**Current Loss of Biodiversity**

**Earth’s Species Diversity Today**

There are more species of life on earth today than at any other time in the past 4 billion years (except perhaps for last qtr of Tertiary; 15M-3M yrs ago)

- Earth’s modern geography favors diversity
  - Today land masses of the world are arranged in a configuration that favors high levels of diversity
    - Widely separated continents
    - With long shorelines
    - With stretches of shallow tropical waters with lots of islands
  - Earth’s varied climate favors adaptations to a variety of environmental conditions

**Species Extinctions today**

Some of the species loss over the past few hundred years has been documented

In the last 500 years the number of species in each of the world’s ecosystems has dropped by 16% on average (NS2013)

- Today: worldwide, over 15,780 species of plants & 1600 species of animals (mainly birds and mammals) and are classified as threatened, rare or endangered

<table>
<thead>
<tr>
<th>Threatened (=vulnerable)</th>
<th>Experiencing a decline in numbers likely to become endangered</th>
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<tbody>
<tr>
<td>Rare</td>
<td>Has small population or restricted to small area but population is relatively stable</td>
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<tr>
<td>Endangered</td>
<td>Faces an immediate threat that could lead to extinction</td>
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**eg. plants**: including 15,780 species of plants

- 10% of world’s 8000 tree species are threatened with extinction
  - Eg. monkey puzzle trees some as old as 2000 yrs have been killed by recent fires
  - [See world atlas of threatened trees: www.globaltrees.org](http://www.globaltrees.org)
  - Eg. of 20,000 known plant species in US over 200 have gone extinct and almost 700 others are endangered

**eg. animals**: over 1600 species of animals (mainly vertebrates)

- Eg. about 39% of world’s fish species are either extinct or threatened (2014)
- Eg. 31% of world’s reptiles & amphibians are now at risk of extinction (2014)
- Eg. about 20% of world’s bird species have gone extinct in historic past; 12% are currently threatened (2014)
- Eg. about 20% of world’s mammal species are threatened (2014)

- Eg. Much less is known of invertebrates:
  - Estimates are that 51% of invertebrates vulnerable/endangered (2014)
  - Eg. US contains the world’s most diverse freshwater clam fauna,
    - 20% are endangered,
    - 12 have gone extinct in historical past

- Eg. other kingdoms: have received hardly any attention
  - Eg. in western Europe 40-50% of fungi are in decline or extinct

**Rates of extinction today**

- Normal (background) rate of extinction for past 600 MY ~ 1 species/year

**Recent data estimates greatly accelerated rates of extinctions today:**

- Fish ➔ 100x’s normal rate
- Birds ➔ 1000x’s normal rate
- Mollusks ➔ 1000x’s normal rate
- Plants ➔ 100x’s normal rate

The same report also concluded that the rate of loss is increasing

While these are the most accurate estimates we have, yet most believe they are all underestimates

- Information depends on scientific interest in a particular taxon
  - Eg. birds vs flies or roundworms
- Depends on the amount of scientific research and level of economic development in a country or region
  - Eg. Some estimate that at least 50,000 invertebrate species/yr go extinct (=140/day)
  - But no hard data to support this claim
  - Eg. Andrew Dobson estimates that 4000-14,000 small animals may be going extinct each year (10-38/day)

Today, the lowest estimates for current rate of extinction are >1 sp/day or at least 400 x’s the natural rate

- We are in the middle of a mass extinction
also,

→ it’s the first mass extinction that is largely caused by human activities.

"human selection" is replacing "natural" selection as the engine of evolution

also,

→ rather than taking millions of years, the current mass extinction is progressing over decades

if we fixed things now we will still lose one fourth to one third of all species in the next 100 years

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**Causes of Extinctions**

A. Natural Causes

B. Human Causes

A. Natural Causes:

eg. Minor (short term) Environmental Variations

*non catastrophic* variations in environment
e.g. late snow, early frost, drought, etc

especially important in small, restricted populations
e.g. cave critters, island life

eg. Natural Catastrophes

sudden *drastic* changes in environment
→ not caused by human activities
e.g. major storms, earthquakes, volcanoes, asteroid impacts, changes in ocean circulation, etc

B. Human Causes

human activities have dramatically increased the rates of extinctions over natural causes

→ rate is 100’s or 1000’s greater than rates due to natural causes

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**Major Human Causes of Species Loss**

1. **Climate Change**
affects 100% of all endangered species

2. **Habitat Destruction**
affects 100% of endangered species

3. **Hunting & Collecting**
affects 60% of endangered species
esp birds and mammals
e.g. commercial, sport, pest control

4. **Bioinvasions**
affects 30–40% of endangered species
especially severe on islands
e.g. new competitors, predators, parasites

5. **Land, Air, & Water Pollution**
(other than global warming)
affects 10–15% of endangered species
e.g. coral reefs, acid rain,

1. **Climate Change**

the earth’s climates have changed drastically over the past 4 billion years of the history of life

climate change *today* is caused primarily by human activities that pump large quantities of greenhouse gasses, primarily CO₂, into our atmosphere at a rate above what the environment can naturally absorb

natural processes produce and cycle ~230 Billion tonnes of CO₂ each year

from the first Homo sapiens to 1850 human activities such as land clearing and farming have released an additional 350 Billion tonnes of CO₂ into the atmosphere

from 1850 to 2000 another 440 Billion tonnes were released

human activities currently (2010) pump ~7 Billion tonnes of CO₂ into the air each year over and above the amounts produced by natural cycling

≈ 2 M lbs/sec (2012) (up 3% from 2011)
sometimes the carbon we’re responsible are hidden:

feeding and taking care of a pet dog generates about the same amount of CO₂ as driving a toyota land cruiser 6000 miles a year; a cat is comparable to driving a Volkswagen golf

the primary human causes global greenhouse gas emissions (2010):
1. cars & trucks
2. methane from farm animals
   (2008 livestock (cattle, deer, goats, etc) burps 
   ~18% of greenhouse gas emissions
3. gas production
4. rice cultivation
5. coal production
6. commercial & residential energy use from fossil fuels
7. Human waste water disposal
8. Landfills
9. animal wastes
10. residential biofuel combustion

**current climate change is much faster**

ie. took 20,000 years from maximum of last ice age to warm ~9° F (~5° C )

will take ~100 years (2100) to warm another 9° F

it is not the simple rise in average world temperature that is the problem

**accompanying this increase are:**

   → much more severe weather; storms, hurricanes, cyclones, monsoons

   → more extreme droughts
   especially in drought and famine prone areas in poor nations

   → significant and permanent changes in regional climates
   some areas will become drier, others wetter
   major growing areas will shift

   → earth's water cycle will be significantly altered
   regional loss of groundwater resources
   more droughts especially in S hemisphere

→ sea levels will rise
   destroying coral reefs
   flooding coastal areas
   drowning island nations

**measurable effects of climate change are already being measured:**

**rising temperature**

eg. Global warming is having a significant impact on hundreds of plant and animal species around the world -- although the most dramatic effects may not be felt for decades, according to a new study in the journal Nature.

"Birds are laying eggs earlier than usual, plants are flowering earlier and mammals are breaking hibernation sooner,"

Their overall analysis of studies involving temperate-zone species revealed that springtime events -- such as blooming, egg laying and the end of hibernation -- now occur about 5.1 days earlier per decade on average.

eg. Other studies confirmed that a variety of species -- including butterflies and marine invertebrates -- have shifted their ranges northward as temperatures increased.

eg. Measurements taken in Alaska revealed that growth in white spruce trees has been significantly stunted in recent years - another expected consequence of a rapidly warming climate

eg. in past 30 years cold adapted species in formerly cold seas have declined and are being replaced by warm water species

eg. across the animal kingdom, from fish to mammals, individual animals are getting smaller as temperature increase

eg. armadillos are expanding their range northward
   armadillos arrived in Texas in 1880's and in Florida in the 1920's
   today the armadilla has invaded Illinois, Indiana, Kansas and Missouri

   **and may soon be in Virginia, Maryland and New Jersey**
   some of these changes are genetic → life is adapting and evolving in response to climate change
   the concern is that most species will not be able to adapt quick enough

eg. disease vectors are moving northward; asian tiger mosquito which carries several tropical diseases including malaria is moving northward into the united states and europe

**sea level is rising**

eg. in last 120 yrs sea level has already risen 30" in Virginia beach (land is also sinking)

eg. Naval base in Norfolk is currently replacing 14 of its piers at $60 M each to protect the repair facility

eg. In US ~3.7M people (lower 48) live <3.3’ above sea level
   sea levels are rising faster than originally predicted; by 3-4’ by 2100
   a rise of just 2’ will cause $1 Trillion in US property and structure loss – half in Florida alone

**ocean temperature has increased**

Overall, the world’s oceans are warmer now than at any point in the last 50 years.
The change is most obvious in the top layer of the ocean, which has grown much warmer since the late 1800s.
This top layer is now getting warmer at a rate of 0.2°F per decade.

helps to alter major weather patterns

the arctic is warming faster than predicted (2012)

**extreme weather is getting more extreme**

**oceans are becoming more acidic**

the oceans surface waters are slightly alkaline, 8.1 on a scale where 7.0 is neutral

as CO\textsubscript{2} builds up in the ocean it causes waters to become more acidic

since the onset of the Industrial Revolution, ocean pH has dropped by .1.

by 2100, pH could decline another .3 units and some parts of the ocean may become corrosive to shelled animals

shelled creatures, particularly newborns are unable to make shells

older ones grow slower

oyster and coral reefs are being affected

as oceans warm and become more acidic they are also losing oxygen

estimates are that up to 7% of the oceans oxygen will be lost by the end of the century

many current changes are triggering positive feedback loops that will further exacerbate the effects of climate change:

large amounts of methane exist on the sea floor as liquid lakes

as climate warms methane gas will be released triggering methane eating bacteria

these bacteria will deplete large amounts of oxygen in these ocean plumes

these same processes will produce large amounts of carbon dioxide which will significantly increase acidification of ocean waters

2014 evaluation of future economic costs of climate change over the next 5 to 25 years in US:

- higher sea levels, hurricanes and storm surges will cost up to $7.3B/yr in US
- up to 20% loss in crop production/yr in US
- up to $12 B annual increase in energy production in US

some possible scenarios by 2100:

- up to $507 B loss in coastal property
- 70% loss of average annual crop yields
- over 80% of the Amazon rainforest will be destroyed by change, deforestation and fires
- lack of water, crop failure and rising sea levels could force up to 200 M people from their homes by 2050
- millions of people in India and China depend on monsoon rains to water their corps and for drinking water.

2. **Habitat Destruction** (affects 100%)

mainly affects land based ecosystems

N America and Europe have little virgin ecosystems left

as land was settled, forests were destroyed

eg. by 1870 Tennessee had only 5% of its original forests

in Africa, ~ 2/3’s of all natural areas have been sacrificed for farming or other human uses.

- today, almost all loss is in undeveloped countries

- each year an area the size of Washington state is cleared
  - ~ 1 acre/second

- a study from the UN Environmental Program (2012)
  - estimates that 90% of tropical deforestation is due to organized crime
  - they control up to 30% of world timber sales
  - ~ one third of world’s amphibian species are threatened with extinction
  - main cause is habitat destruction

These monsoons will become much more irregular and much less dependable

- frequency of fires in Australia will rise by 10-50% as land becomes considerably drier

- recent research (2005) indicates that up to 1/3rd of all species will be driven to extinction by 2050 due primarily to global warming

- combined threats of higher sea levels, increased temperature, acidification and and loss of oxygen could cause the irreversible loss of coral reefs in the next 50 or 100 years

**food production is decreasing**

**heat stress on populations is increasing**

New (2008) analysis of Neanderthal genome suggests that they went extinct because their DNA could not adapt quickly enough to climate change after the last ice age
3. **Hunting & Collecting** (affects 60%)

- in 1980's up to 19 M mammals, birds and reptiles were hunted and killed in the amazon
- today hunting affects
  - 42% of recent bird extinctions
  - 33% of recent mammal extinctions
- 90% of large predatory marine fish (eg. swordfish, marlin, and tuna) have been wiped out by overfishing
- use of the internet has dramatically increased the illegal trade in wildlife products
- includes:
  - **hunting**
  - **commercial trade in endangered species and products**
  - **traditional medicines**
  - **exotic pets**
  - **plant collecting**
  - **predators and pest control**

a. **hunting**

- some of earliest extinctions affected by humans
- **eg. Pleistocene Extinctions**
  - 70-80% of all large mammals in the Americas

- due mainly to global warming from last ice age combined with human effects of hunting large game
- many genera of larger birds and mammals went extinct
- 50% of large mammal genera became extinct
- (eg. 33 lg mammal genera vs 13 lost in preceeding 2 million years)
- **eg. Passenger Pigeon (Ectopistes migratorius)**
  - inhabited eastern N America
  - 200 yrs ago was the world's most abundant bird
  - \(3-5\) Billion
  - once accounted for \(\sim 1/4^{th}\) of al N Am birds
  - \(1830's\) Audubon saw a single flock estimated at 80 sq miles (~1 Bill birds);
  - took 3 hours to pass overhead
  - when they roosted in the forest
  - roost sometimes covered 40mi long x 30 mi wide
  - almost every tree had nests
  - ground would become covered with several inches of dung
  - were easily slaughtered for meat
  - large groups of hunters would congregate at these roosting areas
  - birds wouldn't fly away if threatened
  - hunting reached height after civil war
  - \(1879\) bird carcasses were sold for 50¢/dozen
  - \(\rightarrow\) pigeon hunters made $10-40/day (240-960 birds)

- over 20 yrs of hunting and habitat loss at end of 1800's the population was decimated
- last wild bird was shot in 1900
- last individual (Martha) died at the Cincinnati Zoo in 1914
- **eg. Buffalo**
  - 1800's were 60 M in US
  - \(1860's\)
    - coming of RR gave easier access
    - millions killed for hides
    - 100,000's for tongues
    - to "get rid" of indians
  - Buffalo Bill killed 4280/18 months
  - \(1894\)
    - last wild bison was shot in Colorado
    - there were 250 left in captivity
- **eg. elephants**
  - hunted illegally for ivory
  - 22,000 elephants are killed each year in africa (3% of the population is lost/yr) (<600,000 left)
  - mostly for carving religious and ceremonial objects
  - especially in China (status symbols)
  - recently, 6.2 tonnes of seized ivory was destroyed from about 700 slaughtered elephants
  - some of the money from ivory poaching supports terrorist groups such as al-Shabaab
eg. Whaling
not only can hunting cause a direct loss of species but it can also significantly affect climate change
a new (2010) study estimated that commercial whaling in the 20th century reduced the biomass of whales from 110 million tonnes to ~ 5 million tonnes
this resulted in an input of 385 million metric tonnes of CO2 into the atmosphere
→ equivalent to the amount produced by driving 128,000 Hummers for 100 years
→ or burning a temperate forest the size of Alabama
eg Sharks
100 M sharks are killed each year, mainly for their fins (to make shark fin soup)
many species are now in decline
b. Commercial Trade in Endangered Species products
despite legal protection in many countries, products from endangered species are widely traded within and between nations
WWF estimates >$100 M of wildlife and wildlife products are illegally traded in US each yr
WWF est 1/3rd of all wild animals, plants and products enter US illegally each year
developing countries in Asia, Latin America, Africa (with richest biodiversity) are main sources of wild animals and products
eg. world trade in butterflies & moths→ $100 M/yr
→ esp Papua New Guinea
eg. Tiger
5000-7000 on planet; most are captive
skins up to $100,000 each
bones → more value → oriental medicine
eg. African Elephant
1980: est 1.3M elephants
2014: est <600,000 elephants left
in 2011 (NG) elephant poaching reached its highest levels in a decade; 25,000 elephants were killed by poachers even though almost every country has banned international trade in ivory
347,000 lbs of ivory were seized in SE Asia in 2011; almost 40% of it in China & Hong Kong
much of the ivory is used to make catholic and muslim religious icons, amulets and charms
especially in the Phillipines where smuggling ivory for carving "Santo Ninos" is considered an act of devotion
eg. Polar Bears
shot from planes for fun
eg. Japan, Taiwan, Hong Kong
→ buy 3/4ths of all cat & snake skins
eg. an Albino Python brings $20,000
the internet is becoming the most important driver of global trade in rare and endangered species
WWF (2008) found >7000 species were illegally traded for $3.8 M on auction sites, classified ads, chat rooms
most in US but also Australia, Europe, China and Russia
c. Traditional Medicines
the greatest overexploitation of larger animals today is connected with the production of products for traditional eastern medicines
26,000 species are directly endangered by illegal “drug” markets in E. Asia
"Chinese pharmacies are sucking up the world’s wildlife like vacuum cleaners"
→ Judy Mills, WWF
the healing power if these concoctions is believed to be due to the magical properties of the animal; the true therapeutic value of these treatments has rarely been demonstrated
eg. seal penises → improve sexual potency
bears gall → fight dysentery and jaundice
cobra blood → cures nearsightedness
undershell of land tortoise → promotes bone development in children
earthworms → cure nerve spasms
eg. tiger products alone:
a single tiger can bring $325 ,000 when fully processed:
fat → treats leprosy (India)
claws → tranquilizers (Laos)
skin of ear → heals dog bites (Laos)
teeth → soothes fevers and sore genitals (Laos)
ground bone → salve for rheumatism (Vietnam)
testicles → treatment for TB
stomach → cure upset stomach
eg. Black Rhino
~3000 alive today
killed for ivory (horns)
→ aphrodisiacs
powdered horn sells for $28,000/kg
eg. at least 165 reptile species are used in folk medicine concoctions around the world
88 of these are on the endangered species list (2008)
the efficacy of most treatments has not been investigated
90% of the ~2000 medicinal herbs traded worldwide are not cultivated
→ they are collected in uncontrolled way
eg. Spain → 75M thyme plants/yr are pulled up roots and all
e.g. US most yew trees in US have been destroyed for bark & needles → used to produce medicine approved for treatment of ovarian & testicular cancer
wild ginseng → roots used as aphrodisiac
d. Exotic Pet Trade

even though many species are not endangered yet exotic pet collection takes heavy toll on wild animal populations
in US (1980’s):
- 500,000 birds sold as pets
- 2M reptiles
- 1M amphibians and mammals
- 128M tropical fish
some are illegally imported
eg. birds
- 5M live birds are sold worldwide
in US (1980’s): 500,000 birds sold as pets
European Countries →buy 3/4th’s of live birds
bird collectors will pay $10,000 for a rare hyacinth macaw from Brazil
$12,000 for a pair of golden-shouldered parakeets from Australia
mortality rate of live animal trade is enormous:
→~50 animals caught or killed for every live animal that gets to “market”
eg. Tropical Fish Trade
exotic fish support a $4B/yr aquarium industry
75% of all saltwater aquarium fish come from reefs of Philippines and Indonesia
e.g. 1.5M kg of coral/yr is harvested for aquarium trade and gift shops
esp in US-florida (1989 imports were banned)
~1/3rd from Philippines
e. Live Plants
US→ buys 99% of all live cacti
1990 ~1M cacti were shipped from Mexico to US up to $1000 for a rare specimen
75% of all orchids
4. Bioinvasions (exotic animals and plants)
30-40% of organisms on US endangered species list are there at least partly due to bioinvasions
most invasive species that arrive are unintentional introductions
but many are exotics that are legally imported

In the US, the US is the world’s largest importer of alien species
over 2000 species of exotic vertebrates and invertebrates have been imported legally to the US
→ 13% of these have known risks for disease and adverse effects on native wildlife
bioinvasive plants cost US farmers >$10 Billion/yr
sometimes intentional, sometimes accidental
eg. 7300 species in N. America were introduced species
including ~5000 plants and ~2300 animals
eg. nearly 84% of coastal waters around US have been invaded by nonnative species
eg. estimates are that 10,000 aquatic invaders are in transit at any one time
most organisms that arrive on foreign soils fail to establish themselves
eg. only ~15% of nonnative plants become invasive
a few become established and are beneficial
eg. seaweed in Hawaii has become a major part of diet for endangered green sea turtle
about 10% of exotics that become established have some major ecological effect
effects of invasion can ripple through ecosystem → as ecosystems lose their diversity they become more susceptible to collapse
in US: invasive non-native organisms have contributed to the decline of 42% of federally listed threatened and endangered species
the proliferation of 79 of these bioinvaders on land has cost the US economy $97B
coastal invaders in US cause $120Billion in damage to coastal fisheries and ecosystems each year
bioinvasions have particularly severe effects on islands and in freshwater ecosystems
Exotic Species can invade new areas in a variety of ways:
a. stowaways in container traffic

b. ballast water

28,000 merchant vessels in world
1 lg bulk carrier can use 50 M gallons of water as ballast
even an "empty" set of tanks can contain several
can suck in fish, shellfish larvae, algae, plankton sediment with its organisms

c. Air Traffic

eg. brown tree snake in wheel wells of planes from Guam
d. Agriculture, Forestry, Ranching, Aquaculture

is based on effective bioinvasion (20-70% of sp in croplands are exotics)
but can bring in unexpected pests, parasites and predators

→ croplands are home to:
50,000 plant pathogens
9,000 insects and mite species
8,000 weed species

→ 40% of worlds 155 major crop pathogens now have a worldwide range

cattle can radically alter plant communities (eg hill country)
e. Biotechnology

newest potential threat – don't know enough about its effects
1000's of transgenic crops are growing; given disease resistance, tolerance to herbicides, etc

don't know yet whether these new genes can "escape" and get into pest species
or affect ecosystems in unknown ways

Exotic Species can reduce native species in several ways:

a. direct predation
b. new herbivores on threatened plants
c. may outcompete natives for resources
d. may alter natural cycles
e. may interbreed with natives
f. can transmit new diseases or cause death

Examples of Bioinvasive Species in US

eg. many nuisance birds (starlings, sparrows, pigeons are alien and were brought here from Europe on purpose
eg. cats kill between 1.4-3.7 Billion birds/yr in US
they kill at least 7 Billion small mammals/yr in US
even more devastating effects on islands where there is a larger number of threatened or endangered birds and small mammals

eg. Kudzu “the vine that ate the South”
among the fastest growing plants on earth
introduced to US from Japan in 1876 as an ornamental plant and to control erosion
is now a serious pest across more than half of the US.
It grows too quickly for manual cutting to be effective
researchers are experimenting with biological controls such as fungi, viruses and insects that attack the plant but these also attack beneficial plants
will become even more of a problem with climate change

eg. Hydrilla (Hydrilla verticillata)
native to Africa, Australia and parts of Asia
freshwater plant in ponds, lakes, reservoirs introduced to Florida in 1960
millions spent each year to control it combatting it in central Texas by lowering lakes each year and introducing sterile Carp to eat it

eg. zebra mussel

named for distinctive striped shell pattern
arrived in US in 1986 via ballast water from European freighter into Lake Erie
now found throughout the Great Lakes
voracious eaters that disrupt food chains by competing for same food as native species
extremely fertile and can disperse at any stage of life
able to strongly attach to any hard surface by tough byssal threads

→ have found 15000 attached to a single 4" clam
able to completely boc k water inlet pipes of water treatment plants and power plants
highly costly to remove
have been found clinging to boats and are quickly spreading throughout the US
not yet in Texas but already have been found in Oklahoma

eg. Fire Ants
originated from South America
today in 13 states in east and occasionally found along california coast
fire ant densities in US are 10 x’s greater then their numbers in south America
experimenting with phorid wasp parasitoid recently found a lethal virus that infects fire ants

eg. Tamarisk tree
suck up water along Rio Grande and promote flooding by blocking water channels with dense growth

eg. a "worst case" fiasco (Laycock, Alien Animals)
before Columbus Jamaica was a green jungle
1494 Capt Bligh and others imported sugar cane to the island, cleared forests and set up plantations
black rats from the ships also came ashore and thrived
rats ate sugarcane and became a major pest by the 1600's researchers found that the "Tom Raffle" ant could kill young
rats → it was introduced into Jamaica to try to control the rat population
worked for a while but then the ants also became a major pest and the rats continued to thrive
imported the "giant African toad" (Bullfrog, 7.5 lbs) that was known to eat rats and ants
the toad ate rats but didn’t eat the ants; rats quickly recovered
in 1872, mongoose (cobra killer) was introduced → a voracious predator; 4 males, 5 females
in 6 months saw a noticeable decrease in rodent population
they were so overjoyed with their success that the mongoose was imported into Cuba, Puerto Rico, Barbados, etc
didn’t consider:
1. its mostly diurnal (day); rats are mainly nocturnal
2. have an extremely rapid reproductive rate
3. mongoose is a voracious eater: eats rodents, insects, snakes, birds, amphibians, vegetation
as rats dwindled and mongooses increased they began to attack:
garden patches
poultry
young goats, lambs, pigs, kittens, puppies
bananas, pineapples, corn, sweet potatoes, coconuts, etc
by end of 1800’s the mongoose was considered the greatest pest ever in Jamaica → caused near extinction of several species → increased insect pests as their natural predators dwindled

Organics
Prescription drugs, caffeine, and other medications can pass through both the human body and sewage treatment facilities
Some of these may be toxic to aquatic life
Others, especially steroids, estrogen, testosterone and similar regulatory hormones, are likely to interfere with the development of organisms.

eg. Eutrophication
easily decomposed organic matter; eg sewage, fertilizers, some detergents, feedlot runoff
cause rapid decomposition by microorganisms
consumes all oxygen in water and causes fish kills
eg. "dead zones" in Gulf of Mexico
from nutrient enrichment from Mississippi drainage; fertilizers and organics
this dead zone is one of the largest in the world and covers up to 7000 sq miles
causes major fish kills and kills benthic fauna

eg. Sedimentation
sediments eroded during construction or agricultural practices are washed into waterways
damages fish spawning grounds and smothers bottom dwelling organisms
a major cause in the decline of coral reefs

5. Air, Water and Land Pollution (10-15%)
esp coral reefs, freshwaters, northern forests (acid rain)

eg. Acid Precipitation ("Acid Rain")
especially from sulfate and nitrate pollutants
especially from coal fired power plants
→ react in the atmosphere to form sulfuric and nitric acid
affects mostly the northeastern US, E Canada and Eastern Europe
can be deposited as rain, snow, fog or on dry particles in the air (not just 'rain')
over time can acidify soil and damage or kill vegetation
and lower the pH of ponds and lakes to kill aquatic fauna
eg. 2% of New England lakes are acidic enough to no longer support brook trout

eg. Hazardous Chemicals
→ there are 77 trillion pounds of hazardous wastes generated annually in US alone
→ equivalent to over 19,000 lbs/square mile over entire US land surface
→ 90% is not disposed of properly

eg. Insecticides, Herbicides and other Toxic Organics
Why Should we Care about the loss of Biodiversity?

Of what economic value is nature?

We are slowly beginning to see that one of the main flaws of a market based economy is that the prices of goods and cost of extraction rarely reflect the full value of an untouched ecosystem or the costs of environmental damage and losses when that ecosystem is destroyed.

Traditionally, the only "value" given to nature and natural areas was any Direct Economic Value that could be extracted from it, treated as "raw land".

Natural areas and their biodiversity were given NO direct commercial value. The only potential profits depended on what value could be extracted from it.

The primary focus of most of the world's economy is unsustainable use (destruction) of the world's ecosystems, usually involves a single use, usually resulting in the destruction of the ecosystem.

This market value almost always trumps the moral and ethical values for preserving diversity. Natural areas and biodiversity are given almost no value unless it can be exploited.

Eg. Swamp land is "worthless" unless drained and developed.

Tends to favor unsustainable uses.

Fisheries → overfishing
Mining → damage to land and waters
Timber → loss of forests
Agriculture → loss of prairies and soil

→ the damage & pollution is paid for by the public.

Eg. Superfund sites we pay for with our taxes.
Eg. Mining subsidies make it cheaper to mine raw ore than to recycle metal.
Eg. We actually pay subsidies to coal and oil companies to extract these resources, and then we also pay for the cost of oil spills, water pollution and cleanup by taxes & medical bills we pay for oil spills and pollution they cause.

In the past it has been extremely difficult to calculate the equivalent monetary value of "unspoiled nature".

We are only now beginning to appreciate that nature has an intrinsic worth of its own.

How to estimate the value of Biodiversity

I. Aesthetic, Cultural, Moral and Ethical Values

Eliminating a few species won't cause ecosystem collapse.

Probably won't irreversibly affect human progress.

But do we have the right to "play god"?

Not only with individual lives, but with whole species and ecosystems.

Do we need "divine permission" to kill them?

Do species have a moral right to exist independently of our need for using them?

Is it our duty to be global stewards?

How do you put a price on this value?

Eg. Companies hiring in Oregon have found that potential employees are willing to take less pay (~$500/month) to live and work in Oregon.

→ Combined total is equal to all of the state's lumber and wood products payrolls.

Above and beyond our current economic systems, but as we learn to weigh the value of preserving nature against the immediate financial return resulting from its destruction we are beginning to realize that quite often these short term financial gains are much less than the economic value of leaving nature "unspoiled".

We are only now beginning to appreciate that nature has an intrinsic worth of its own.

This market value almost always trumps the moral and ethical values for preserving diversity.

Natural areas and biodiversity are given almost no value unless it can be exploited.

Eg. Swamp land is "worthless" unless drained and developed.

Tends to favor unsustainable uses.

Fisheries → overfishing
Mining → damage to land and waters
Timber → loss of forests
Agriculture → loss of prairies and soil

→ the damage & pollution is paid for by the public.

Eg. Superfund sites we pay for with our taxes.
Eg. Mining subsidies make it cheaper to mine raw ore than to recycle metal.
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II. Social and Human Costs of Nonsustainable Uses

e.g. people living in greener surroundings suffer significantly less from numerous health problems and therefore significantly reduce medical costs

e.g. coronary heart disease
neck and back complaints
depression and anxiety
respiratory & urinary tract infections
asthma, migraines, headaches, diabetes

e.g. as rainforests are cleared there is usually a dramatic increase in land degradation and pollution that is borne by the indigenous people

greater chances of droughts or floods
new agricultural pests
loss of topsoil
sedimentation of streams and rivers
diminished yields from their crops
fewer fish in streams
shrinking supplies of game, fruits, nuts

e.g. also the indigenous people usually suffer directly due to rising:
alcoholism
drug abuse
domestic violence
homelessness
emigration

etc.

these costs are not part of the profit plan of the companies destroying these resources
they are paid for by the government and indirectly by the citizens themselves through taxes

III. Sustainable Uses of Biological Resources

there are some methods of harvesting products that cause no long term harm to ecosystems
rather than a single use it can be used over and over

today this is a relatively small (but growing) part of the world economy

eg. lumber
rainforest timber could be harvested sustainably but today only ~0.1% actually is logged this way

eg. non wood products
many important compounds come from or were 1st discovered in wild organisms
e.g. rubber tree, antibiotics, aspirin, dyes, foods and spices, etc

eg. "ecotourism"

tourism, if properly planned, can become one of the largest sectors of a sustainable world economy
→ transforms wilderness into prosperity

>100 countries have adopted our system of parks as a model

e.g. Kenya
→ tourism is the largest single source of income for the country

e.g. 1 ha of land in Kenya’s Amboseli(?) National Park brings in $40/yr; a similar area used for agriculture brings in $1/yr

IV. Future Economic Potential

e.g. Gene Banks for agriculture and livestock

foundation for all agricultural plants and animals
all modern crop varieties were originally produced using native plants

eg. Future Commercial Products and pharmaceuticals

e.g. there are attempts to pay indigenous tribes for their knowledge of medicinal uses of plants in their area

V. “Nature’s Services”

only recently have we begun to appreciate the direct economic value of preserving nature

→ what do we get if we leave it alone?

we are slowly learning how to estimate the real economic value of natural areas if preserved and trying to balance that against its economic loss if destroyed

e.g. Habitat and refuge for diversity & nursery areas for commercially important species

e.g. 70% of US commercial fish species use coastal wetlands as part of spawning and nursery areas

while we are overfishing our oceans we are also rapidly destroying these nursery areas

we can use this information to calculate an actual value/acre of wetlands for nursery areas

eg. Water Supply and Flood Control

e.g. removal of wetlands and the construction of levees along the Mississippi have dramatically increased the magnitude and cost of major flood events

the value of leaving the wetlands intact is estimated to be ~ $200/ha in erosion and flood protection

eg. Waste & Nutrient recycling, water purification & Pollution Control

e.g. would cost $100,000/yr to duplicate water purification and fish propagation value of 1 acre of wetland

eg. Early Ecological Warning System
some organisms are good indicators of ecosystem degradation
  - eg. Bald Eagle
  - eg. lichens
  - eg. stream insects & mussels

**eg. Climate Regulation**
- destruction of forests
  - decomposition and burning releases CO₂ into the air
- eg. 1 ha of "carbon storage" function of forests
  - ~ $3000 value

**eg. Pollination and Agriculture**
- >90% of worlds flowering plants are animal pollinated
  - including 80% of worlds 1330 cultivated crop species
- 1/3rd of US agricultural crops is insect pollinated
- eg pollination US valued at ~ $6.7 B/yr(2006)
- honeybee pollination services are 60-100 x’s more valuable than the honey they produce

**eg. Biological Pest Control**
- pesticides used in agriculture kill both pests and beneficial animals as well
  - becomes a vicious cycle of needing more and more pesticides
- loss of these beneficial insects has led to a rise in vector-borne diseases

A new world view of environmental conservation is slowly emerging.

We are beginning to see and understand the interconnections between our environment, our economies and social issues.

Conservation needs to be seen as an **investment** not a cost

We can now make a strong argument that economics are one of the strongest incentives to **preserve** nature rather than to **destroy** it:

an analysis by Cornell University (1997) estimated that throughout the world, the services provided by the myriad species of all forms of life were valued at almost $3 Trillion dollars annually.

  - world GDP (2010) = $60 – 70 Trillion
  - for US alone the value was set at over $300 Billion
  - US GDP (2010) = $14 Trillion

"Economics of Ecosystems" 2010 estimate the value of the earth’s biomes based on "nature’s services and sustainable uses:

  - coral reefs: up to $1,195,000/ha/yr
  - coastal wetlands: up to $215,000/ha/yr
  - other coastal systems: up to $80,000/ha/yr

much wild populations are beneficial in less direct ways:

  - eg. Bat colonies in Texas can eat 250 tons of insects each night

inland wetlands: up to $45,000/ha/yr
rivers & lakes: up to $13,000/ha/yr
tropical forests: up to $23,000/ha/yr
temperate & boreal forests: up to $4,900/ha/yr
woodlands: up to $2,000/ha/yr
grasslands: up to $3,100/ha/yr

these numbers are considered low and still do not yet include as yet unquantifiable values of these ecosystems

Much of our economies were originally set up with no consideration of environmental value

We are slowly changing our economies and technologies to be be more environmentally friendly

**A. Increasing Efficiencies**

  - for **individuals**, modern technologies tend to be less polluting, more energy efficient than those they replace
    - eg. using electricity for light and energy is less polluting than candles and wood stoves
    - eg. the automobile is less polluting and uses fewer resources than the horse & buggy

the problem today is a problem of **scale**; there are so many more people that even thought individual efficiency has increased dramatically, total environmental burden has increased
this is why we need institutional controls and rules; individual efforts are swamped by the total effects
e.g. compact fluorescent bulbs vs incandescent bulbs – choice or requirement?
every dollar spent saves 6 $ on lighting over life of bulb; but “up front” costs are higher

B. Tax Structure

taxes discourage what they tax
traditionally, taxes are levied on wages & profits
→ payroll taxes discourage incentive to work
→ taxes on profits discourage creativity and ingenuity
→ we penalize people for being successful
there is no real “social value” to our taxing system; just easy to do it this way
the very rich pay the least relative to their income
instead our taxing policies could discourage nonsustainable activities
we need to decide what activities should be discouraged and tax them the heaviest

e.g. as we do cigarettes and alcohol today
e.g. carbon emissions & pollution
e.g. toxic wastes
e.g. use of pesticides
e.g. gasoline tax
one estimate of auto costs:
traffic jams
decreased property value
military protection of eastern oil fields
injury and accidents
total cost $400 B/yr US; or 3-5$/gal; we pay less than $1/gal in gas tax

C. Pollution Permits

determine a ceiling of allowable emissions based on past emissions
polluters then have to buy permits if they want to go above their allowable limit
→ auction off “permits to pollute”
if a company wants to drastically reduce their own emissions they could then sell their allocation to another company

C. Subsidies/Tax Credits

some of the money collected in taxes are then used to subsidize various activities
direct subsidies can help to hold down consumer prices or prop up prices for producers
traditional subsidies are needed in some cases for markets to perform “properly”
many of our oldest subsidies are meant only to support resource intensive and environmentally destructive industries
→ worldwide, government subsidies shunt about $500 Billion/yr toward activities that harm the environment
→ these subsidies are paid for by our taxes
many of these subsidies essentially sell resources for much less than their actual value
eg. US subsidizes fisheries fleet at over $700M/yr as most major world fisheries are collapsing and estimates are that we have 50% more boats than we really need
→ each ton of fish uses ½ ton of fuel to catch because of too many boats going after fewer and fewer fish
eg. ~10 yrs ago, California land owners could buy water from the government for $2.80/1000m³; but it cost the government $49 - $325/1000m³ to provide it
subsidies “give away” valuable ecological assets and actually discourage ecological values

e.g. the US has given away almost 1 Billion acres of land and offered cheap access for mining and logging to even more
→ hard rock mining is essentially “free” on public land
eg. in 1994 a canadian company bought over 1500 acres of federal land for $3/acre to get access to the $10 Billion dollars of gold it contained
eg. Oil & coal companies today are heavily subsidized; they are making more profits than ever before yet are directly responsible for only a small fraction of the pollution and damage they cause
we could offer tax credits for companies that encourage sustainable use or reduce pollution
→ if wind and solar got the same subsidies as coal and oil, in a few years we probably wouldn’t need to buy our petroleum from the mideast
carbon emissions and overall pollution levels could be drastically reduced

D. Market Pricing

prices rarely reflect the full costs of resources and environmental damage incurred when making a product
the market system should reflect, not hide, ecological realities of the economy

make producers responsible for their products

e.g. Germany: manufacturers must recover their packaging and reuse or recycle it

e.g. Europe: many rules that require manufacturers to pay for collecting and recycling TV’s, computers, appliances, etc

e.g. computer take back programs

e.g. bottle bills

E. Human Rights Issues

a large part of saving biodiversity may be by promoting human rights issues for the indigenous people

in the past many governments gave away forests for exploiting and made the native tribes move