- Last wild group run down and shot for "fun" by Saudi soldiers in 1970's; antelope was extinct in the wild.
- Captive-bred herds since reintroduced into former range in Saudi Arabia & Oman.

FOUNDATION SPECIES CONSERVATION

Foundation species help determine the make-up and integrity of ecosystems; without them, ecosystems become less stable.

- Keystone predators
- Ecosystem engineers
- Critical pollinators



FOUNDATION SPECIES

- Some foundation species act as facilitators that have positive effects on the survival and reproduction of many of the other species in the community
- Black rush (*Juncus*): shade reduces evaporation; snorkel-roots oxygenate sediment



Salt marsh with *Juncus* (foreground)

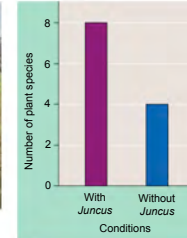


Figure 53.19

UMBRELLA SPECIES CONSERVATION



Grizzly bear

Umbrella species tend to be big, charismatic species with big ranges. Protect them, and you protect everything else by default.

UMBRELLA SPECIES

Because the Endangered Species Act (as it stands currently) mandates protection of habitat in addition to the species itself, umbrella species help protect many others.



Restoration: Habitat Recovery

- **Bioremediation**
 - Lichens to remove heavy metals
 - Bacteria to detoxify oil spills
- **Ecosystem Augmentation**
 - Replenish factors limiting recovery
 - Legumes in tropical soils



Metal-concentrating lichens

Remembering our connections to the natural world



Paleolithic mural, Lascaux, France

Figure 55.24