AP ENVIRONMENTAL SCIENCE

UNIT 9

Global Change

TOPIC 9.1

Stratospheric Ozone Depletion

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.A

Explain the importance of stratospheric ozone to life on Earth.

ESSENTIAL KNOWLEDGE

STB-4.A.1

The stratospheric ozone layer is important to the evolution of life on Earth and the continued health and survival of life on Earth.

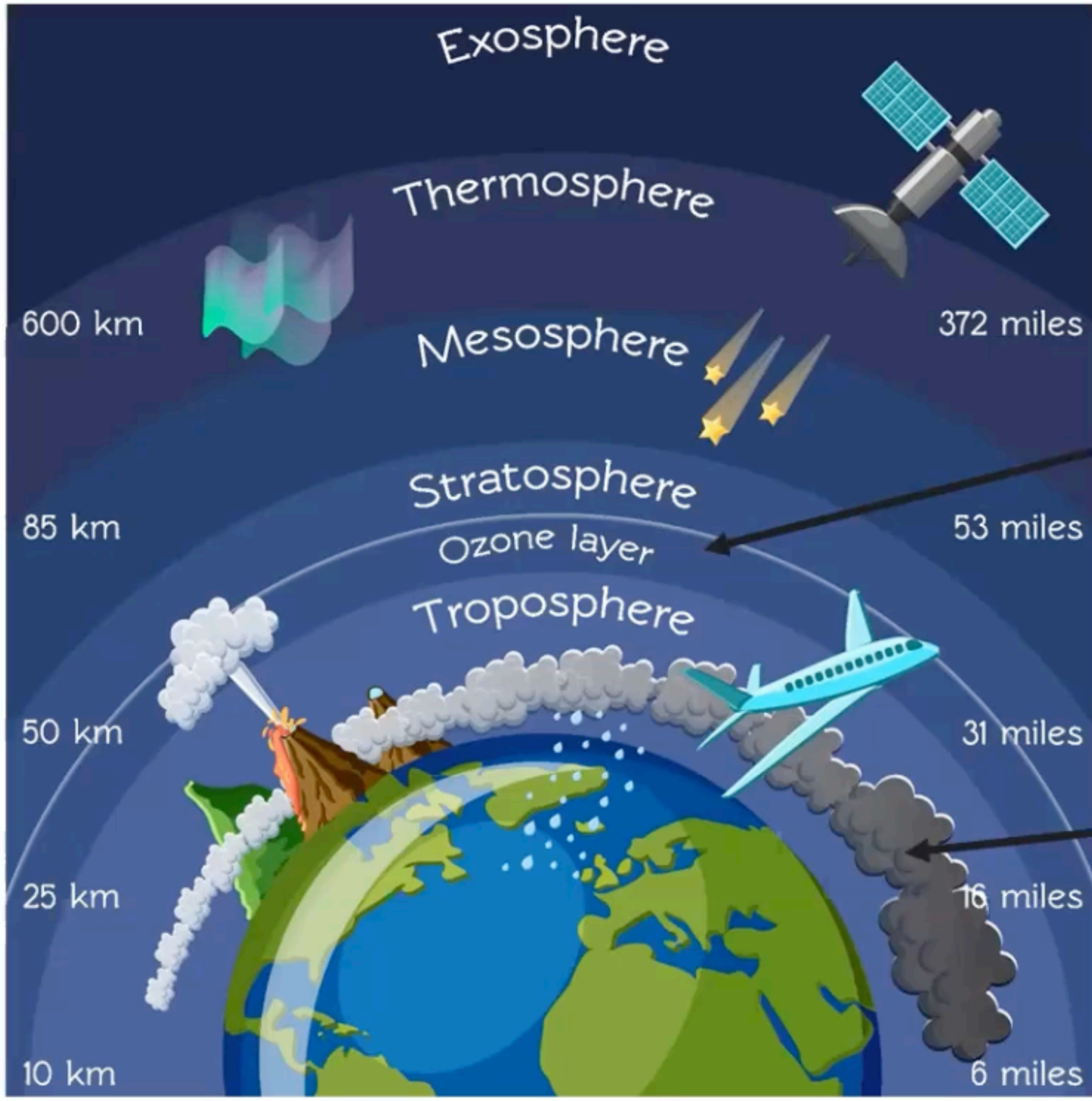
STB-4.A.2

Stratospheric ozone depletion is caused by anthropogenic factors, such as chlorofluorocarbons (CFCs), and natural factors, such as the melting of ice crystals in the atmosphere at the beginning of the Antarctic spring.

STB-4.A.3

A decrease in stratospheric ozone increases the UV rays that reach the Earth's surface. Exposure to UV rays can lead to skin cancer and cataracts in humans.

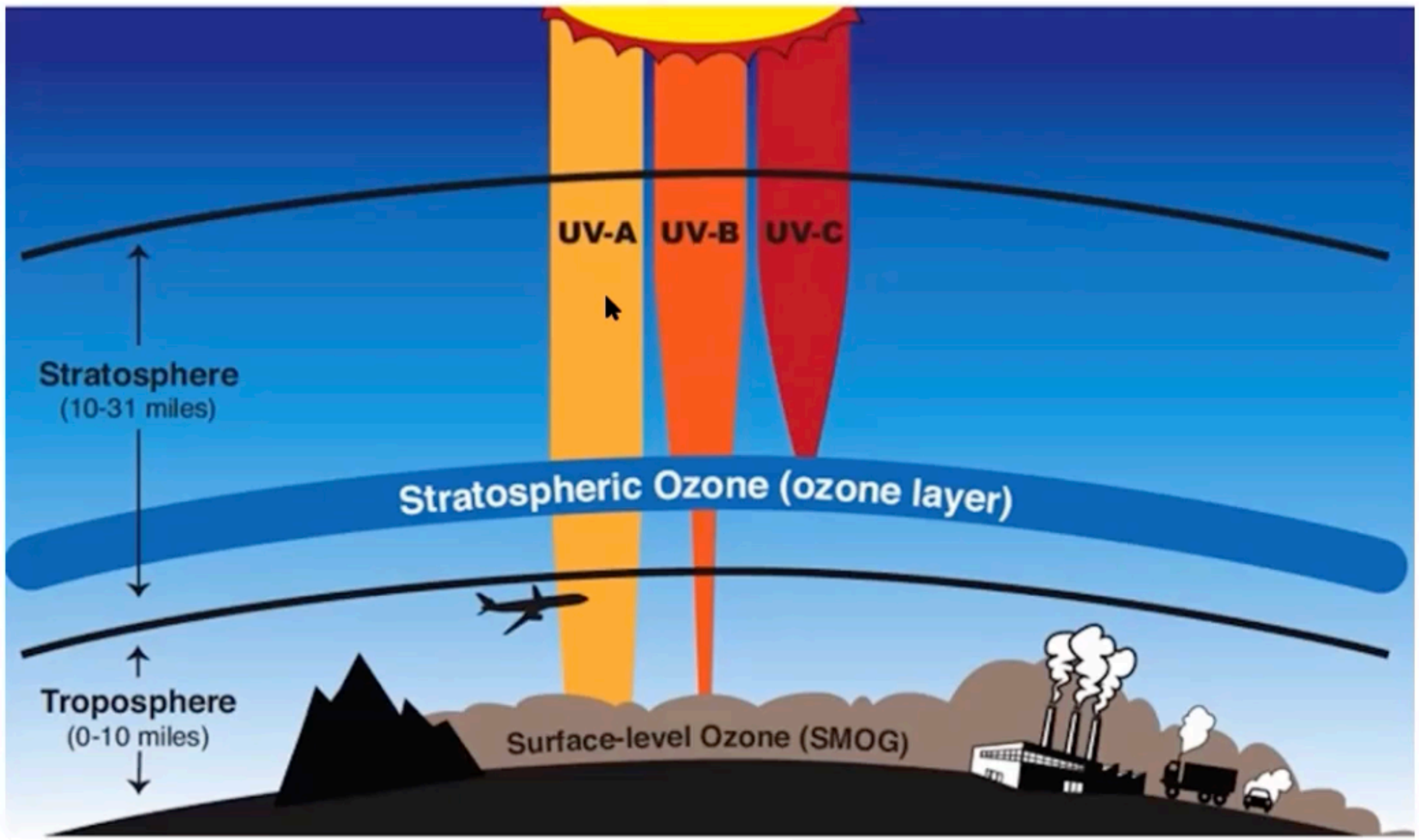
Troposphere vs Stratosphere



- Naturally-occurring ozone (O_3) that provides protection from UVB-UVC rays

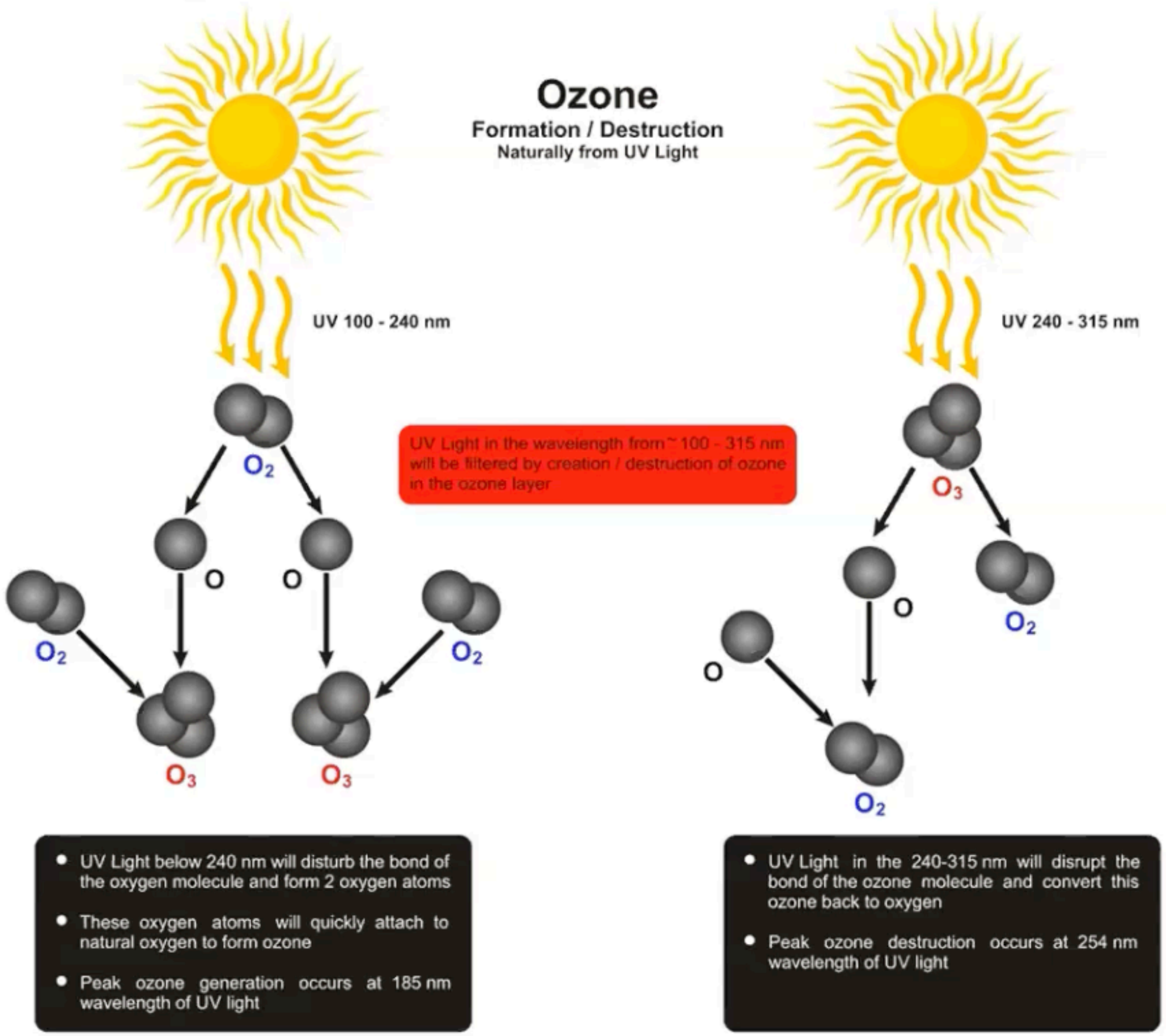
- Ozone (O_3) from photochemical smog; harmful
- Greenhouse gases/greenhouse effect

Stratospheric Ozone



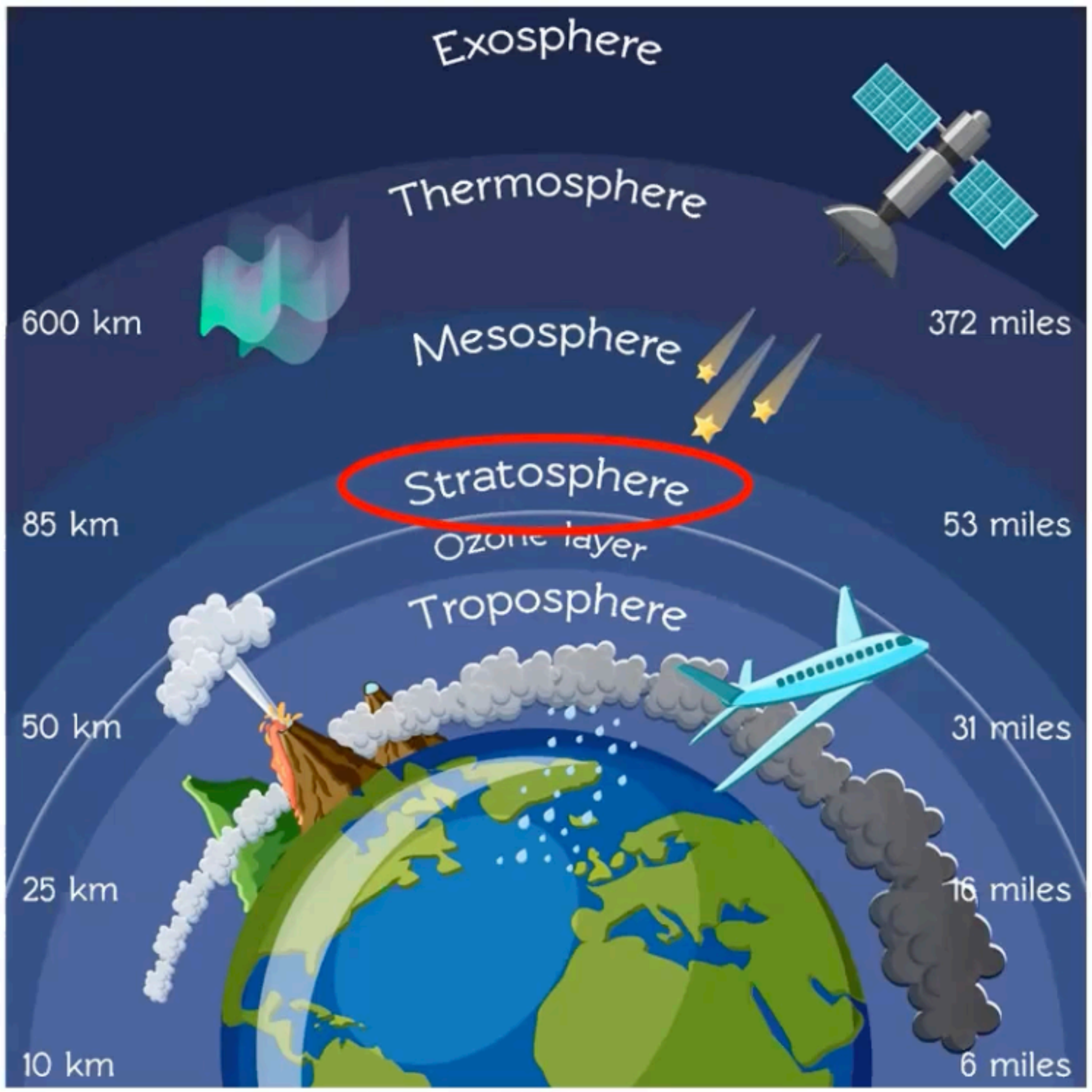
Stratospheric Ozone

UVC



UVB

Antarctic spring

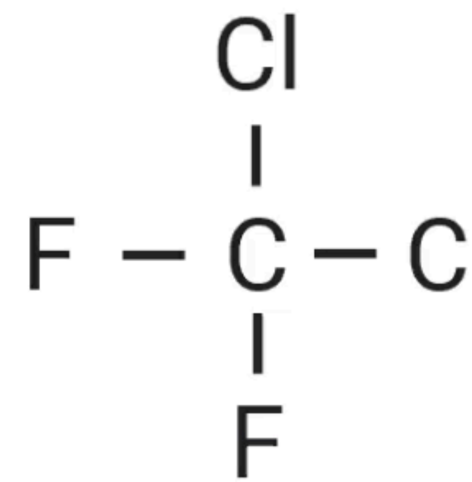


1. Antarctic winters can create stratospheric clouds full of ice crystals.
2. Crystals melt in the beginning of the spring.
3. Chemical reactions convert less reactive chlorine to a more reactive form.
4. Chlorine degrades ozone into atmospheric oxygen (O_2).
5. The ozone layer thins.

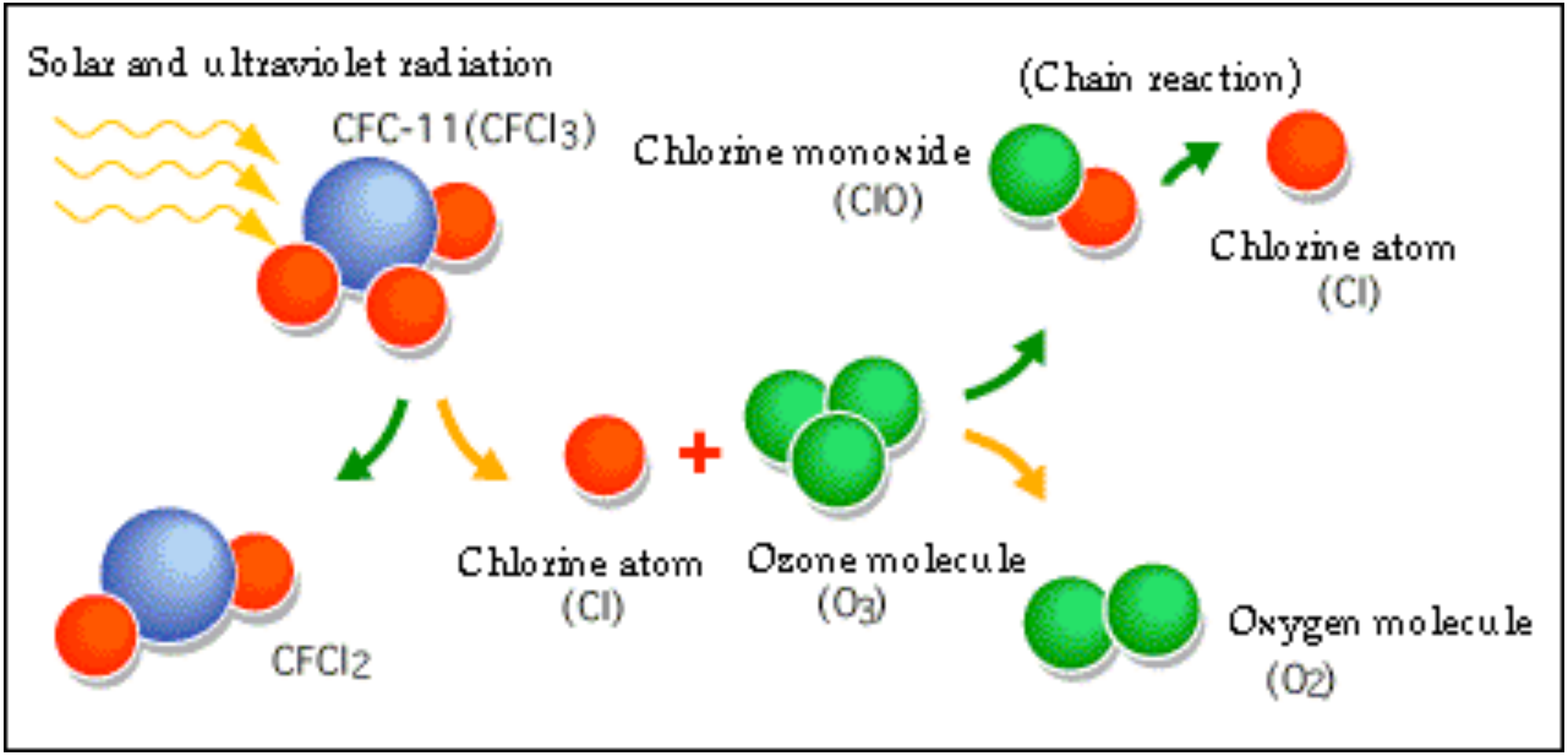
Chlorofluorocarbons (CFCs)

Kuchina/Shutterstock.com

- Refrigerant/ coolant
- Propellant
- Some types of plastics

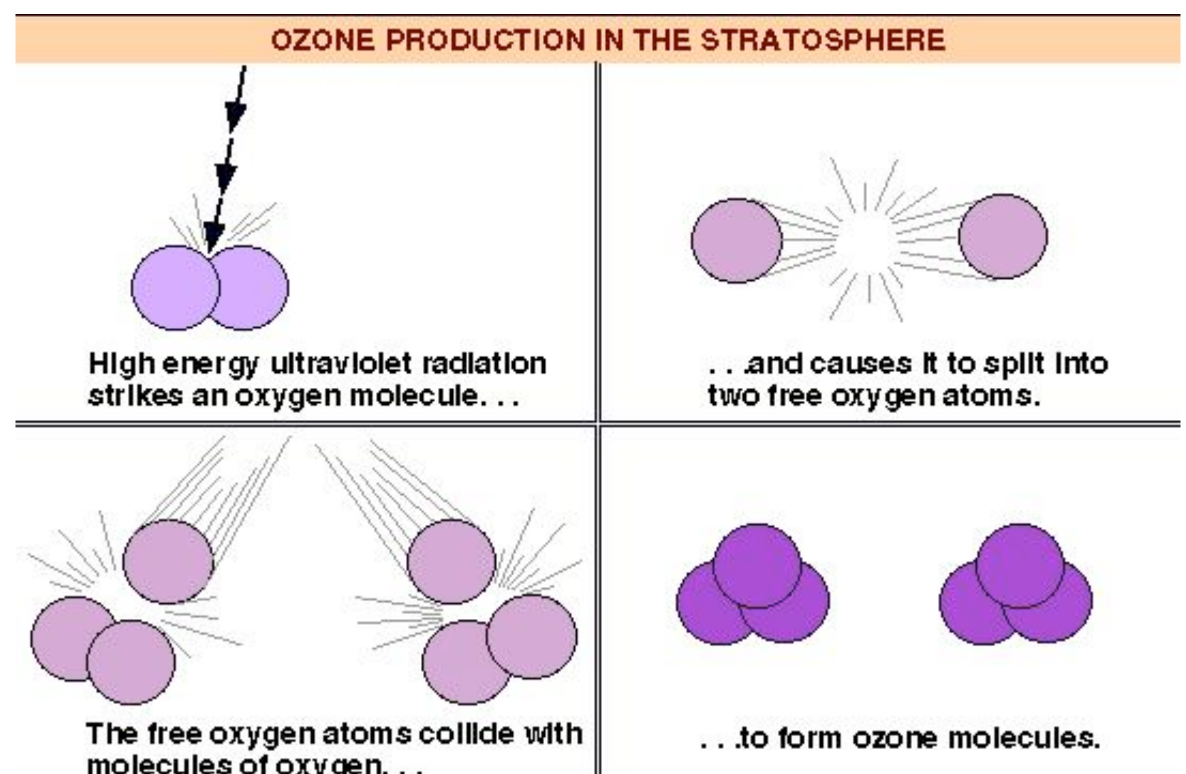


Depletion of Atmospheric Ozone

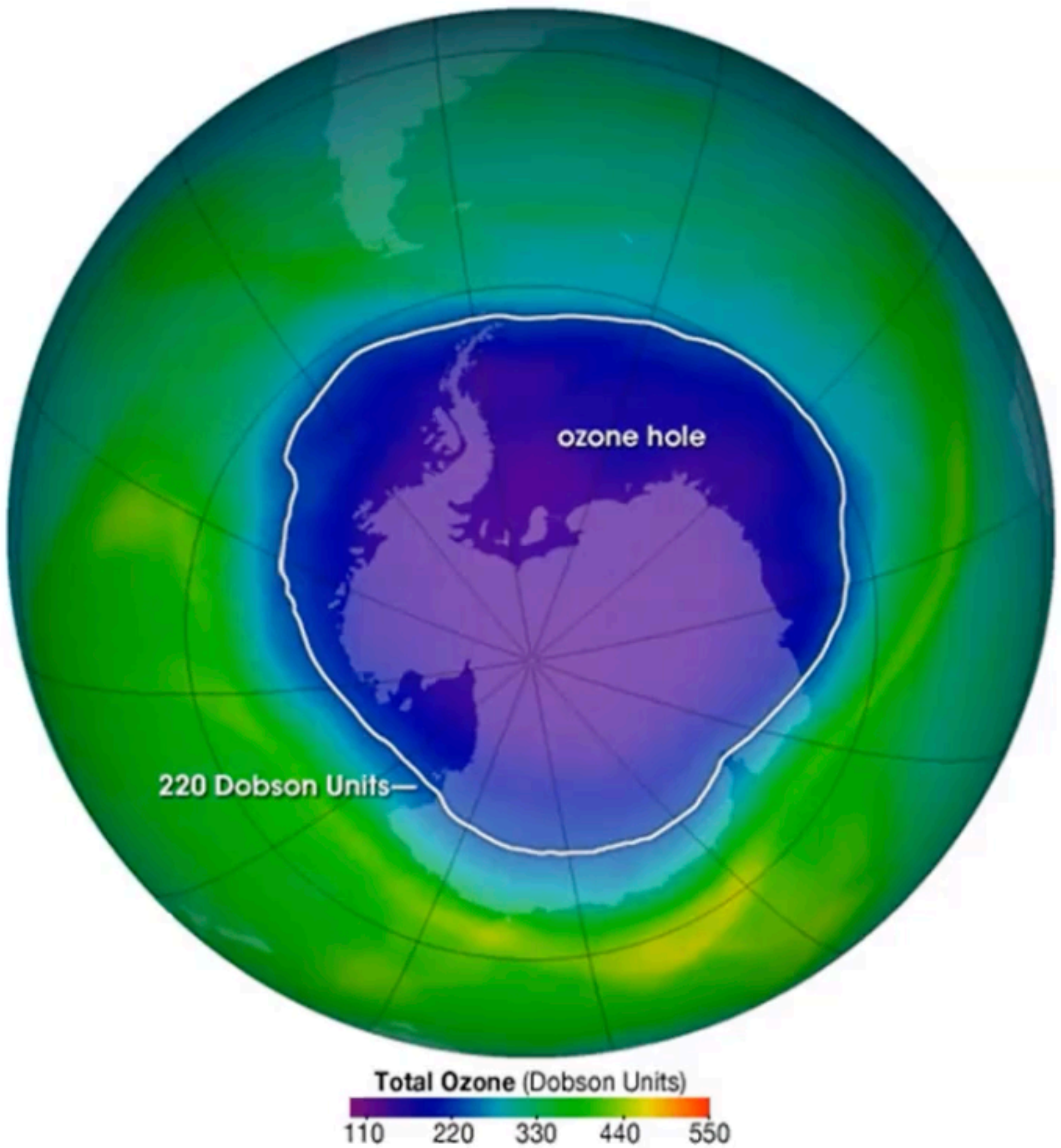


CFC Destruction of Ozone

Natural Production of Ozone



Effects of ozone depletion



Credit: NASA Ozone Watch

1. Thinning of ozone layers, especially at poles
2. Disruption of terrestrial photosynthesis
3. Disruption of photosynthesis by phytoplankton
4. Disruption of food chains/webs
5. Impacts populations of some organisms like amphibians
6. Impacts human health: skin cancer, cataracts

MCQ Practice

Which component of CFCs catalyzes the conversion of ozone into atmospheric oxygen?

- (A) carbon
- (B) fluorine
- (C) chlorine
- (D) hydrogen

MCQ Practice

Which of the following is NOT true about stratospheric ozone?

- (A) Stratospheric ozone thinning increased after the creation and widespread use of CFCs.
- (B) Stratospheric ozone thinning contributes to an increase in skin cancer and cataracts in humans.
- (C) Stratospheric ozone naturally absorbs UV radiation via its formation and destruction.
- (D) Stratospheric ozone thins naturally in the Antarctic every April.

TOPIC 9.2

Reducing Ozone Depletion

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.B

Describe chemicals used to substitute for chlorofluorocarbons (CFCs).

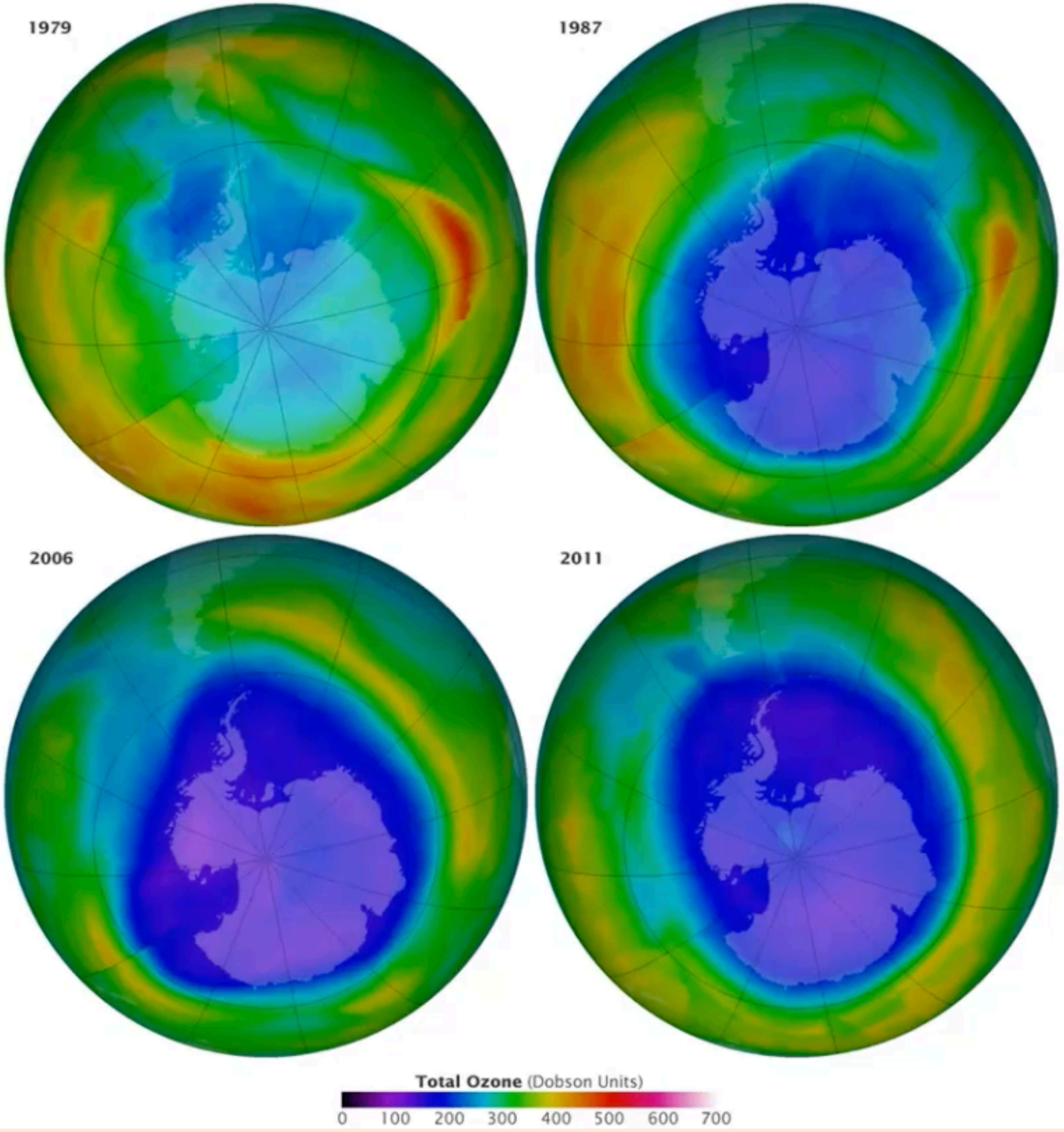
ESSENTIAL KNOWLEDGE

STB-4.B.1

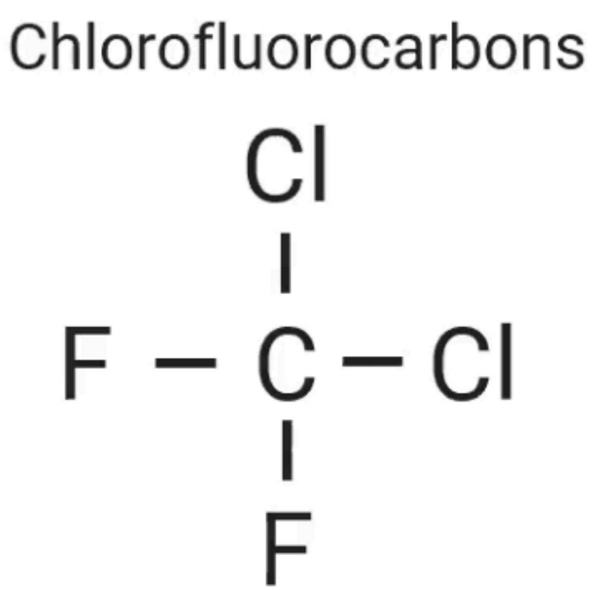
Ozone depletion can be mitigated by replacing ozone-depleting chemicals with substitutes that do not deplete the ozone layer. Hydrofluorocarbons (HFCs) are one such replacement, but some are strong greenhouse gases.

Montreal Protocol

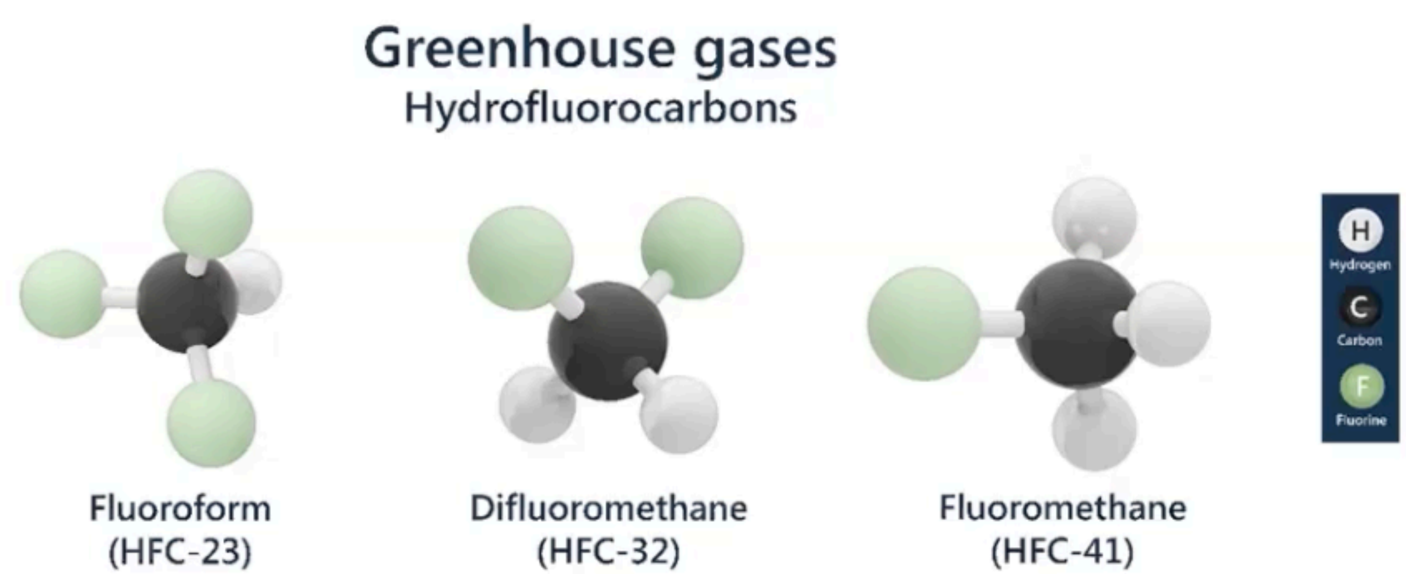
Antarctic ozone



HFCs replace CFCs



Credit: Morris



Orange Deer Studio/Shutterstock.com

- **UV radiation damages DNA, experts expect to see a rise in mutation rates and cancer.**
  - **The effect is unpredictable for crop plants and phytoplankton.**
- Bad News: ozone levels have decreased 2-10% in the last 2 decades.
- Good News: Since 1987, 190 countries have signed the Montreal Protocol (a treaty that regulates ozone depleting chemicals)
- Good News: Most nations have ended the production of CFC's and the ozone depletion is slowing.
- Bad News: The chlorine molecules already in the atmosphere will remain there for at least 50 more years

Ozone depletion mitigation

1. Montreal Protocol:
    - International treaty
    - Reduction/phase out of CFCs
2. CFCs are persistent.
    - It will take decades for CFCs currently in stratosphere to completely dissipate, allowing ozone layer to fully repair.
3. HFCs replaced CFCs:
    - No chlorine to catalyze transformation of ozone into atmospheric oxygen
    - Powerful greenhouse gas

TOPIC 9.3

The Greenhouse Effect

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.C

Identify the greenhouse gases.

ESSENTIAL KNOWLEDGE

STB-4.C.1

The principal greenhouse gases are carbon dioxide, methane, water vapor, nitrous oxide, and chlorofluorocarbons (CFCs).

STB-4.C.2

While water vapor is a greenhouse gas, it doesn’t contribute significantly to global climate change because it has a short residence time in the atmosphere.

STB-4.C.3

The greenhouse effect results in the surface temperature necessary for life on Earth to exist.

LEARNING OBJECTIVE

STB-4.D

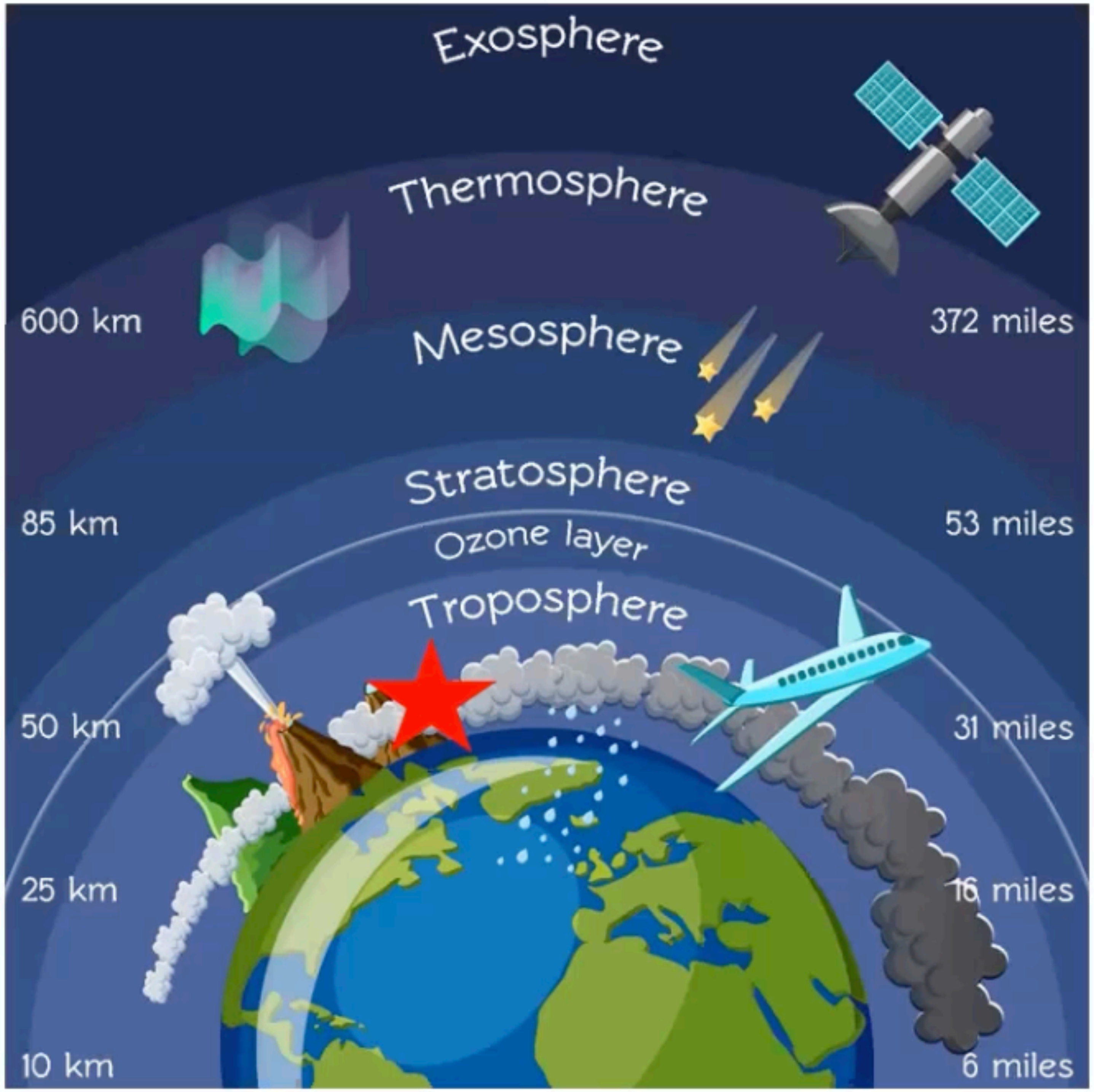
Identify the sources and potency of the greenhouse gases.

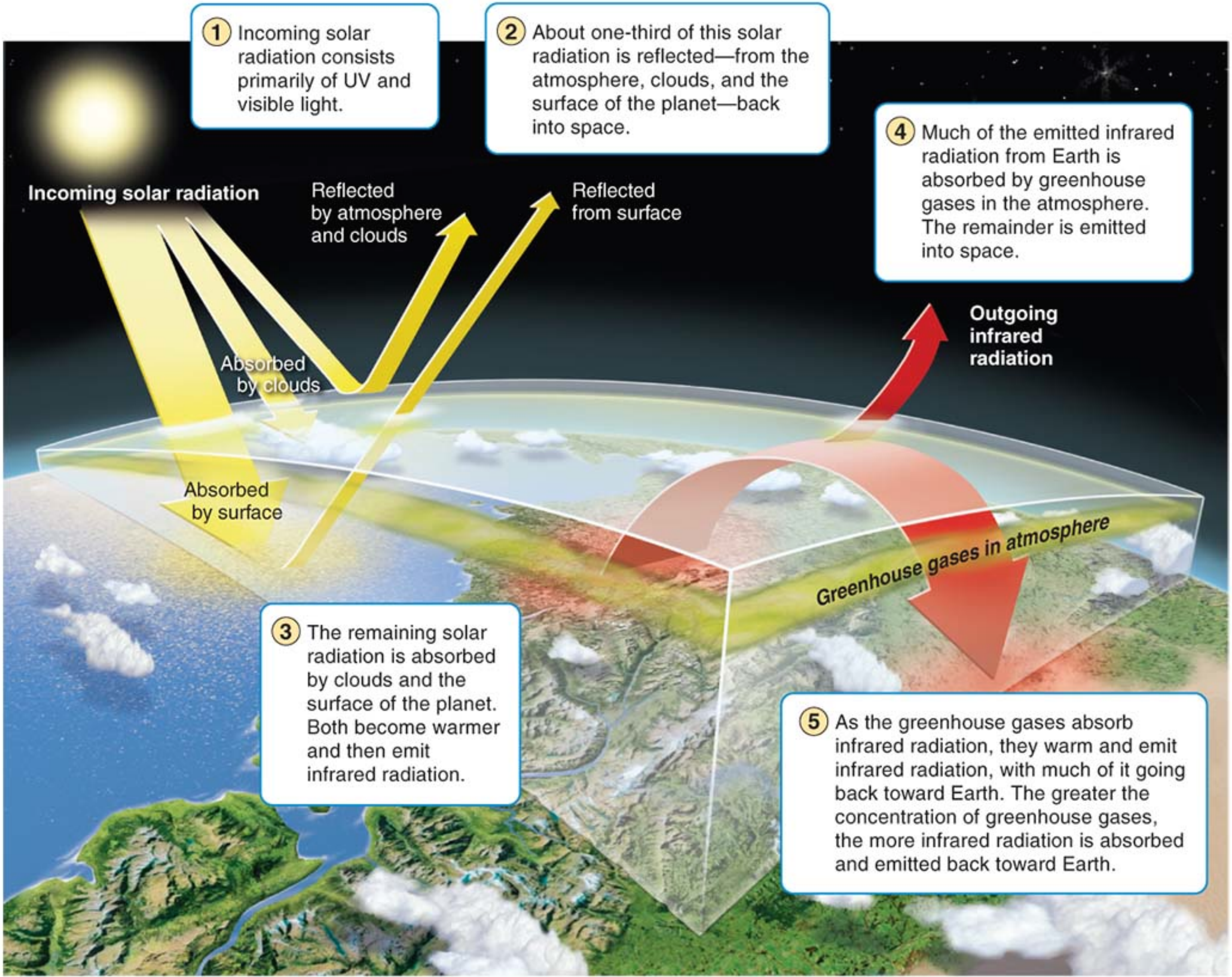
ESSENTIAL KNOWLEDGE

STB-4.D.1

Carbon dioxide, which has a global warming potential (GWP) of 1, is used as a reference point for the comparison of different greenhouse gases and their impacts on global climate change. Chlorofluorocarbons (CFCs) have the highest GWP, followed by nitrous oxide, then methane.

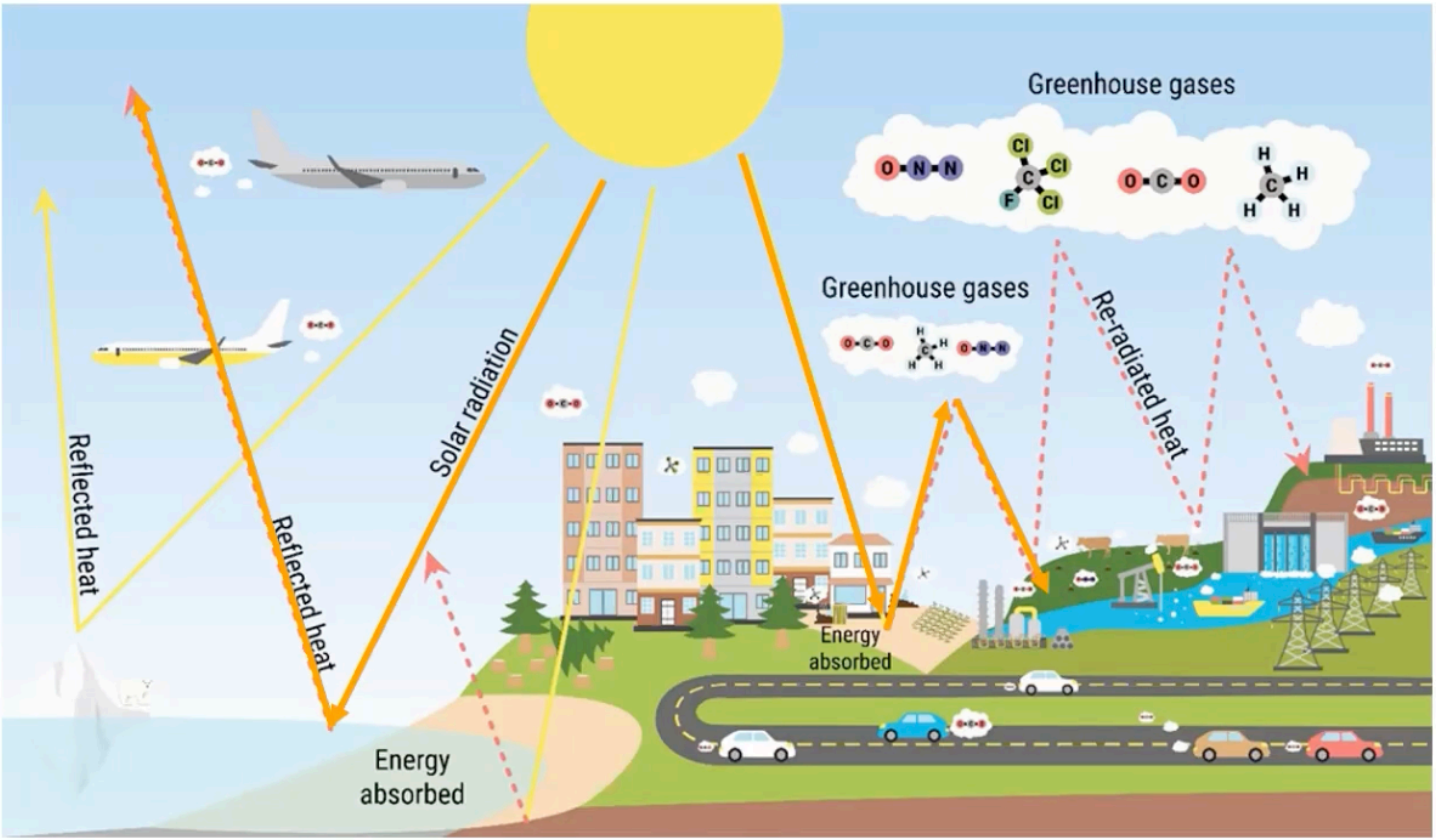
The greenhouse effect occurs in the troposphere





1 Incoming solar radiation consists primarily of UV and visible light.
2 About one-third of this solar radiation is reflected—from the atmosphere, clouds, and the surface of the planet—back into space.
Incoming solar radiation
Reflected by atmosphere and clouds
Reflected from surface
4 Much of the emitted infrared radiation from Earth is absorbed by greenhouse gases in the atmosphere. The remainder is emitted into space.
Outgoing infrared radiation
Absorbed by clouds
Absorbed by surface
Greenhouse gases in atmosphere
3 The remaining solar radiation is absorbed by clouds and the surface of the planet. Both become warmer and then emit infrared radiation.
5 As the greenhouse gases absorb infrared radiation, they warm and emit infrared radiation, with much of it going back toward Earth. The greater the concentration of greenhouse gases, the more infrared radiation is absorbed and emitted back toward Earth.

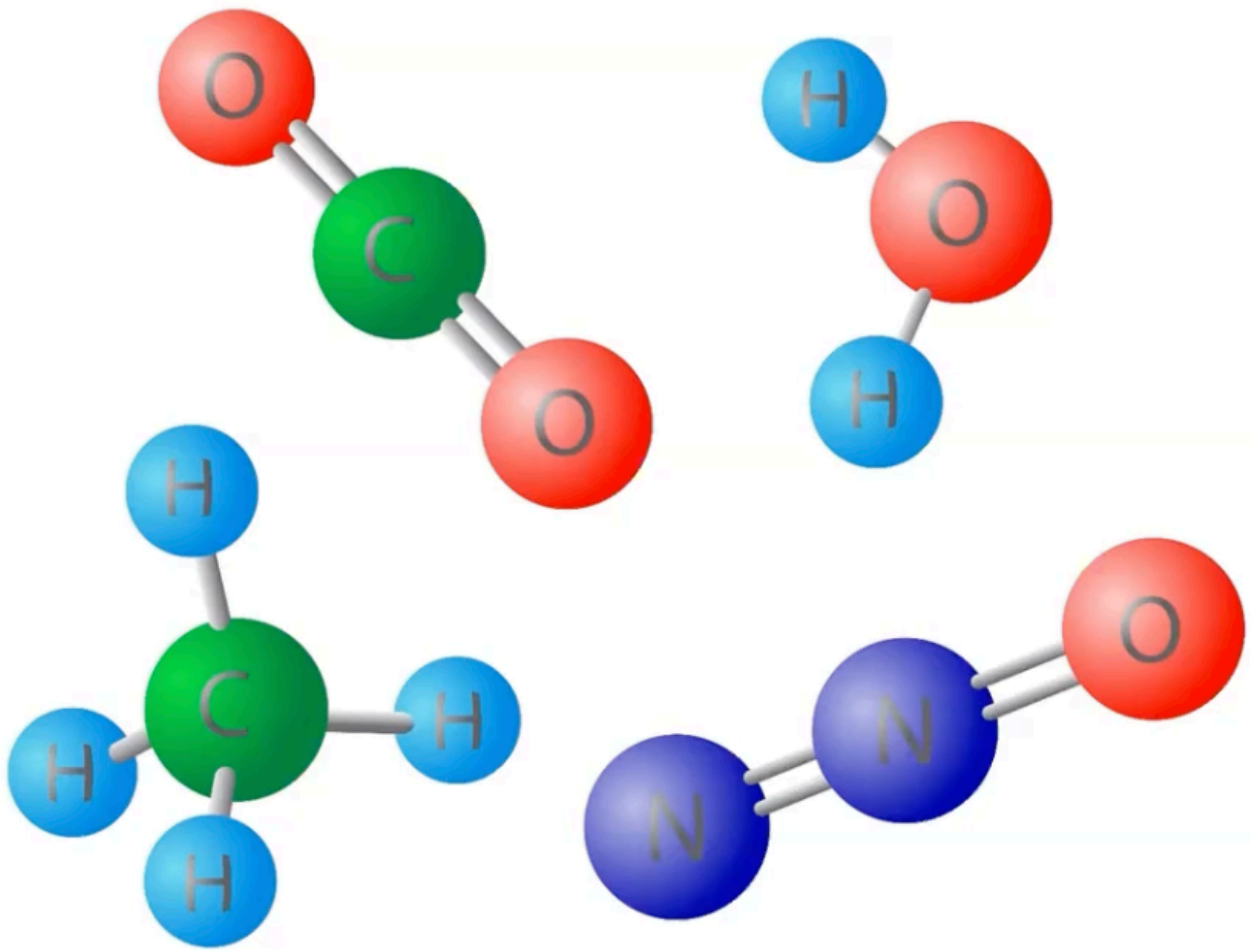
The greenhouse effect



The greenhouse effect keeps Earth warm

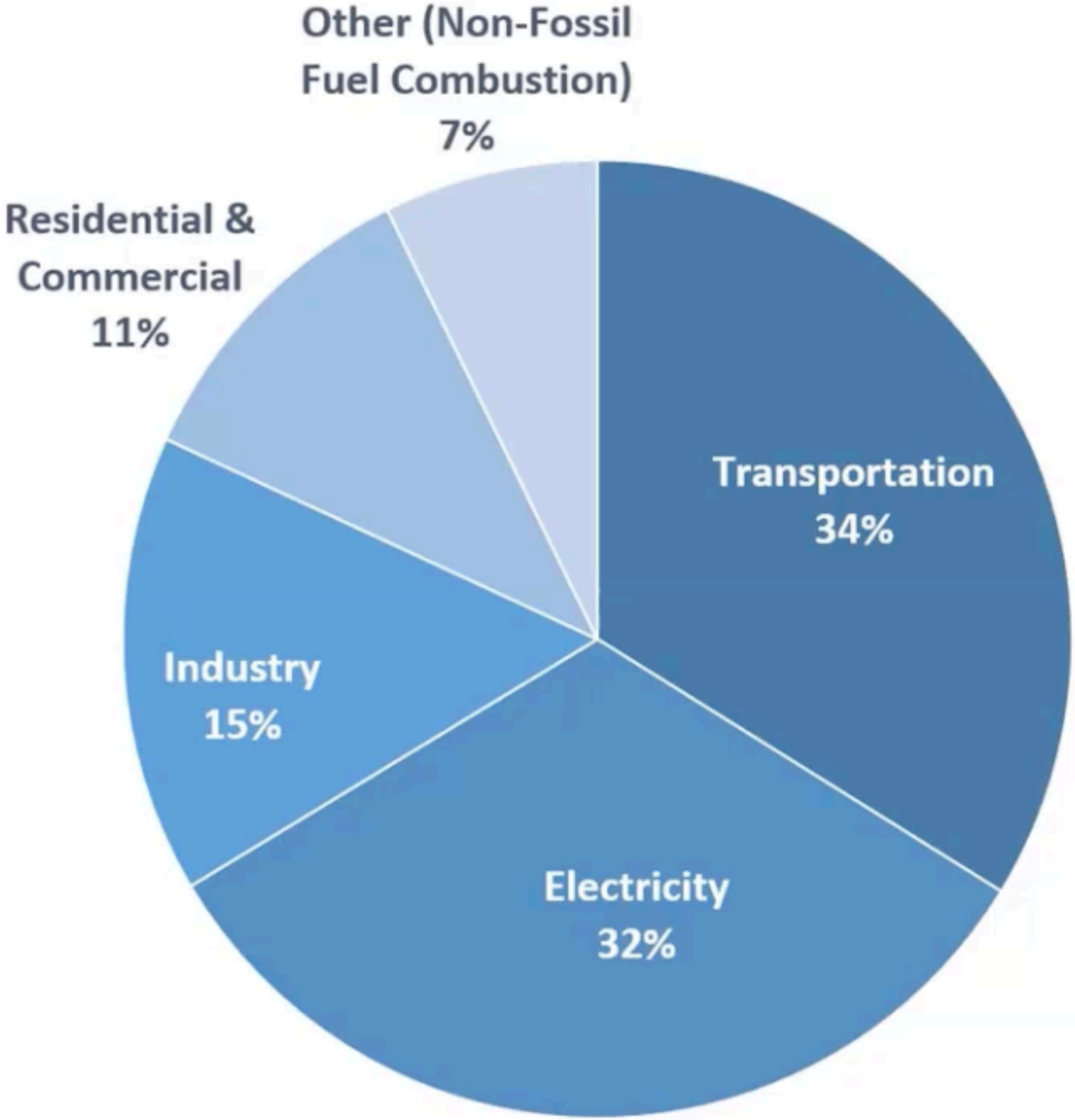
1. The sun's solar radiation warms the Earth.
   - Some energy is reflected, some energy is re-radiated as heat back into space.
   - Some re-radiated heat is absorbed by greenhouse gases in the troposphere, then emitted again toward the surface of the Earth as heat.
2. The "greenhouse effect" helps to keep the Earth at a temperature that can support life.
3. The greenhouse effect and the ozone layer are in two separate layers of the atmosphere.

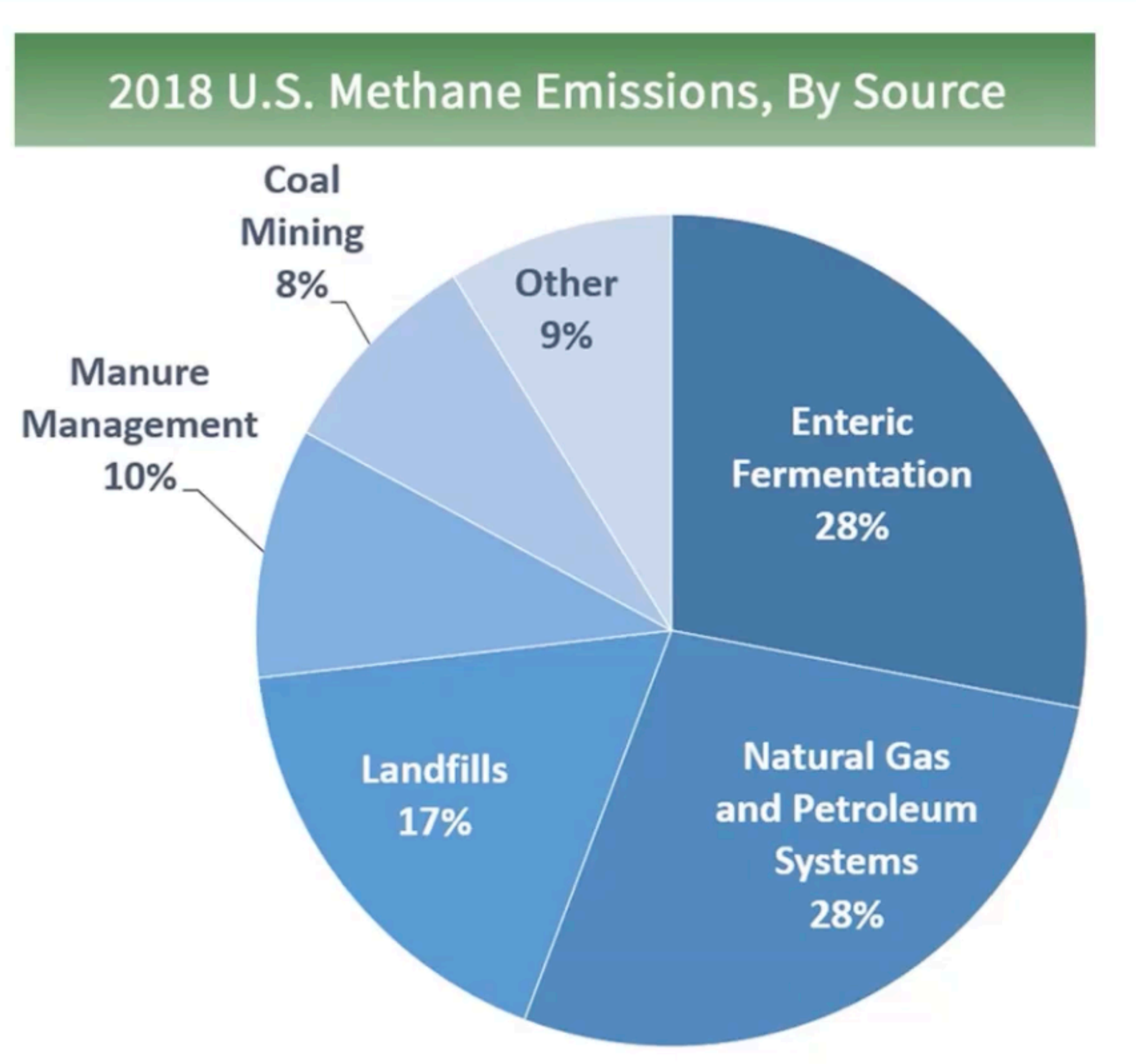
Greenhouse gases



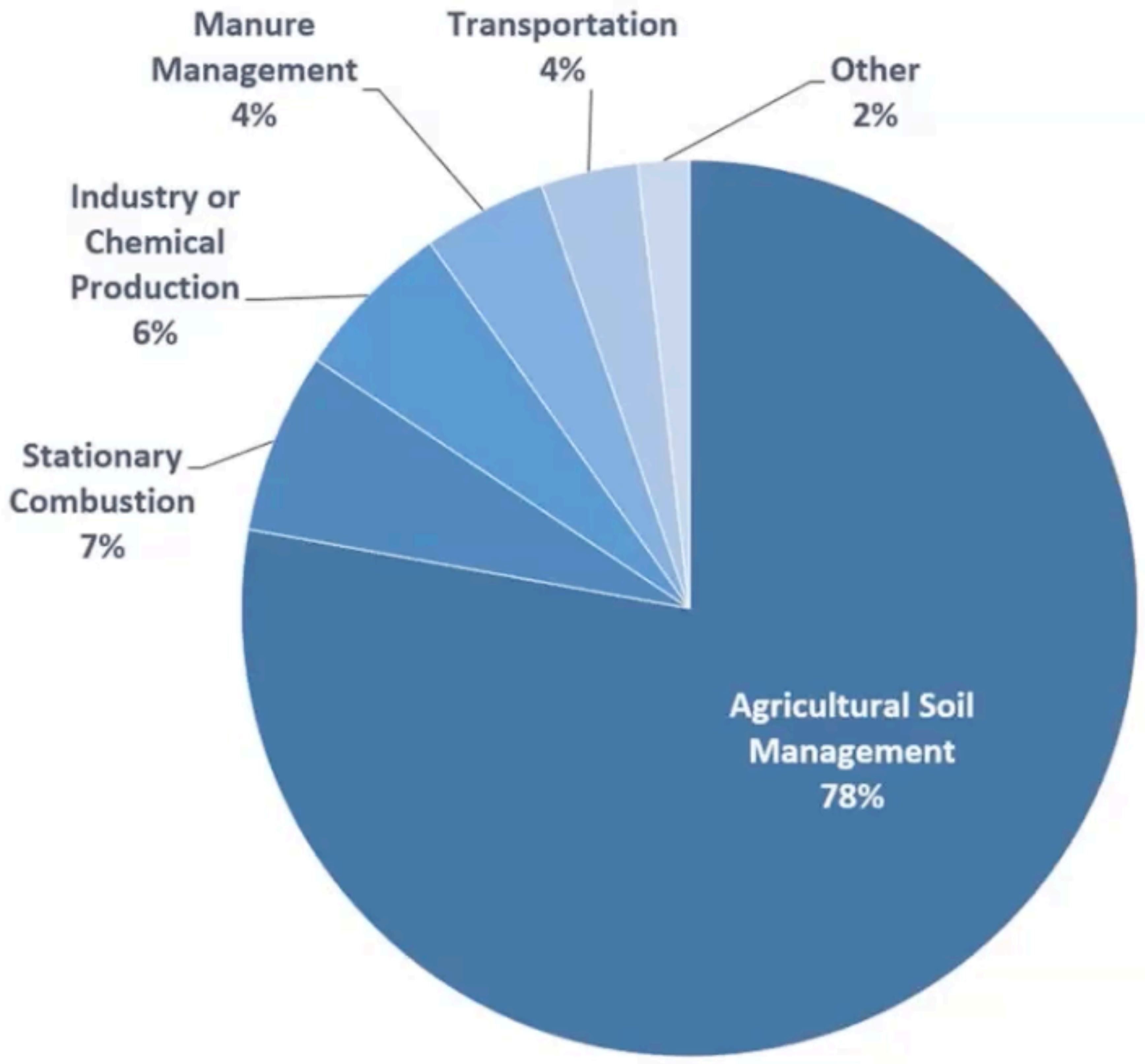
- Carbon dioxide – CO_2
- Methane – CH_4
- Water vapor – H_2O
- Nitrous oxide – N_2O
- Chlorofluorocarbons (CFCs) – CF_2Cl_2 (this is one example)
- Hydrofluorocarbons (HFCs)
- Tropospheric ozone – O_3

2018 U.S. Carbon Dioxide Emissions, By Source

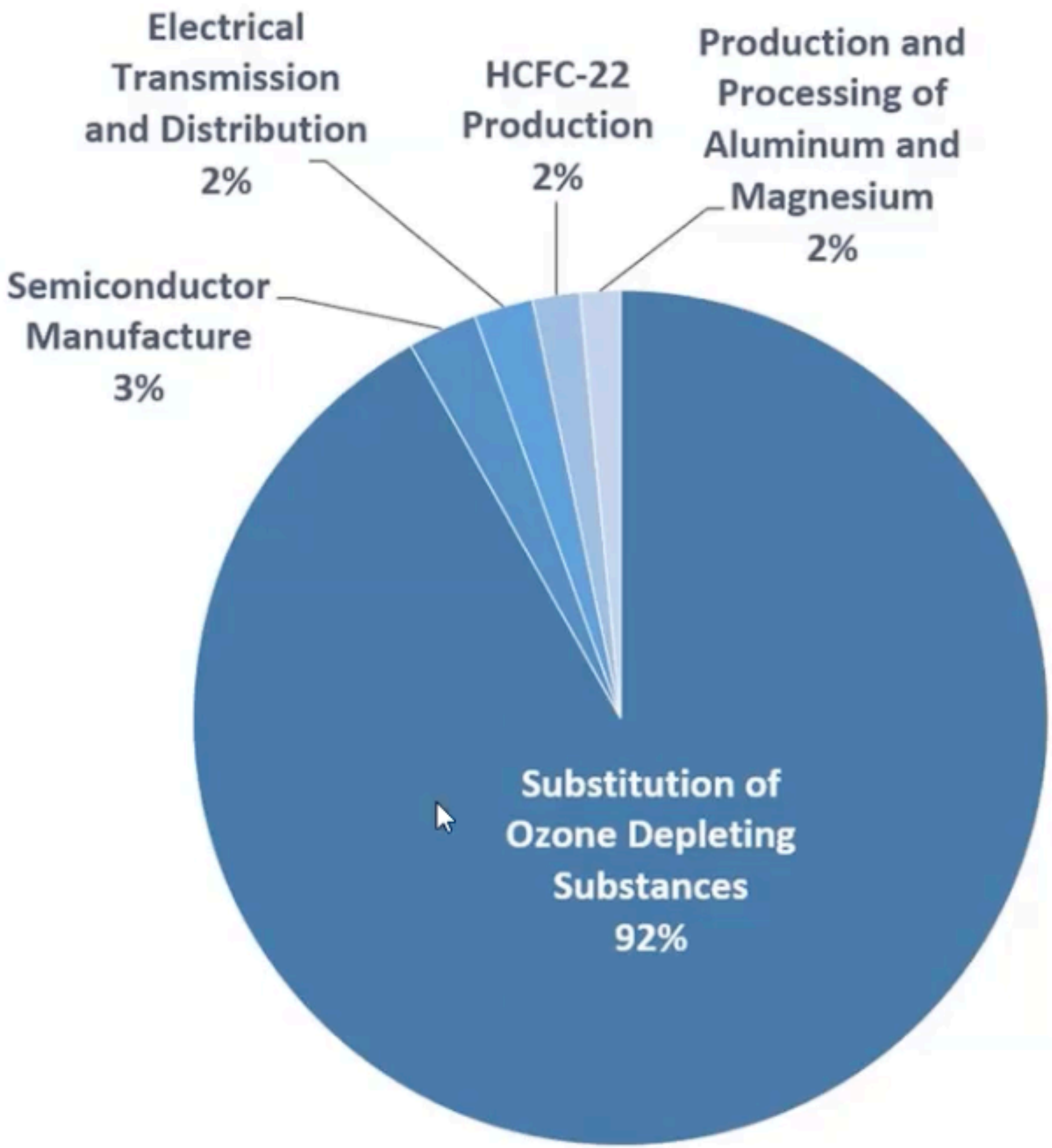



2018 U.S. Methane Emissions, By Source
Coal Mining 8%
Other 9%
Manure Management 10%
Enteric Fermentation 28%
Landfills 17%
Natural Gas and Petroleum Systems 28%

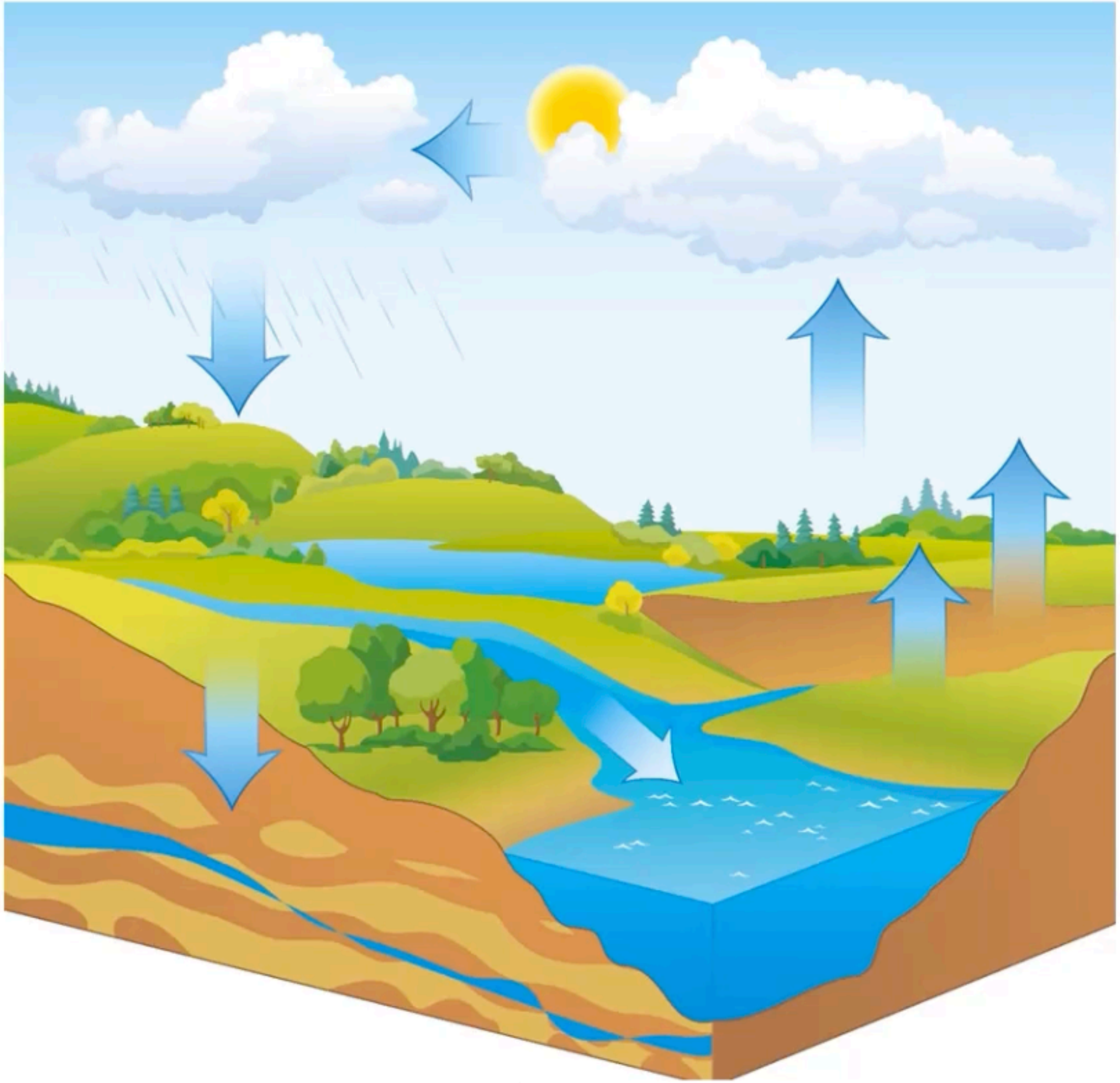
2018 U.S. Nitrous Oxide Emissions, By Source

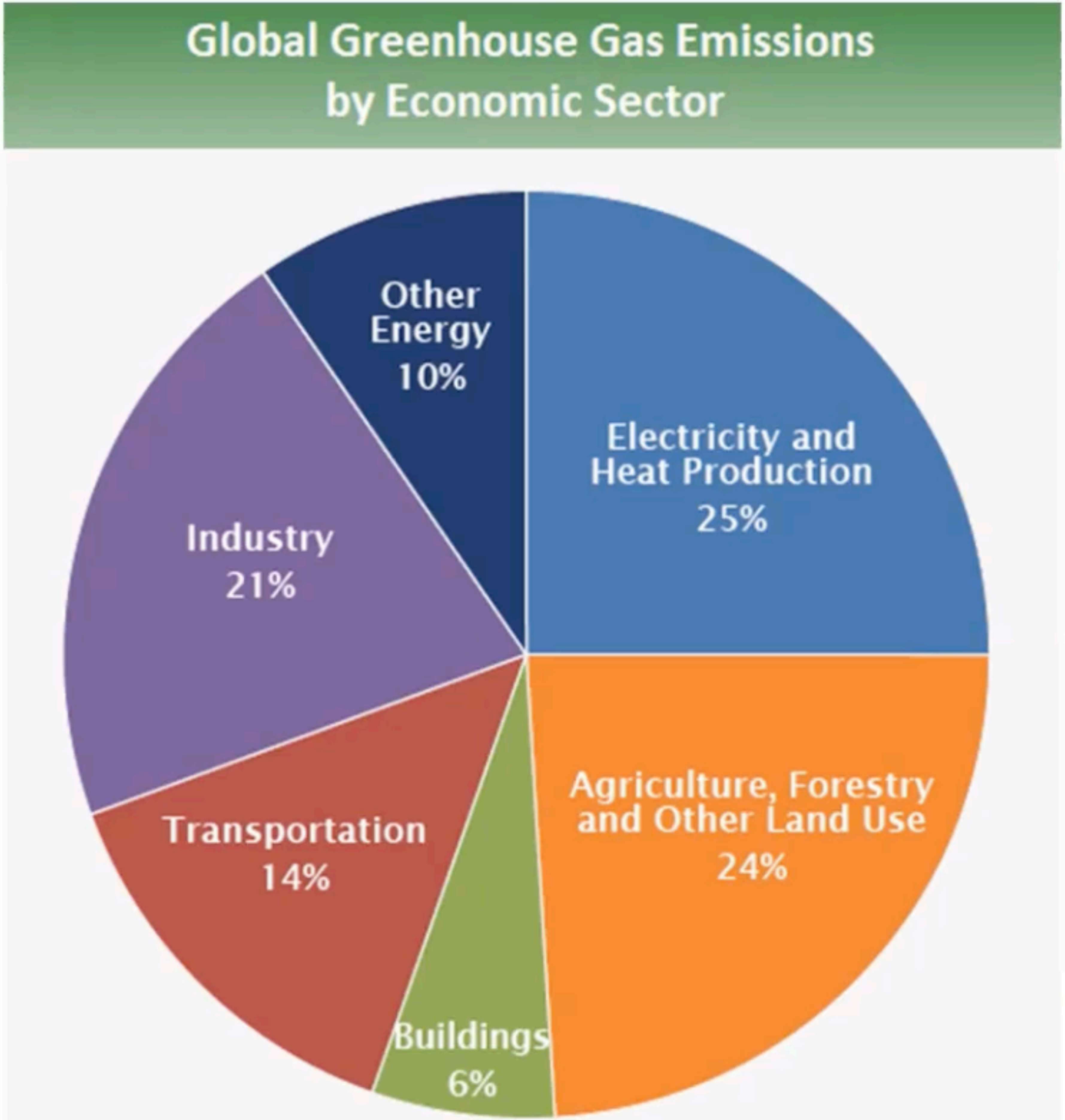


2018 U.S. Fluorinated Gas Emissions, By Source



Water vapor




Global Greenhouse Gas Emissions
by Economic Sector
Other Energy 10%
Electricity and Heat Production 25%
Industry 21%
Transportation 14%
Buildings 6%
Agriculture, Forestry and Other Land Use 24%

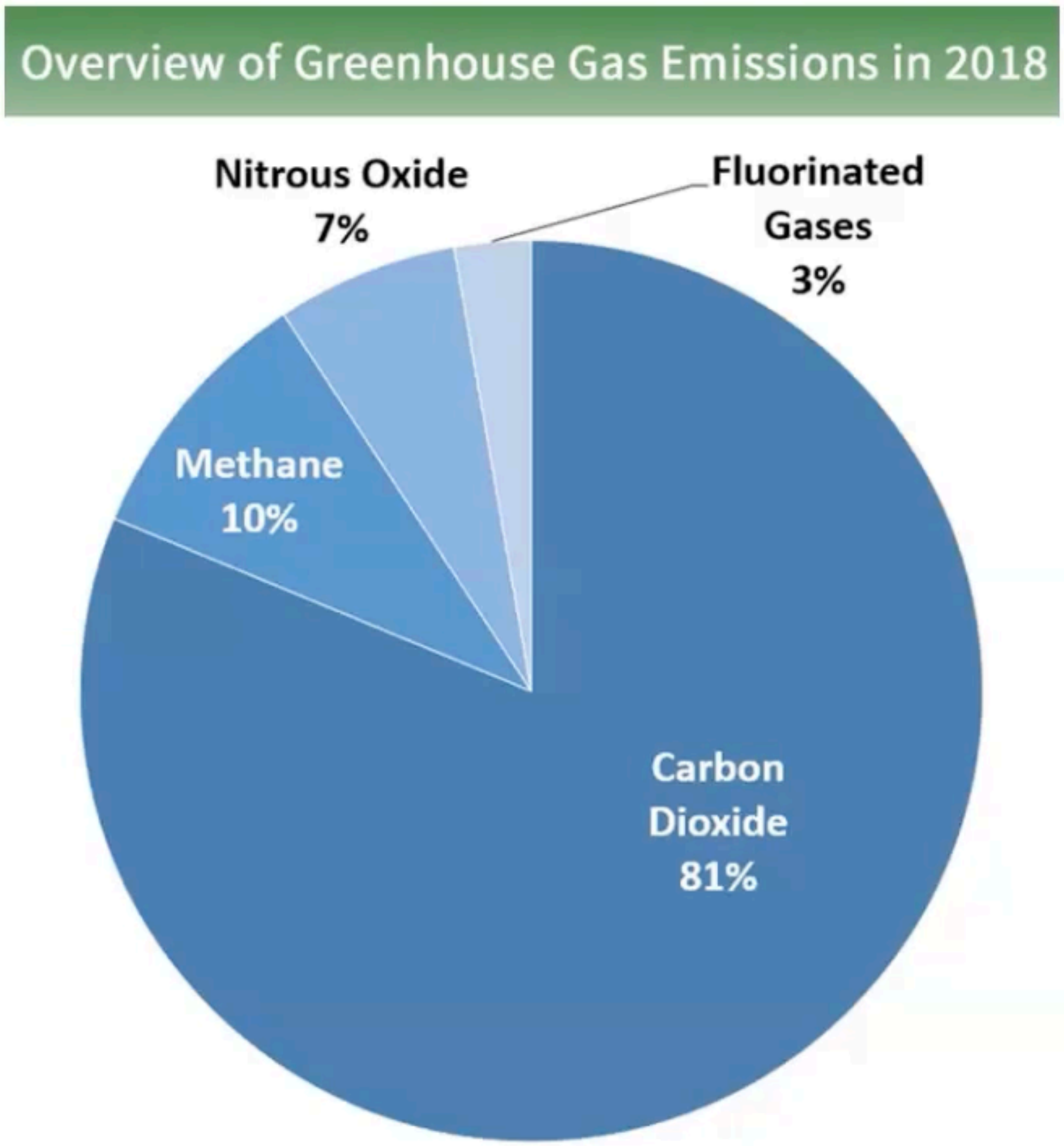
Tropospheric gases create the greenhouse effect

1. Greenhouse gases include carbon dioxide, methane, nitrous oxide, water vapor, tropospheric ozone, CFCs, HFCs.
2. Most occur naturally, but concentrations are increased via anthropogenic means.
3. CFCs and HFCs are manmade.
4. Water vapor does not contribute significantly to the greenhouse effect, due to its short atmospheric residence time.

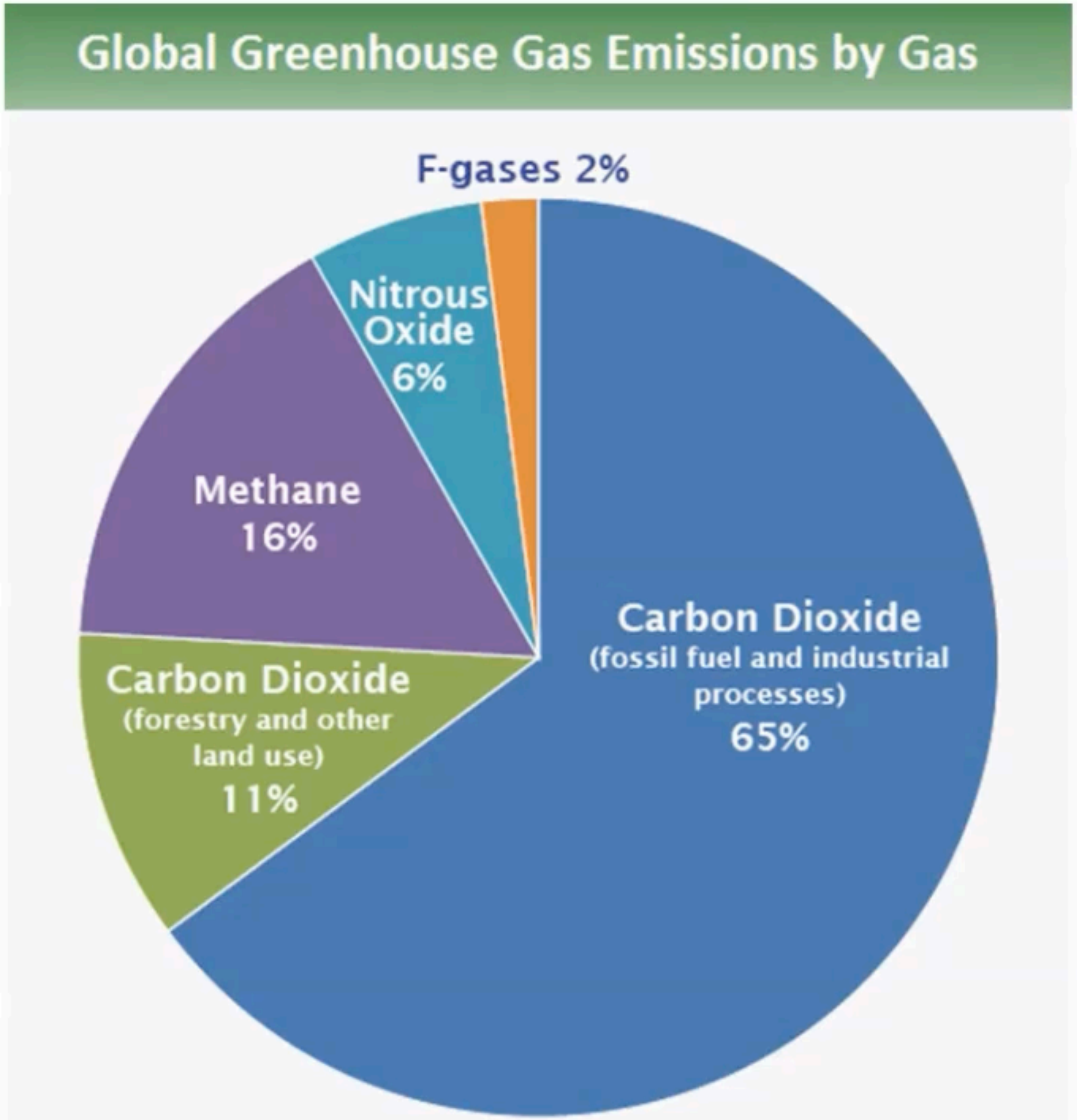
Global warming potentials (GWP)

Greenhouse Gas	GWP (approximate)
Carbon dioxide	1 [standard]
Methane	20
Nitrous oxide	300
Ozone	900-1000
CFCs	4,600-10,000
HFCs	150-12,000

GWP vs concentration



GWP vs concentration



MCQ Practice

Which of the following gases has the lowest global warming potential (GWP), but has the greatest impact on the greenhouse effect due to its greater abundance?

(A) CFCs

(B) carbon dioxide

(C) ozone

(D) HFCs

Greenhouse gases have different impacts on the greenhouse effect

1. Carbon dioxide is a reference molecule for the greenhouse effect, so has a global warming potential (GWP) of 1.
2. GWPs of various greenhouse gases: CFCs/HFCs > ozone > nitrous oxide > methane > carbon dioxide
3. Carbon dioxide has the greatest overall impact on the greenhouse effect because of its concentration in the atmosphere.
4. Human activities influence the concentration of various greenhouse gases in the atmosphere.

TOPIC 9.4

Increases in the Greenhouse Gases

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.E

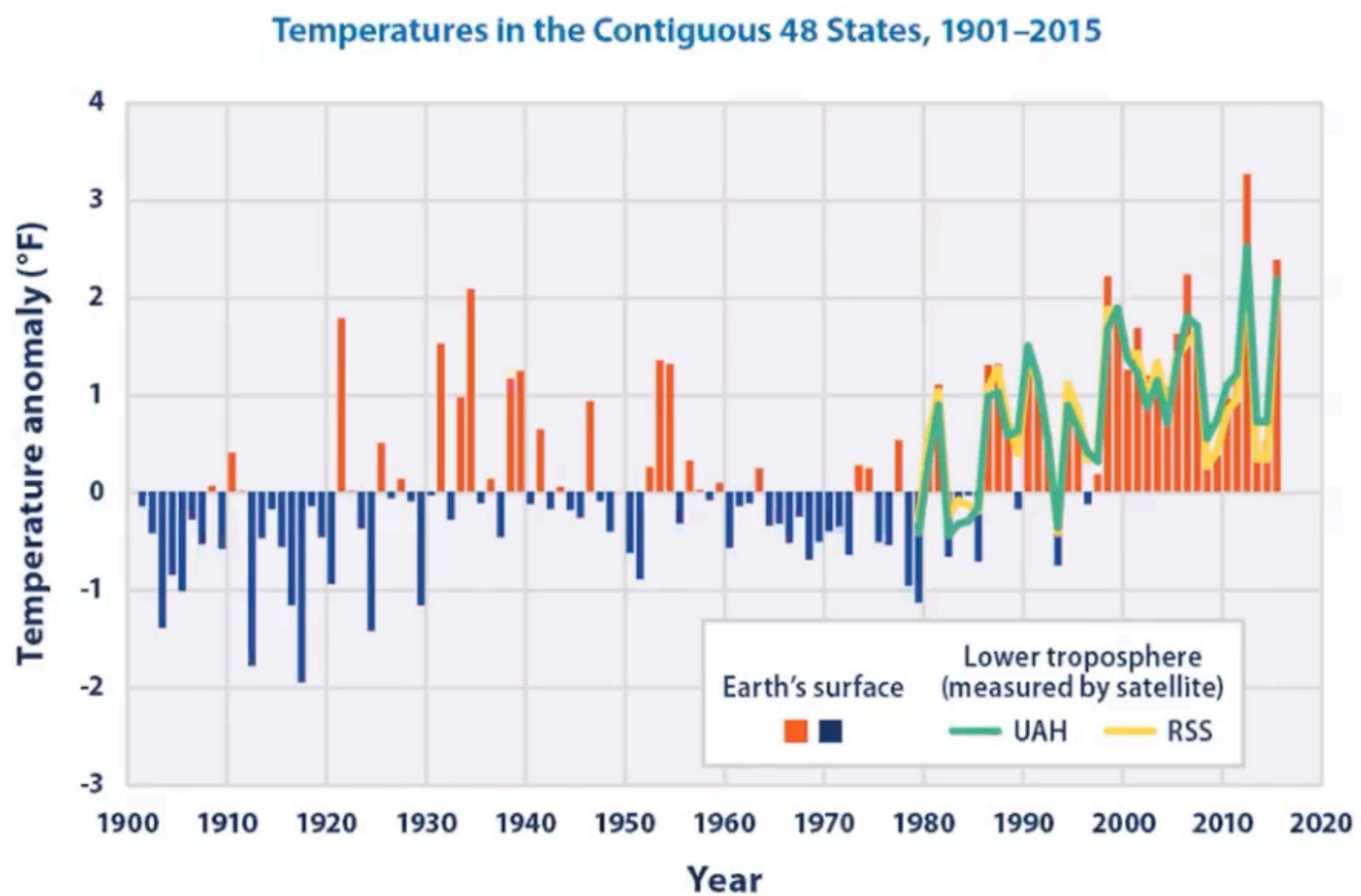
Identify the threats to human health and the environment posed by an increase in greenhouse gases.

ESSENTIAL KNOWLEDGE

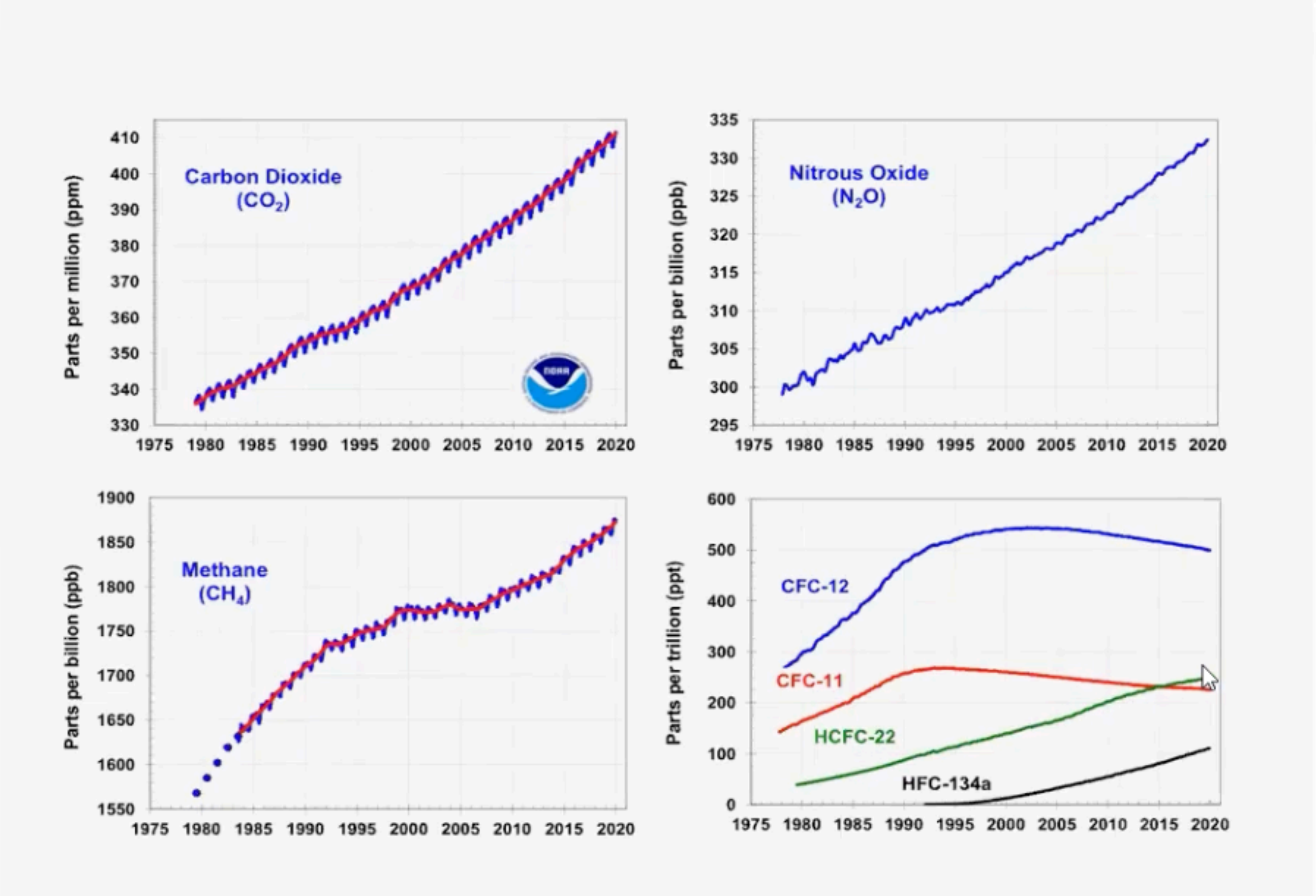
STB-4.E.1

Global climate change, caused by excess greenhouse gases in the atmosphere, can lead to a variety of environmental problems including rising sea levels resulting from melting ice sheets and ocean water expansion, and disease vectors spreading from the tropics toward the poles. These problems can lead to changes in population dynamics and population movements in response.

Historical temperature changes



Historical greenhouse gas concentrations



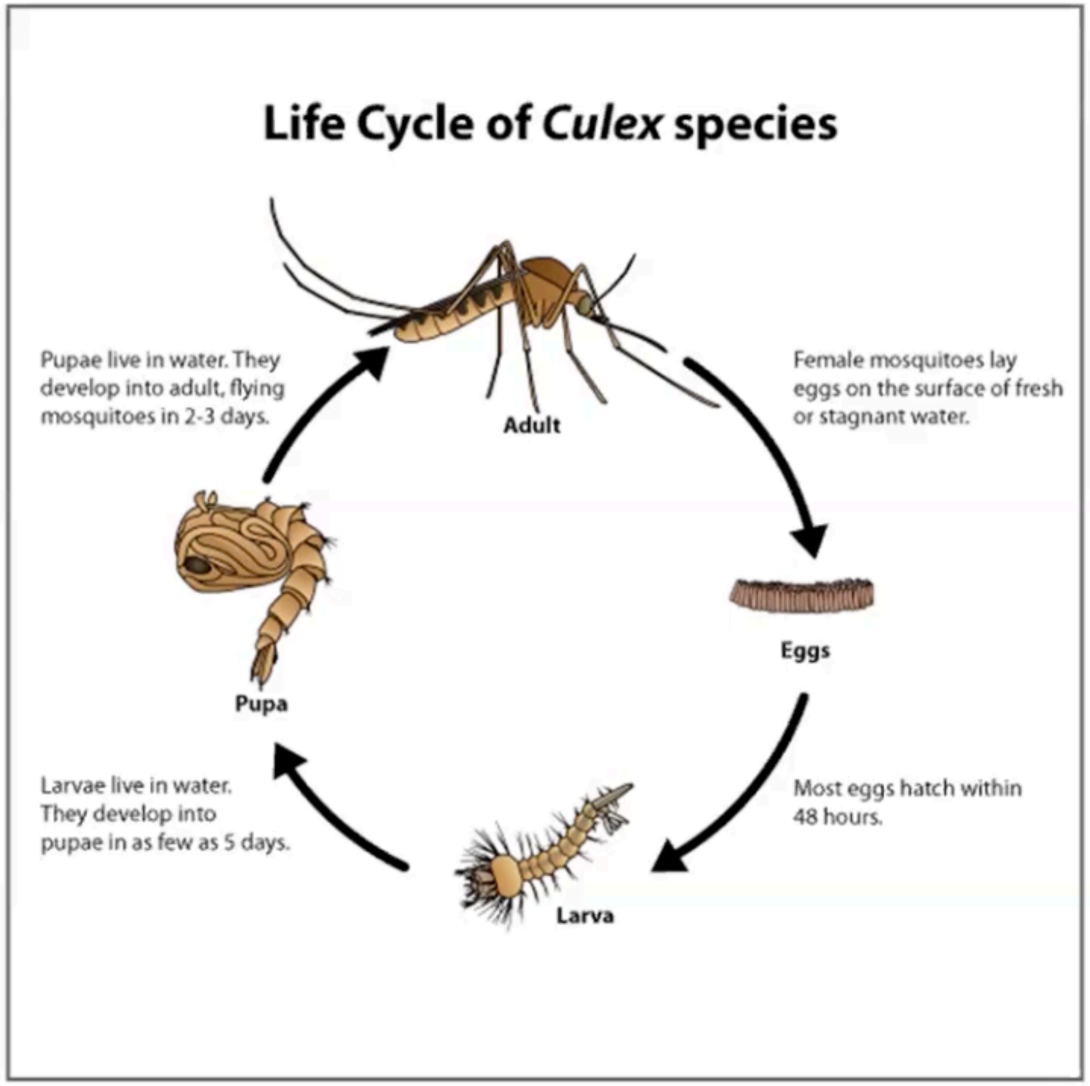
Sea levels rise

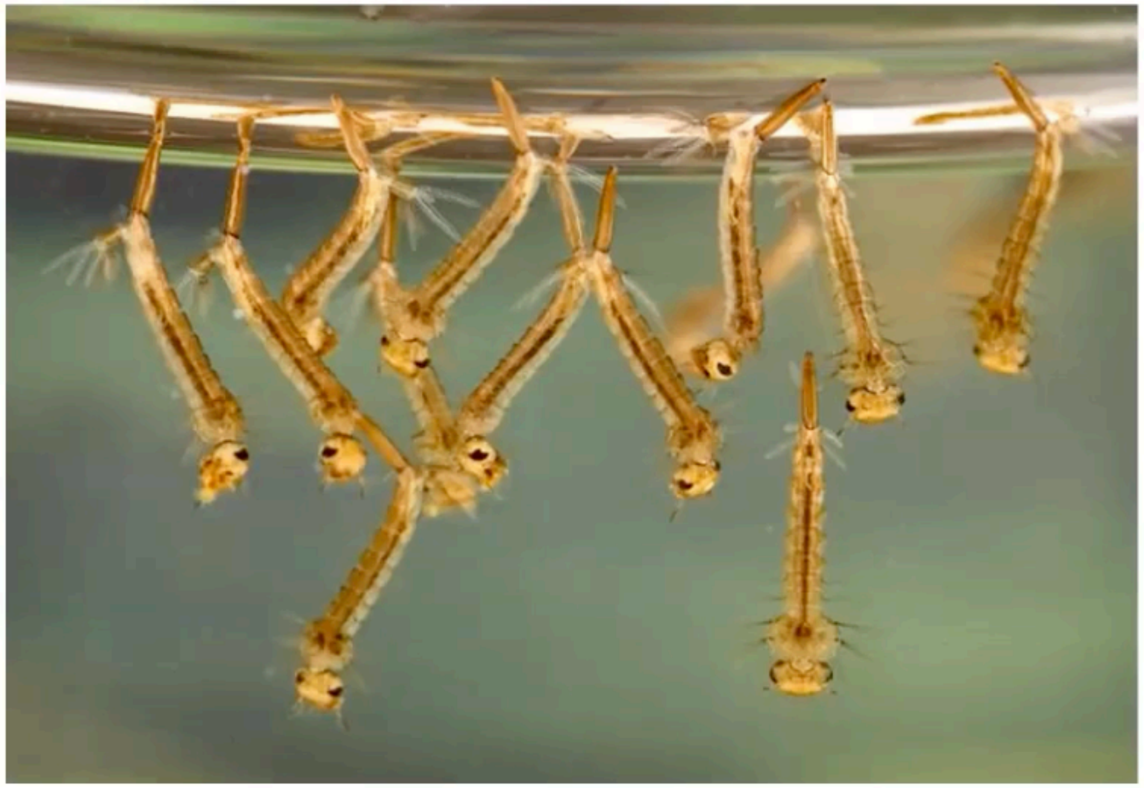
Bernhard Staehli/Shutterstock.com

1. Land ice (ex – continental glaciers, ice sheets) melts, adding to the volume of water in the ocean.
2. Thermal expansion of the ocean, due to warming from climate change, increases the volume of the ocean.

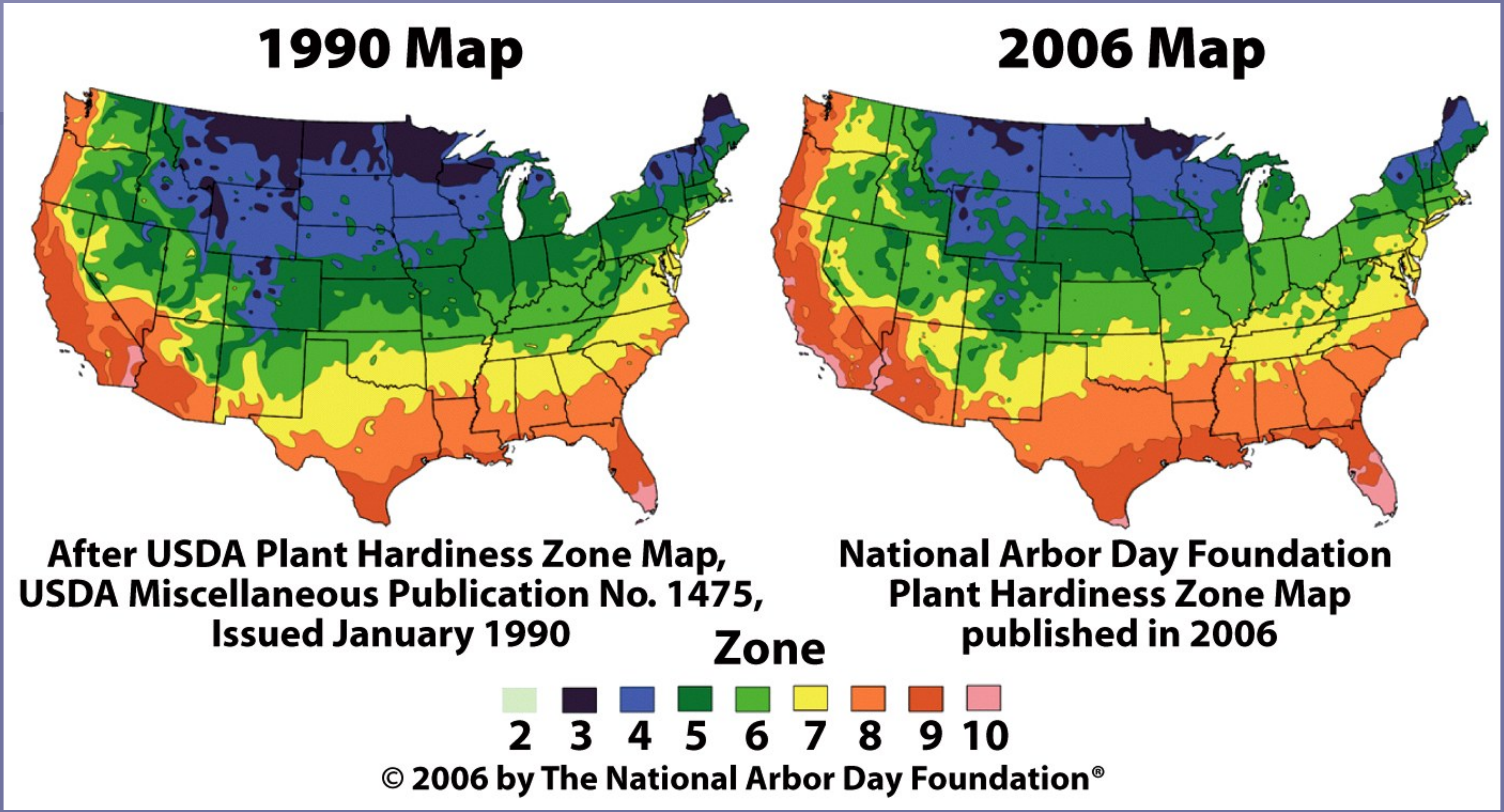
Sea levels rise

Disease vectors expand their range

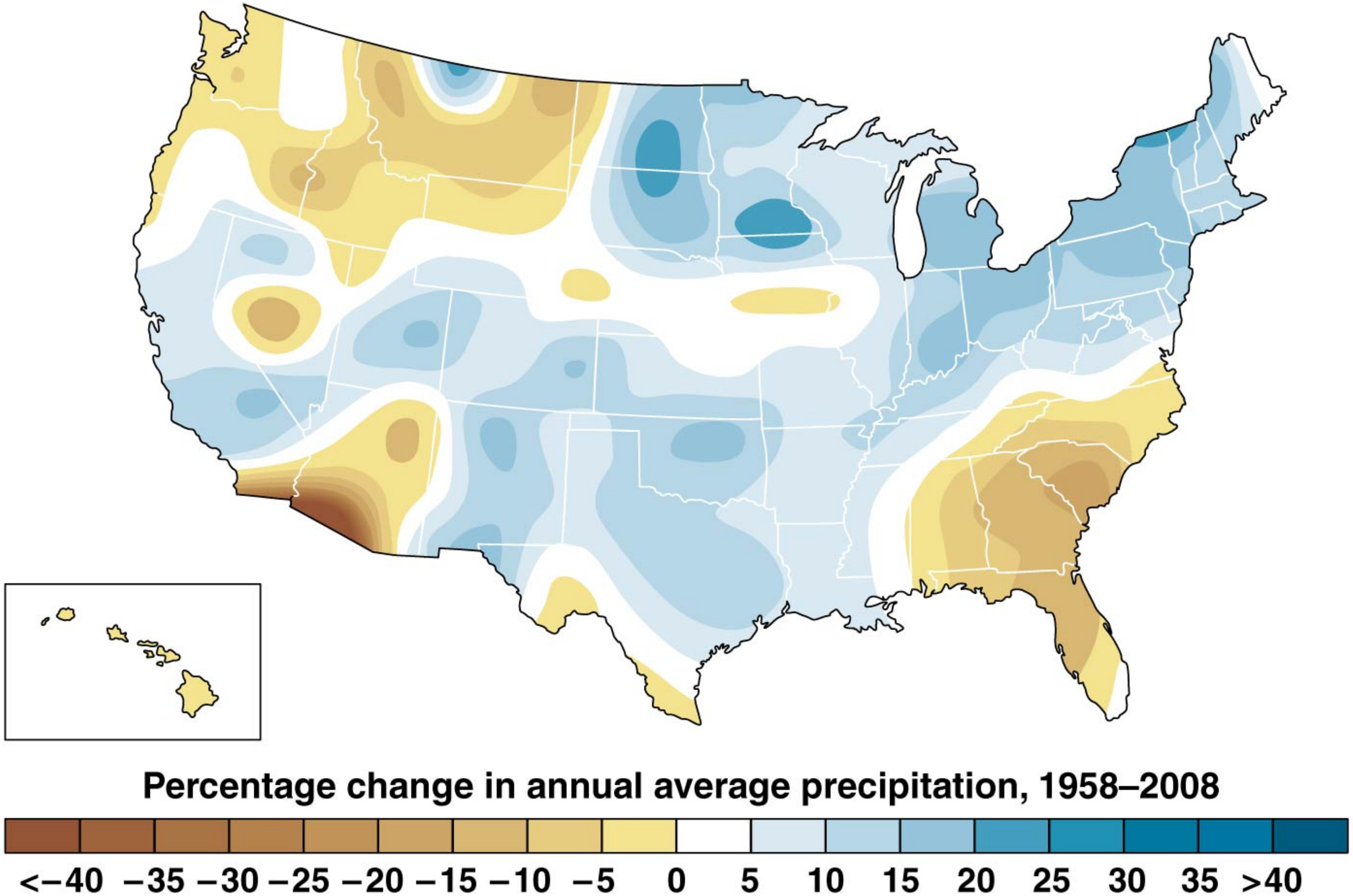




Effect on Organisms: Vegetation

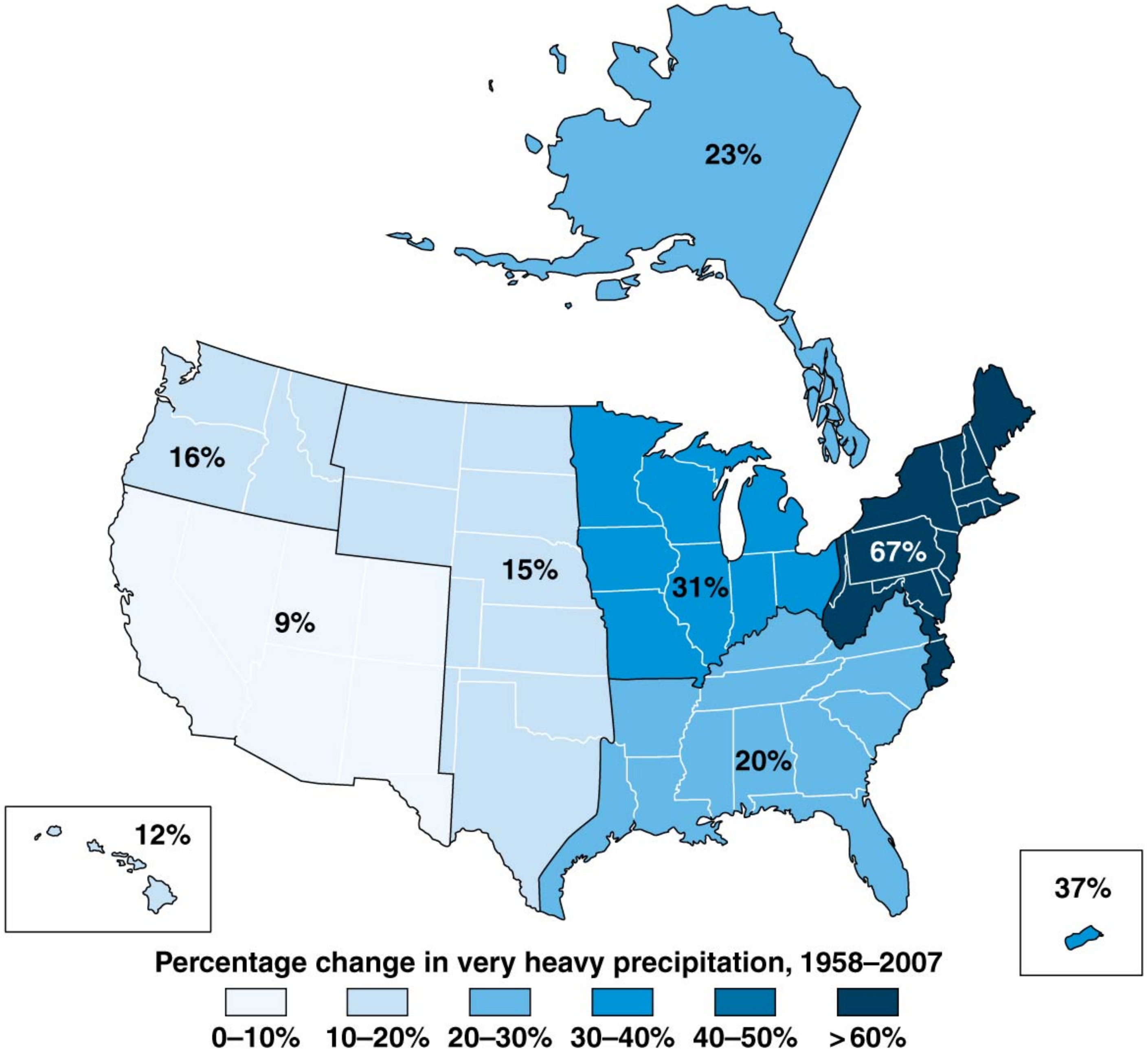


Changes in precipitation patterns



Source: *Global Climate Change Impacts in the United States*, available at www.globalchange.gov/usimpacts

Changes in precipitation patterns



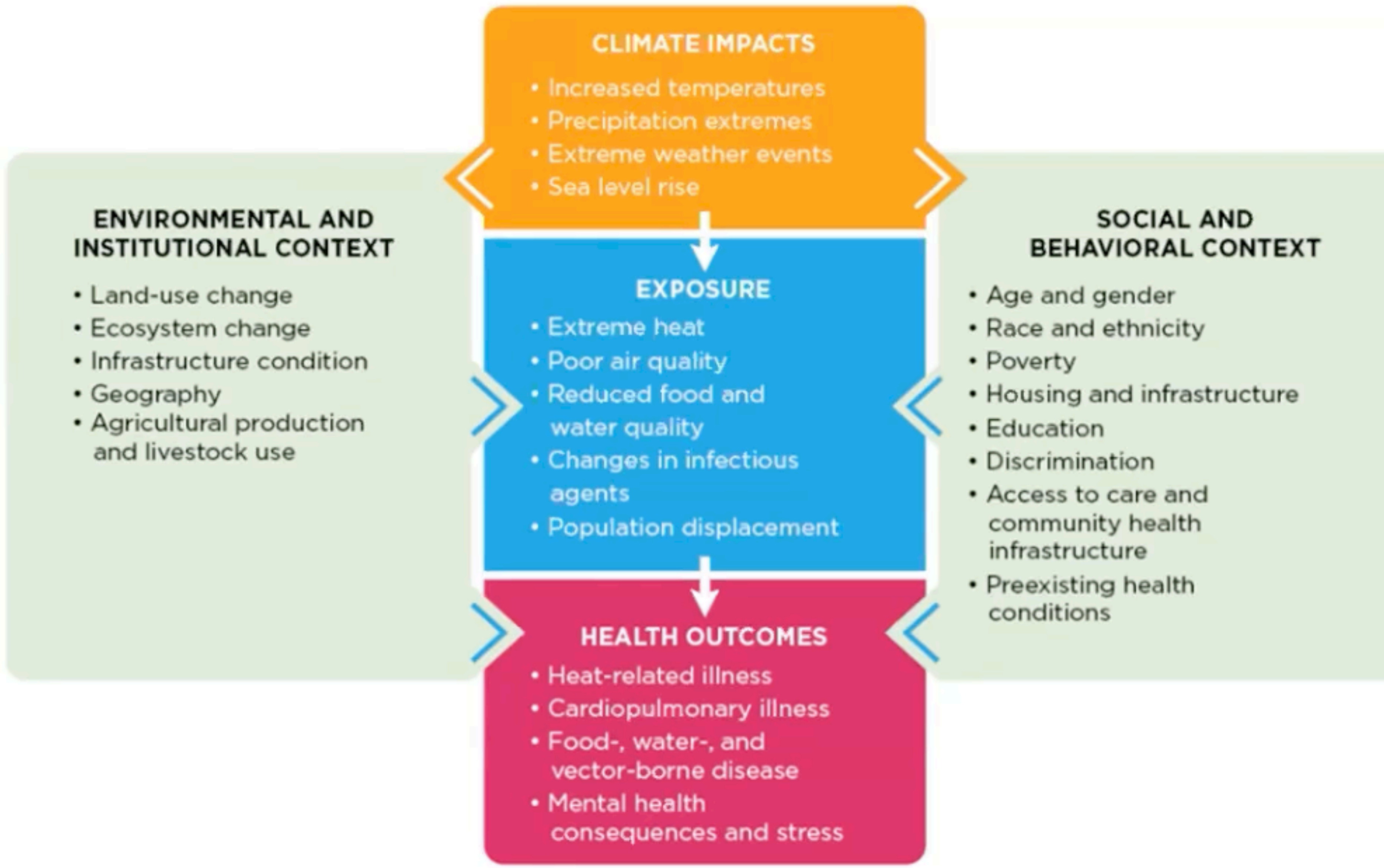
(Left) Source: *Global Climate Change Impacts in the United States*, available at www.globalchange.gov/usimpacts

(Right) Photo credit: Clem Murray/MCT/Newscom

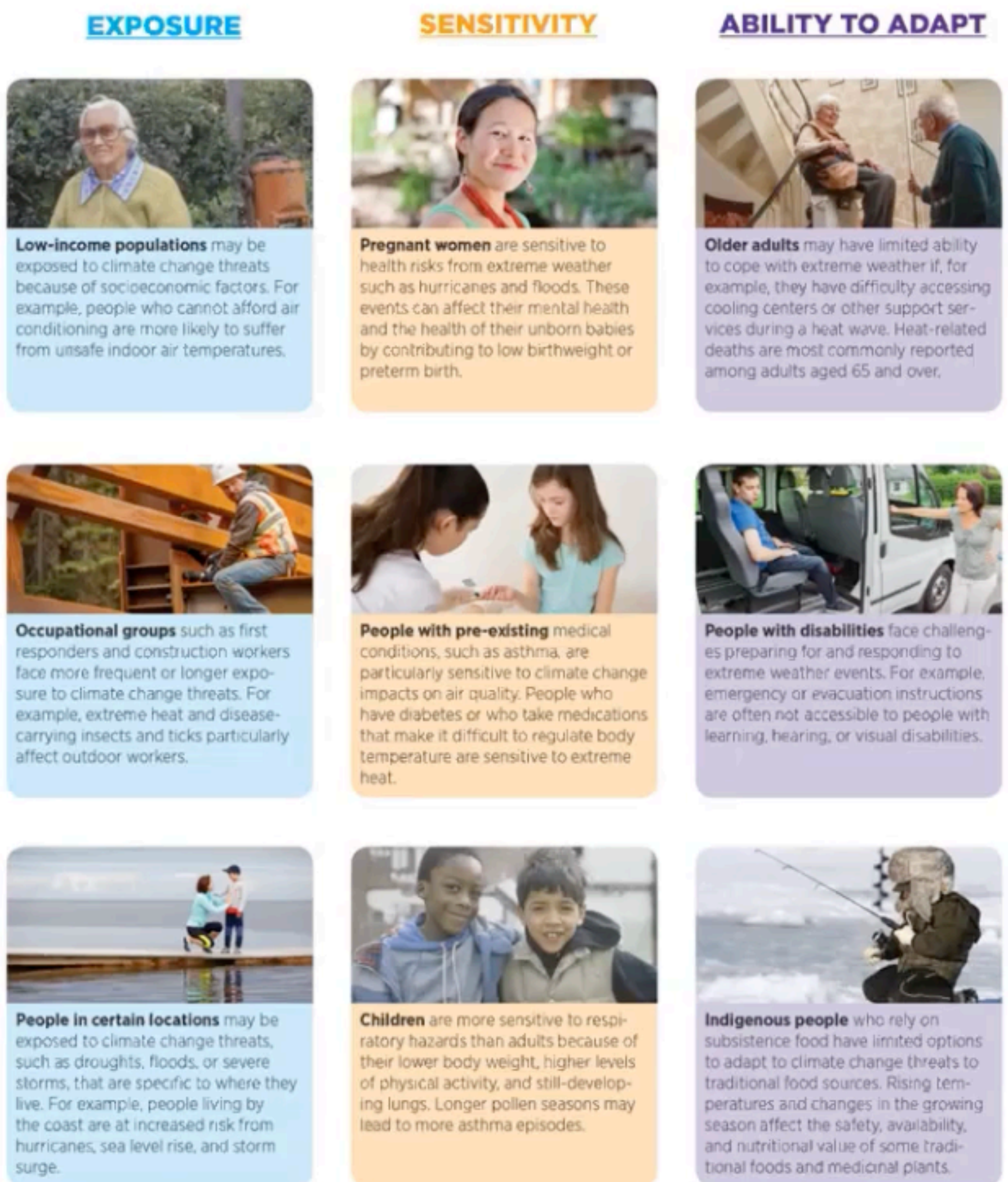
Climate change impacts populations:

1. Habitat destruction
2. Loss of food source
3. Timing of food source availability changes
4. New temperatures beyond range of tolerance
5. New salinity beyond range of tolerance
6. Increased storm intensity
7. Increased possibility of fire
8. Impacted annual group behaviors: timing of migration, hibernation

Climate change impacts populations



Climate change impacts populations



- Low-income populations
- Occupational groups
- People in certain locations
- Pregnant women
- People with pre-existing medical conditions
- Children
- Older adults
- People with disabilities
- Indigenous people

Credit: US Environmental Protection Agency

Climate change has many impacts

1. Sea level rise:
    - Terrestrial ice melts into ocean
    - Thermal expansion of ocean water
2. Increased range for disease vectors
3. Impacts on ecological populations
4. Impacts on human populations, especially those already vulnerable to changes

FRQ Practice

Temperatures in the Arctic and globally have been trending upward from 1900 to 2016.

a. The cause of the temperature trend is a result of increasing concentrations of greenhouse gases in the atmosphere.

   i. **Identify** a greenhouse gas that has a global warming potential (GWP) that is greater than 1.

   ii. **Identify** an anthropogenic source that contributes to greenhouse gas emissions.

b. Greenhouse gases can pose threats to both human health and the environment.

   i. **Describe** one impact that global climate change can have on human health.

   ii. **Describe** one effect global climate change can have on marine organisms.

FRQ Practice Answer Rubric

a. The cause of the temperature trend is a result of increasing concentrations of greenhouse gases in the atmosphere.

   i. **Identify** a greenhouse gas that has a global warming potential (GWP) that is greater than 1.

Choose one of the following:

- Chlorofluorocarbons (CFCs)/Hydrofluorocarbons (HFCs)
- Methane (CH_4)
- Ozone (O_3)
- Nitrous oxide (N_2O)

FRQ Practice Answer Rubric

a. The cause of the temperature trend is a result of increasing concentrations of greenhouse gases in the atmosphere.

ii. **Identify** an anthropogenic source that contributes to greenhouse gas emissions.

Choose one of the following:

- Burning of fossil fuels
- Deforestation/land use changes
- Livestock fermentation (methane release) and waste management
- Methane releases associated with rice paddies
- Use of CFCs/HFCs in products such as refrigeration systems, air conditioners, and manufacturing
- Use of fertilizer

FRQ Practice Answer Rubric

b. Greenhouse gases can pose threats to both human health and the environment.

i. **Describe** one impact that global climate change can have on human health.

Choose one of the following:

- Increase in spread of vector diseases as habitat moves from tropics to poles.
- Increase in algal blooms and waterborne diseases from increased water temperature.
- Increase in exposure to extreme heat and cold/increase risk of illness and death from exposure to increased extreme temperatures.
- Increase in chronic conditions (cardiovascular disease, respiratory disease, etc.) from prolonged exposure to temperature extremes.

FRQ Practice Answer Rubric

b. Greenhouse gases can pose threats to both human health and the environment.

i. **Describe** one impact that global climate change can have on human health.

Choose one of the following:

- Decrease in air quality leading to increased respiratory and cardiovascular diseases (i.e., asthma).
- Decreased water quality leading to contact with contaminated drinking water/water used for recreation/water used for sanitation.
- Decreased food security/disruption to available food/disruption to access to food.

FRQ Practice Answer Rubric

b. Greenhouse gases can pose threats to both human health and the environment.

ii. **Describe** one effect global climate change can have on marine organisms.

Choose one of the following:

- Sea level rise can lead to loss of habitat for marine species.
- Seal level rise can reduce available light in marine habitats, reducing or eliminating primary productivity there.
- Melting land ice can decrease ocean salinity, putting the salinity beyond the range of tolerance for some marine species.

FRQ Practice Answer Rubric

b. Greenhouse gases can pose threats to both human health and the environment.

ii. Describe one effect global climate change can have on marine organisms.

Choose one of the following:

- Ocean warming can lead to loss of habitat for marine species.
- Ocean warming can alter metabolic rates (increase) for marine species.
- Ocean warming can alter reproductive rates and sex ratios in certain species.
- Ocean warming can cause coral bleaching/loss of algae within corals.
- Ocean warming may cause organisms, such as fish, to migrate toward the poles where water is cooler.

Climate change has global impacts

1. Environmental impacts:
    - Changes in ocean salinity and temperature affect marine organisms at every trophic level in many ways.
    - Changes in temperatures affect terrestrial organisms at every trophic level in many ways.
2. Impacts on humans:
    - Impacts include responses to temperature changes, access to food, access to fresh water, and changing land availability.
3. Anthropogenic activities produce the additional greenhouse gases that drive climate change:
    - Many activities – individual actions, agriculture, industry – produce greenhouse gases.

TOPIC 9.5

Global Climate Change

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.1

The Earth has undergone climate change throughout geologic time, with major shifts in global temperatures causing periods of warming and cooling as recorded with CO_2 data and ice cores.

STB-4.F.2

Effects of climate change include rising temperatures, melting permafrost and sea ice, rising sea levels, and displacement of coastal populations.

STB-4.F.3

Marine ecosystems are affected by changes in sea level, some positively, such as in newly created habitats on now-flooded continental shelves, and some negatively, such as deeper communities that may no longer be in the photic zone of seawater.

STB-4.F.4

Winds generated by atmospheric circulation help transport heat throughout the Earth. Climate change may change circulation patterns, as temperature changes may impact Hadley cells and the jet stream.

continued on next page

LEARNING OBJECTIVE

STB-4.F

Explain how changes in climate, both short- and long-term, impact ecosystems.

ESSENTIAL KNOWLEDGE

STB-4.F.5

Oceanic currents, or the ocean conveyor belt, carry heat throughout the world. When these currents change, it can have a big impact on global climate, especially in coastal regions.

STB-4.F.6

Climate change can affect soil through changes in temperature and rainfall, which can impact soil's viability and potentially increase erosion.

STB-4.F.7

Earth's polar regions are showing faster response times to global climate change because ice and snow in these regions reflect the most energy back out to space, leading to a positive feedback loop.

STB-4.F.8

As the Earth warms, this ice and snow melts, meaning less solar energy is radiated back into space and instead is absorbed by the Earth's surface. This in turn causes more warming of the polar regions.

STB-4.F.9

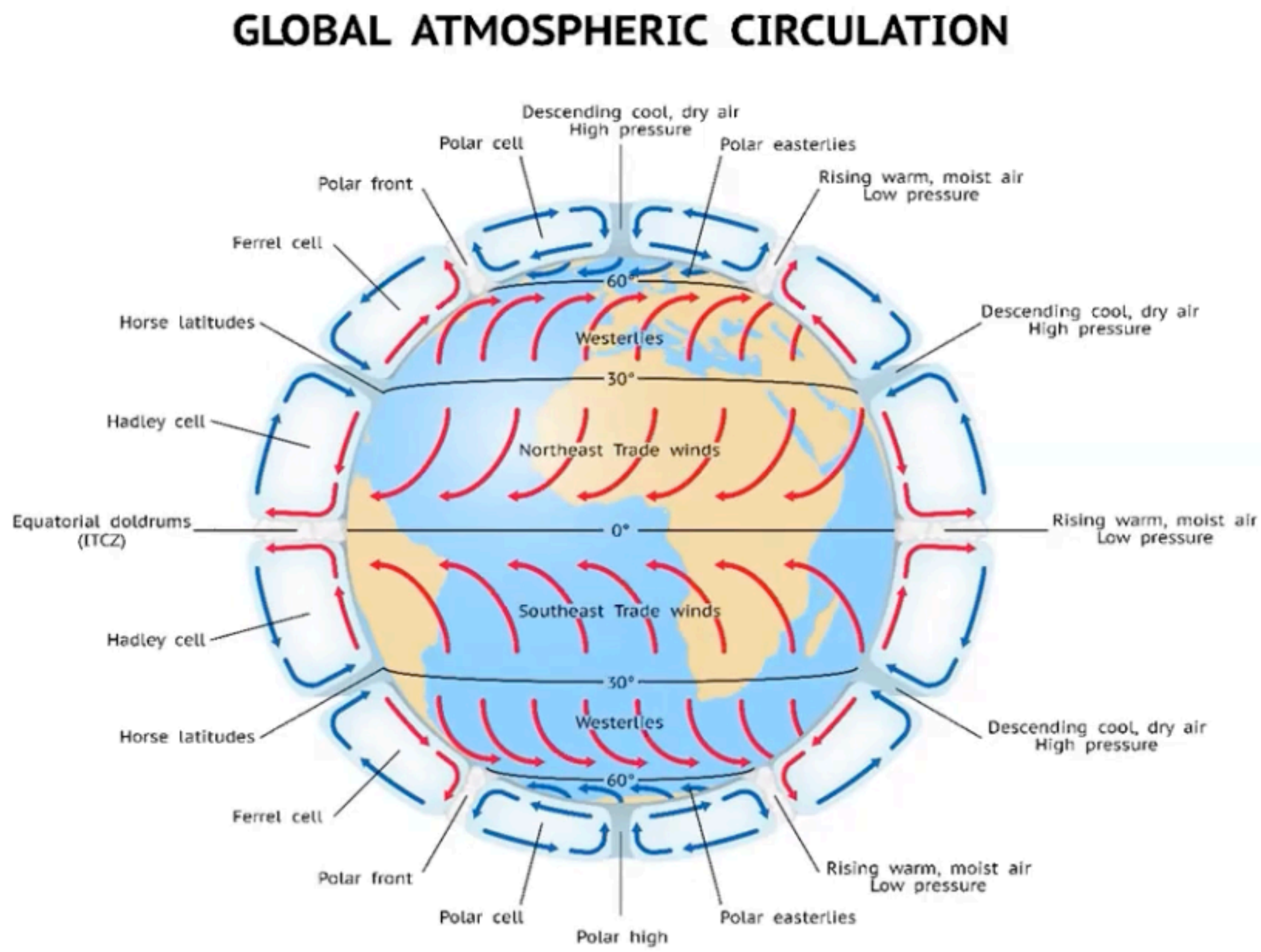
Global climate change response time in the Arctic is due to positive feedback loops involving melting sea ice and thawing tundra, and the subsequent release of greenhouse gases like methane.

STB-4.F.10

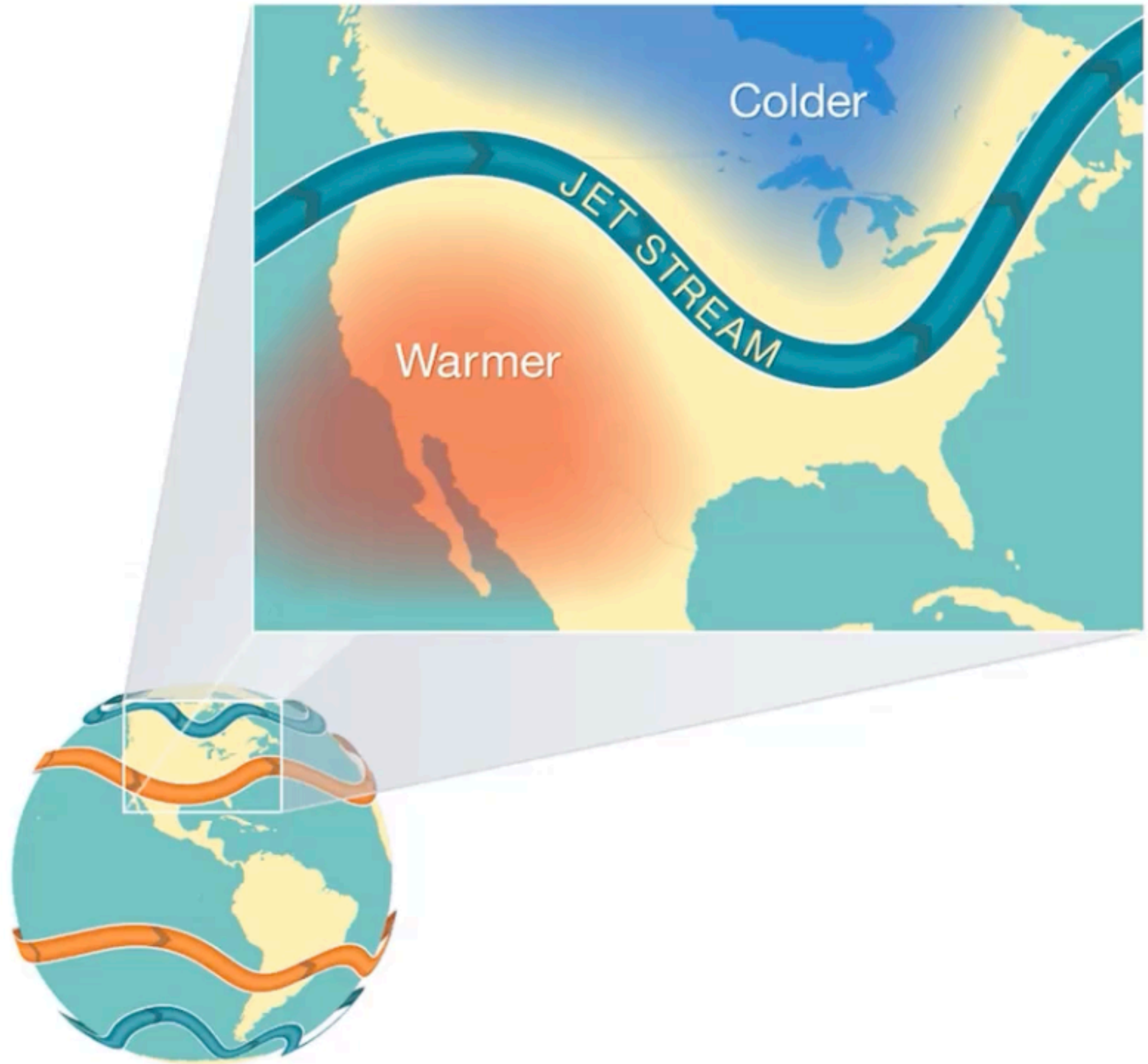
One consequence of the loss of ice and snow in polar regions is the effect on species that depend on the ice for habitat and food.

Historical records of climate change

Changes in air circulation



Changes in air circulation

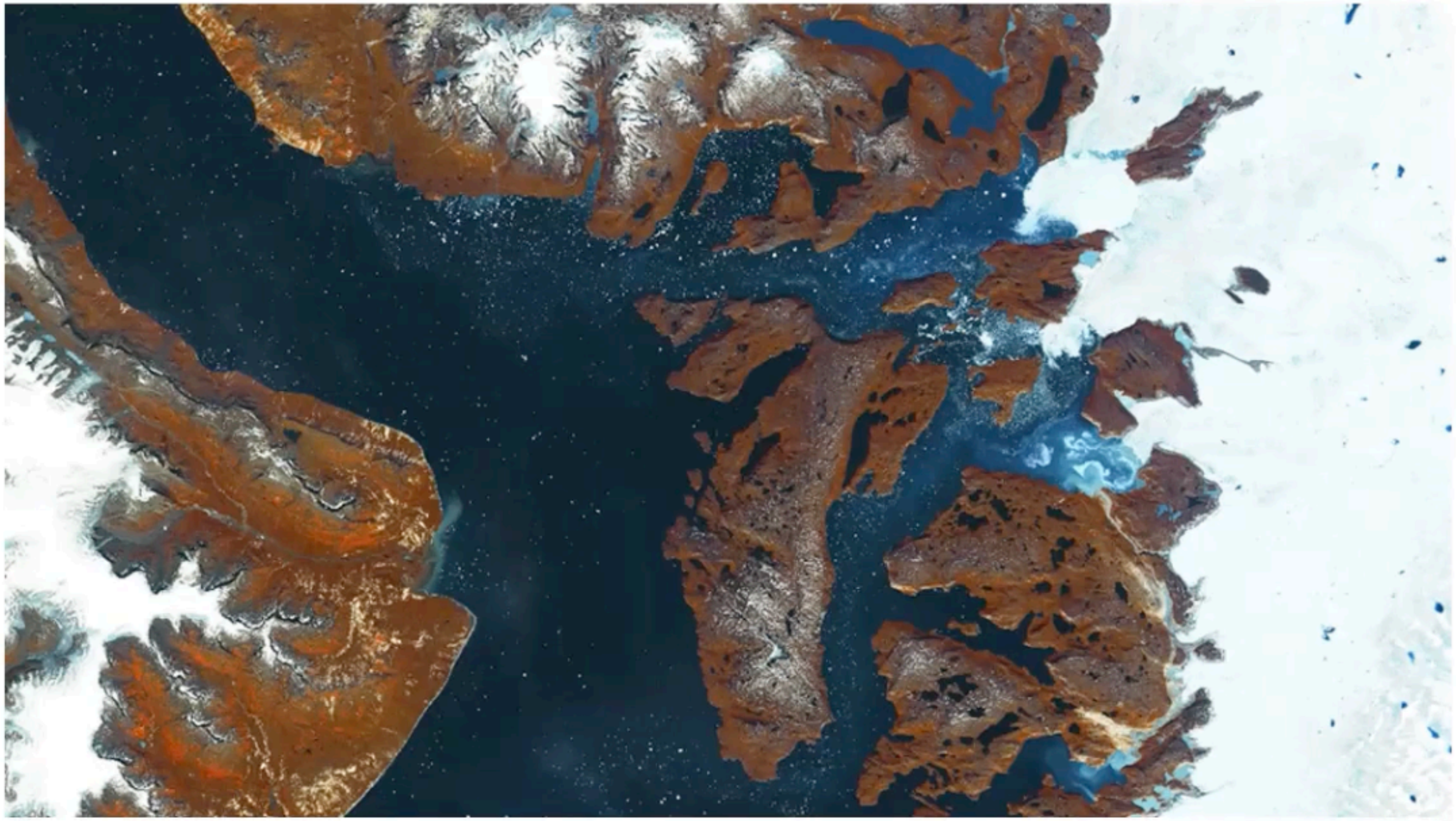


Soil viability and erosion

Climate change has many consequences

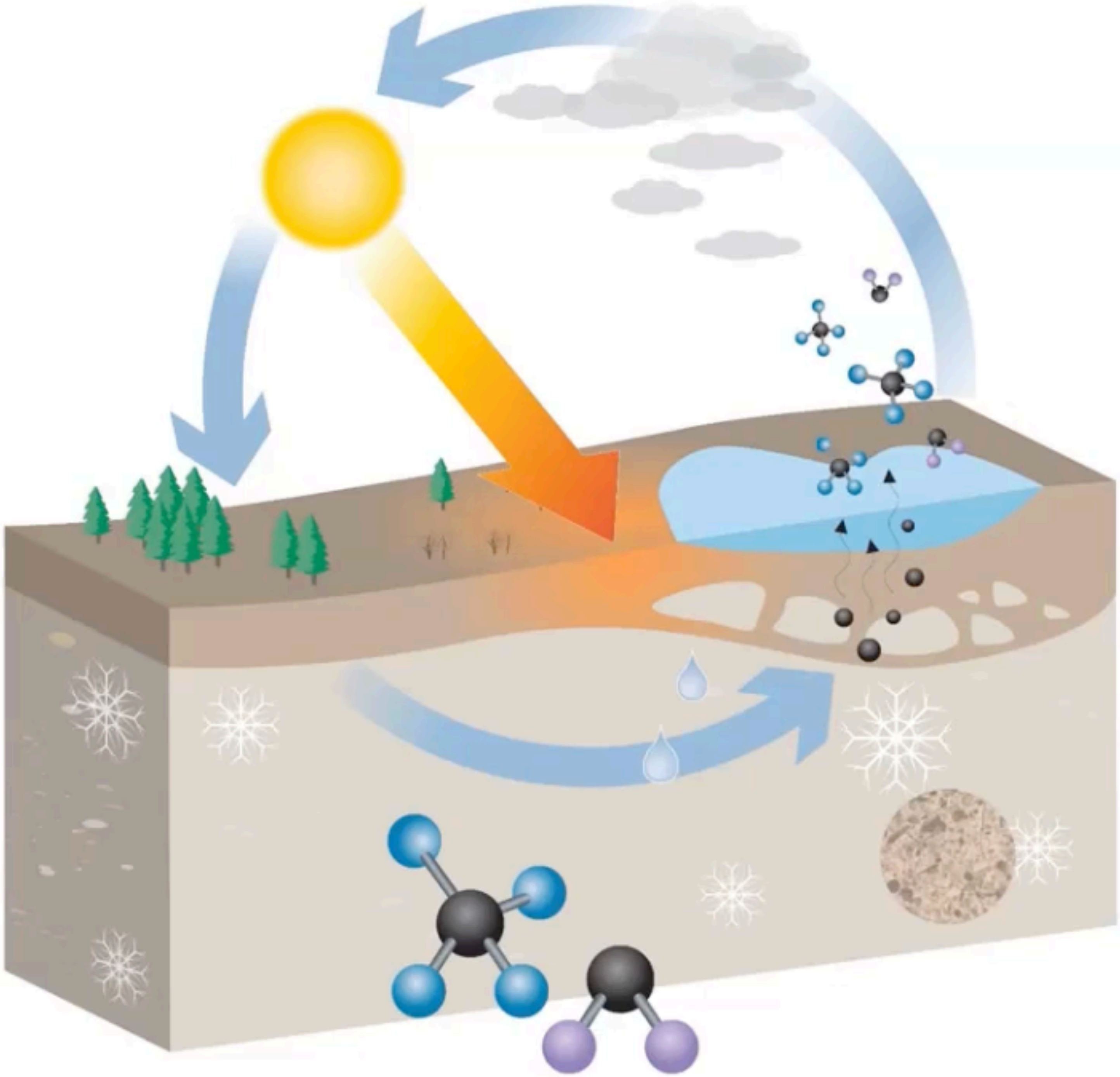
1. Historical data has shown that the Earth has gone through periods of warming and cooling.
    - Ice cores are an important source of that data.
2. Current data shows that the Earth is warming, which is correlated with an increase in the concentration of greenhouse gases in the atmosphere.
3. Climate change may change global wind patterns, affect soil quality.
4. Effects of climate change include rising temperatures, rising sea levels, and displacement of coastal populations.

Polar ice is melting



Permafrost is melting

Permafrost is melting

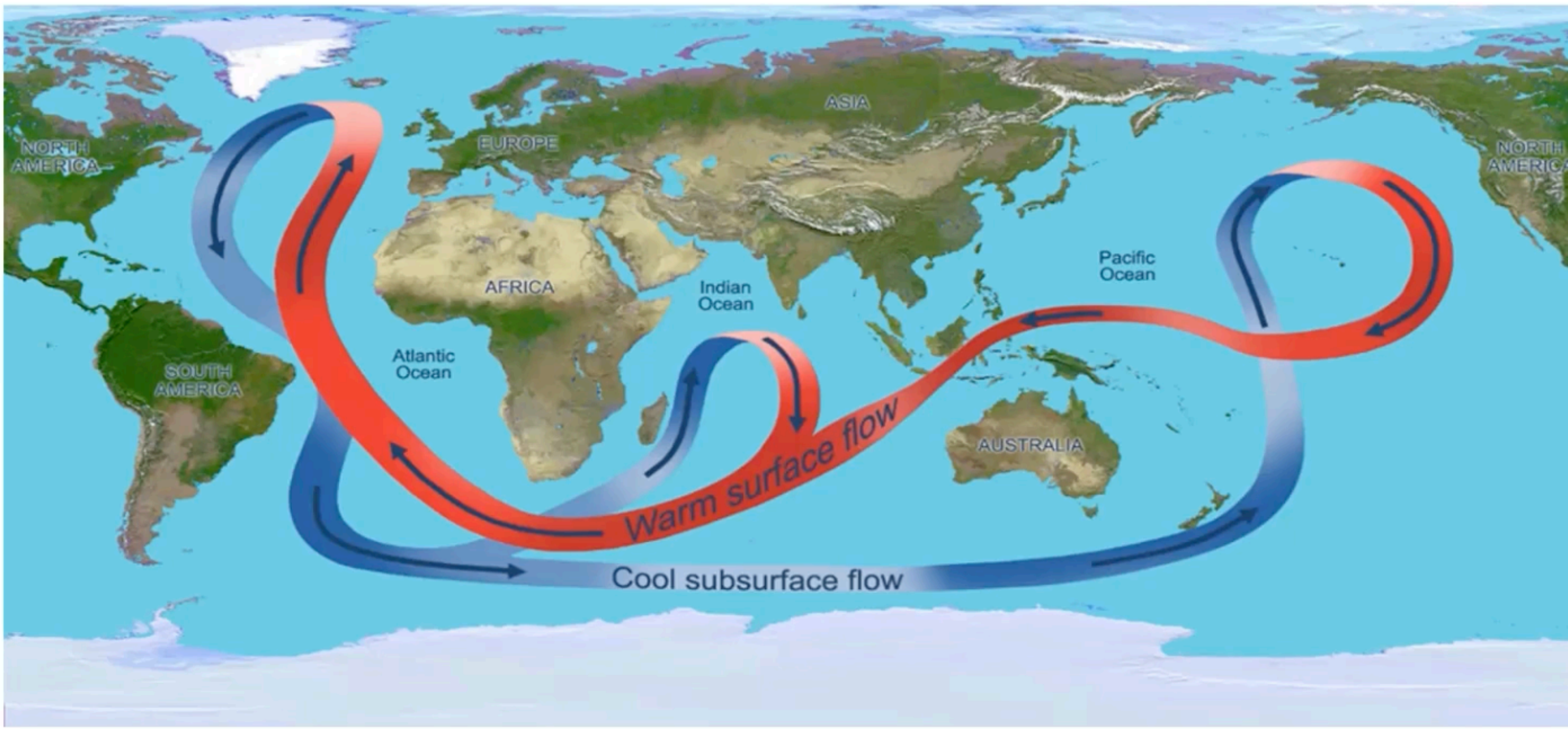


Sea ice is melting

Rising temperatures melt global ice

1. Melting polar ice reveals darker soil and water (lower albedo than ice), which drives a positive feedback warming loop.
2. Melting permafrost releases methane gas, which drives a positive feedback warming loop.
3. Melting sea ice affects species that depend on the ice for habitat and food, such as polar bears and seals.

Ocean currents change



Earliest Blooms Recorded in U.S. Due to Global Warming

In 2010 and 2012, plants in the eastern U.S. produced flowers earlier than at any point in recorded history, a new study says.

Two recent warm spells triggered many spring-flowering plants to blossom up to 4.1 days earlier for every 1 degree Celsius rise in average spring temperatures, which translates to 2.3 days for every 1 degree Fahrenheit.

Many studies have already shown that flowering times have come earlier as a result of recent global warming

Plants need to flower to reproduce. And in order to flower, they need a trigger—which is usually a long winter chill.

The concern is whether plants are "going to be able to adapt fast enough as climate changes radically, [or] is there some physical limit against which you're going to bump up [so] that you can't adapt any longer?"

And…"Across the Pond?"

Bluebells are a classic species of old woodland and are found throughout Britain which is one of its few remaining strongholds in Europe.

Mark Spencer, curator of the British plant collection at the Natural History Museum, said: "February is the earliest we've ever known bluebells to flower. It really is quite extraordinary.


"Combined with changes in the climate, we don't know what is in store in terms of survival for the British bluebell - they may even become seriously threatened as weather patterns change.

Climate change leads to changes in the world ocean

1. Climate change leads to sea level rise.
    - Benefit – new marine habitat created
    - Drawback – increasing depth of ocean impacts organisms that will no longer be in the photic zone
2. Climate change can alter ocean currents
    - Salinity and temperature changes impact water density, which can impact the ocean conveyer belt
    - Altered ocean currents can impact terrestrial climate, especially in coastal areas.

TOPIC 9.6

Ocean Warming

Required Course Content

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.G

Explain the causes and effects of ocean warming.

ESSENTIAL KNOWLEDGE

STB-4.G.1

Ocean warming is caused by the increase in greenhouse gases in the atmosphere.

STB-4.G.2

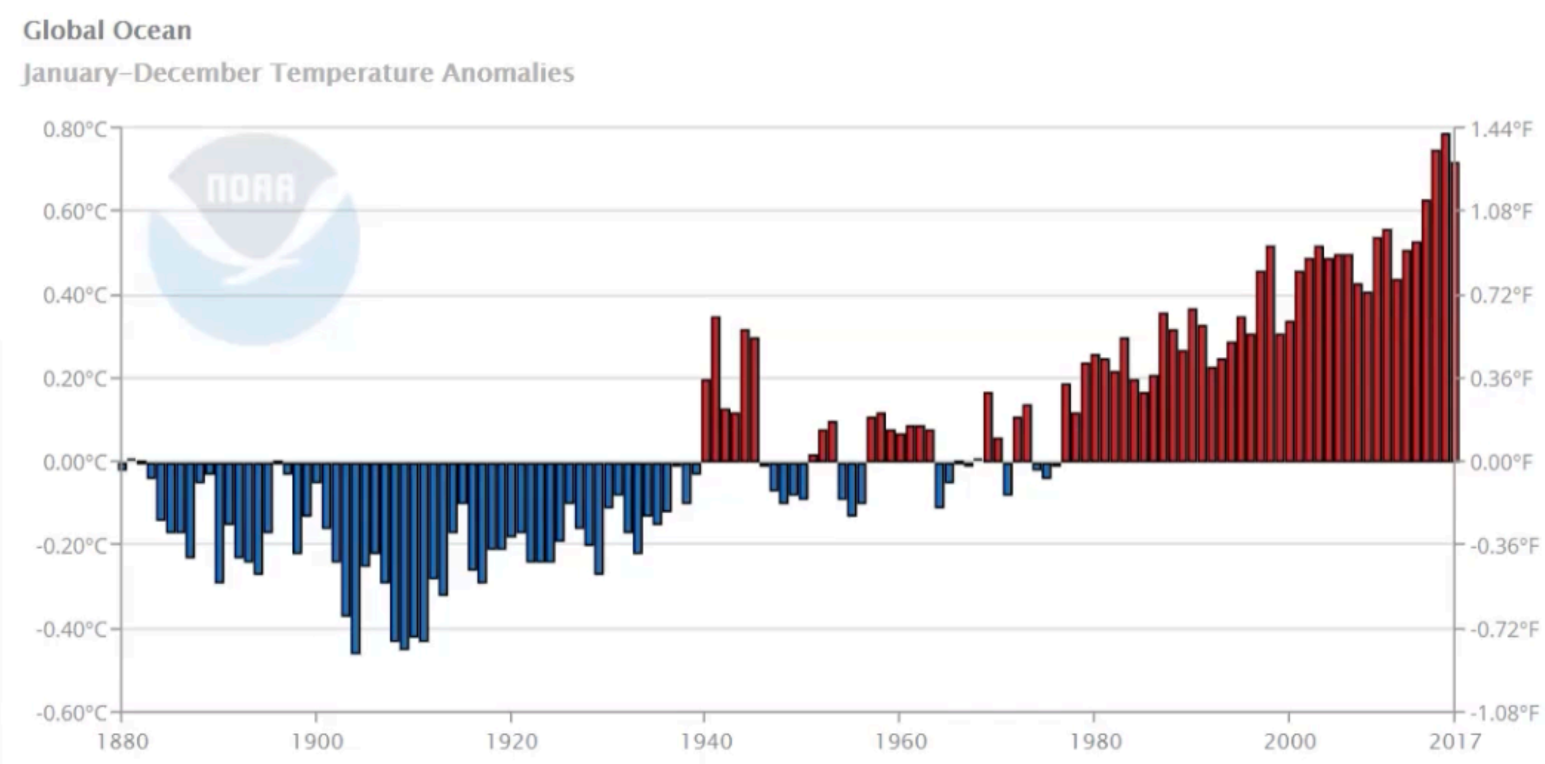
Ocean warming can affect marine species in a variety of ways, including loss of habitat, and metabolic and reproductive changes.

STB-4.G.3

Ocean warming is causing coral bleaching, which occurs when the loss of algae within corals cause the corals to bleach white. Some corals recover and some die.

Ocean Warming – Causes

- Ocean warming is the ***global increase in ocean water temperatures***
  - The amount of warming isn't uniform across the globe—some ocean areas have warmed more quickly than others
- Ocean warming is ***caused by increased greenhouse gases in Earth's atmosphere***, such as carbon dioxide and methane
  - The IPCC estimates that our oceans have absorbed 93% of the excess heat from greenhouse gas emissions since the 1970's



Source: NOAA, National Centers for Environmental Information

Ocean Warming – Effects

- Let's link it! Topics 9.4 and 9.5 discussed…
  - ***Increases in GHG emissions*** can lead to a variety of environmental problems
    - Rising sea levels from
      - Melting ice sheets
      - ***Ocean water expansion***
  - ***Thermal expansion of the ocean*** due to ocean warming causes
    - Rising sea levels
    - Displacement of coastal populations due to flooding

Source: NOAA, Pacific Environmental Marine Laboratory

- Data from NASA's Argo profiling floats indicates that about one-third of sea level rise since 2004 is due to thermal expansion

Ocean Warming – Effects

- Ocean warming affects marine species in a variety of ways
- **Loss of habitat**
  - Reduction of sea ice negatively impacts hunting/feeding patterns
  - Higher water temperatures impact predator/prey interactions, as prey migrate to cooler areas
  - Sea level rise alters coastlines, impacting species that use both land and water resources
  - Rising coastal seas may push some communities out of the photic zone
  - Warming oceans may impact primary productivity of phytoplankton, which are the basis of marine food webs

Source: Shutterstock.com by FloridaStock

Ocean Warming – Effects

- **Metabolic changes**
  - As the ocean warms, marine species may migrate, but they cannot locally escape to cooler areas – they are always surrounded by the warmer water
  - Organisms are pushed to their biological thermal limits and become weakened or die
  - Reduction of biodiversity/disruption of trophic structures
- **Reproductive changes**
  - Organisms weakened by thermal stress do not reproduce well
  - Many marine reproductive patterns (mating times, egg hatching times, larval development) are timed based on specific ocean temperatures – disruption of these temperature patterns leads to reproductive harm

Ocean Warming – Effects

- **Coral Bleaching**
  - Corals have algae that live within their bodies in mutualistic relationship; besides helping provide food for the coral, these algae also give corals their unique colors
  - Warming ocean temperatures stress the corals
  - When stressed, corals expel their symbiotic algae, which gives them a “bleached” appearance
  - Corals CAN recover from a bleaching event, but, if the conditions that caused the bleaching continue, this will often lead to the death of the coral

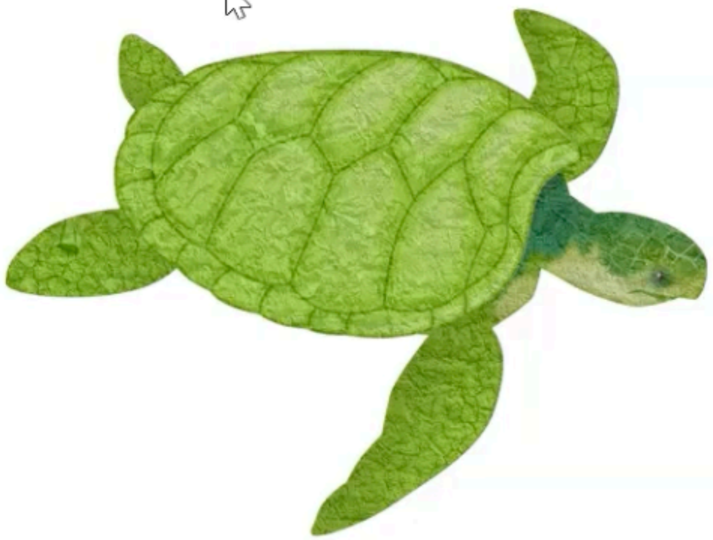
Healthy vs. Bleached Coral

Source: Shutterstock.com by Stephan Kerkhofs

Source: Shutterstock.com by Ekkapan Poddamrong

Why is Coral Bleaching a Problem?

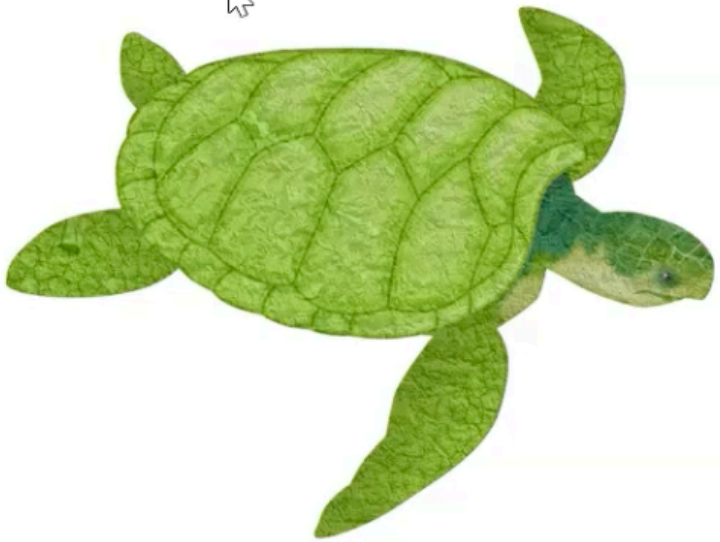
- Coral colonies are the foundation of highly biodiverse reef ecosystems
- The loss of coral colonies means that there will be a loss of habitat for the other species that depend on them
- This loss will also disrupt the trophic structure of the reef ecosystem
- Degraded reefs are vulnerable to invasive species, which have the potential to create permanent negative ecosystem impacts



Source: chiplanay from Pixabay.com

Final Take-Aways

- Increasing GHG emissions are the cause of ocean warming.
- Marine and coastal species are often negatively affected by ocean warming and subsequent sea level rise.
- Effects can include loss of habitat, metabolic changes and reproductive harm.
- Warmer ocean temperature stress corals, which then expel their symbiotic algae. When this happens, the corals "bleach", which may cause them to die.



Source: chiplanay from Pixabay.com

Multiple Choice Practice

When stressed, corals often expel the symbiotic algae living within their tissues, causing them to bleach. Which of the following environmental issues is most closely associated with coral bleaching events?

A) El Niño conditions in the equatorial Pacific Ocean due to weakened trade winds

B) Reduced nutrient distribution due to decreased thermohaline circulation

C) Warmer ocean water temperatures due to increased greenhouse gas emissions

D) Increased turbidity in ocean water due to thermal inversions

Multiple Choice Practice

Which of the following would be a likely consequence of ocean warming?

A) Increased biodiversity in equatorial oceans

B) Stabilization of marine predator/prey interactions

C) Reduced methane emissions from aquatic decomposition

D) Altered reproductive patterns in marine species

Free Response Practice

The Gulf of Maine is located at 43 degrees N latitude in the northern Atlantic Ocean. Researchers in Acadia National Park in have observed increased die-offs of protected Atlantic puffin chicks around the Gulf. Since 2005, sea surface temperatures in the Gulf of Maine have increased an average of 0.23 degrees Celsius per year, a rate of warming faster than 99% of oceans worldwide. During the same time period, yearly spawning biomass of Atlantic herring (*Clupea harengus*) has decreased from approximately 10,000 metric tons in 2005 to 2,000 metric tons in 2015. The preferred food of puffin are Atlantic herring.

Free Response Practice

a) Based on the scenario presented, **explain** a likely cause of increased puffin chick mortality in the Gulf of Maine.

b) **Identify** a possible cause of rising ocean temperatures in the northern Atlantic Ocean and **describe** how this phenomenon causes temperatures to rise.

c) **Describe** one federal or international law designed to…

  i. Address the cause of rising ocean temperatures you identified in part b), OR
  ii. Assist with the conservation of the protected Atlantic puffin, OR
  iii. Regulate overfishing of the reduced herring stocks in the northern Atlantic

Model Response

a) Based on the scenario presented, the likely cause of increased puffin chick mortality is a lack of food/starvation. Their preferred food, herring, have drastically decreased in number, which means there likely aren't enough herring to support the chick population.

b) A possible cause of rising ocean temperatures in the northern Atlantic Ocean is increased concentrations of greenhouse gases in Earth's atmosphere. These gases trap heat in the atmosphere, which leads to increased surface temperatures. The oceans absorb much of the excess atmospheric heat, which causes them to warm, and northern waters are warming more quickly than those in lower latitudes.

Model Response

c) One federal or international law designed to address…

i. The cause of rising ocean temperatures is the Kyoto Protocol, which seeks to limit greenhouse gas emissions from signatory countries

ii. Conservation of the protected Atlantic puffin is the Endangered Species Act, which seeks to protect critical species and the environments in which they are found

iii. Regulate fishing stocks is the Magnuson-Stevens Fishery Act, which established a 200-mile regulated zone along the coasts in U.S. waters to better manage critical fish stocks in federal waters

Source: Clker-Free-Vector-Images from Pixabay.com

TOPIC 9.7

Ocean Acidification

ENDURING UNDERSTANDING

STB-4

Local and regional human activities can have impacts at the global level.

LEARNING OBJECTIVE

STB-4.H

Explain the causes and effects of ocean acidification.

ESSENTIAL KNOWLEDGE

STB-4.H.1

Ocean acidification is the decrease in pH of the oceans, primarily due to increased CO_2 concentrations in the atmosphere, and can be expressed as chemical equations.

STB-4.H.2

As more CO_2 is released into the atmosphere, the oceans, which absorb a large part of that CO_2, become more acidic.

STB-4.H.3

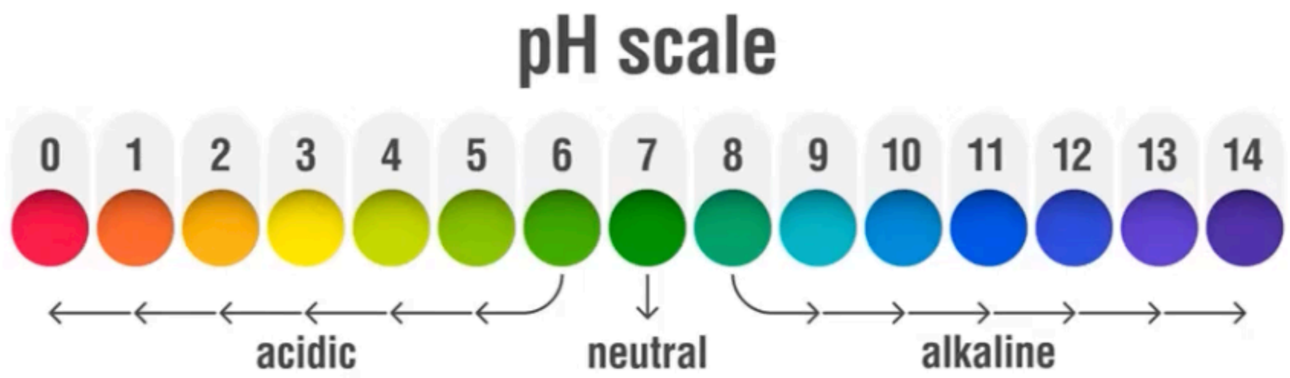
Anthropogenic activities that contribute to ocean acidification are those that lead to increased CO_2 concentrations in the atmosphere: burning of fossil fuels, vehicle emissions, and deforestation.

STB-4.H.4

Ocean acidification damages coral because acidification makes it difficult for them to form shells, due to the loss of calcium carbonate.

Ocean Acidification – What

- Ocean acidification is the ***decrease in pH of ocean waters***
- In the approximately 200 years since the beginning of the Industrial Revolution, the pH of the ocean has fallen by 0.1 pH units, from a pre-1800's level of 8.2 to today's measure of 8.1
- The pH scale is logarithmic - each jump of 1 on the scale represent a ten-fold change in the concentration of hydrogen (H^+) ions - so this drop actually represents about a 30% increase in acidity



Ocean Acidification – Why

- Like ocean warming, ocean acidification is due primarily to increased ***greenhouse gas concentrations in the atmosphere***, specifically ***carbon dioxide, CO_2***

- The more CO_2 is released into the atmosphere, the more the oceans absorb, lowering their pH through specific chemical reactions

Ocean Acidification – Why

- Anthropogenic activities that contribute to ocean acidification are those that lead to ***increased CO_2*** into the atmosphere, including:
  - ***Burning/combustion of fossil fuels***
  - ***Vehicle emissions***
  - ***Deforestation***

Source: Shutterstock.com by Rudmer Zwerver

Source: Shutterstock.com by Hung Chung Chih

Source: Shutterstock.com by Rich Carey

Ocean Acidification – How

- When CO_2 is absorbed by seawater, a series of chemical reactions occur which result in an increase in hydrogen ions
- The water combines with the carbon dioxide to create carbonic acid, which is a weak acid. The carbonic acid then dissociates into hydrogen ions and bicarbonate ions.
- The greater the concentration of hydrogen ions, the lower the pH of the water (more acidic)

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$H_2CO_3 \rightarrow H^+ + HCO_3^-$$

Ocean Acidification - Effects

- The shells of many ocean creatures and the skeletons of corals are made of calcium carbonate, $CaCO_3$

- To make $CaCO_3$ for their shells, marine organisms combine calcium ions, Ca^{+2} and carbonate ions, CO_3^{-2}

Source: Shutterstock.com by luca85

Ocean Acidification - Effects

- With acidification, the increased concentration of hydrogen ions (H^+) from the dissociation of carbonic acid bond with available carbonate ions (CO_3^{-2}) in seawater.
  - Hydrogen ions bond more readily with carbonate ions than calcium ions do.
- When hydrogen ions bond with carbonate ions, a bicarbonate ion, HCO_3^-, is formed.

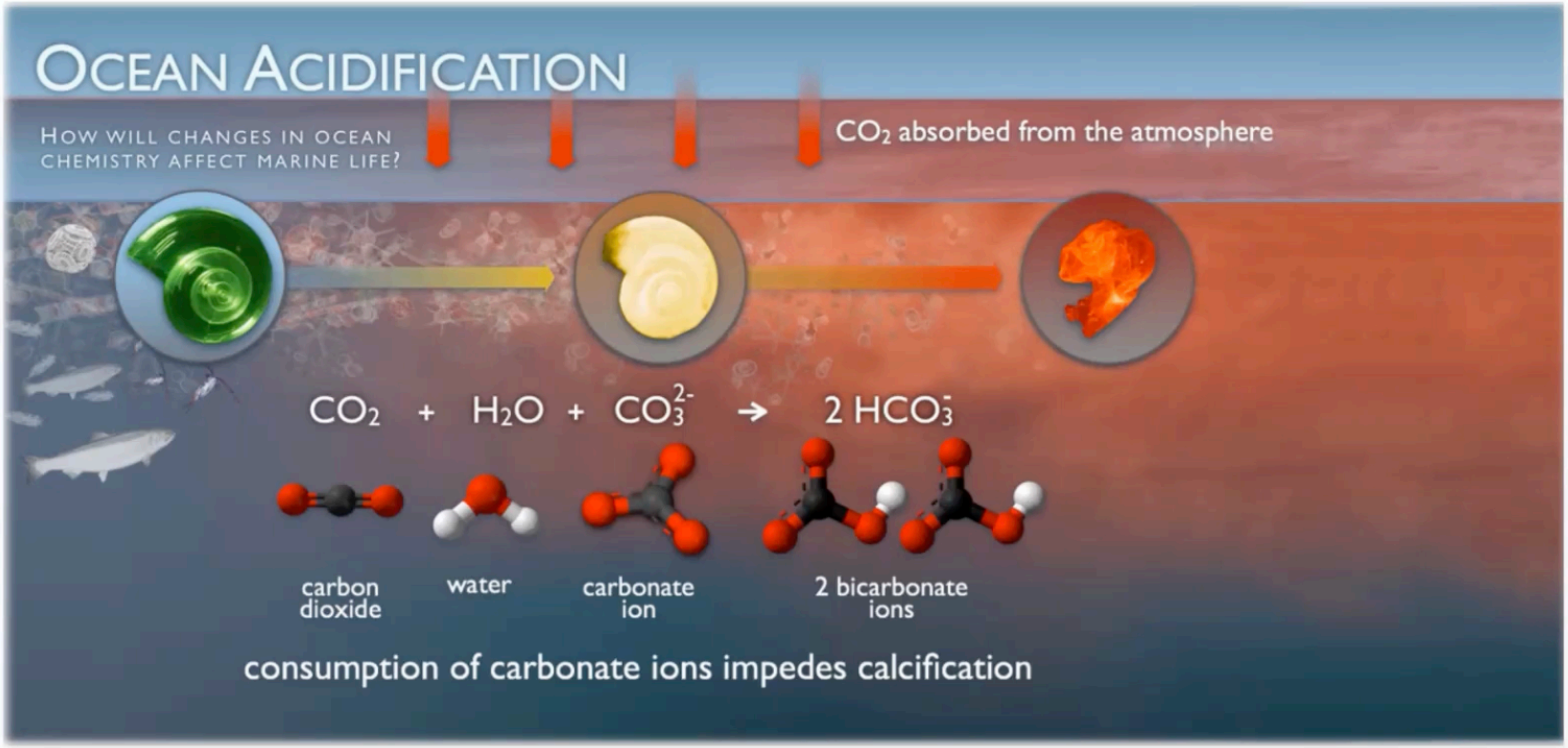
$$CO_2 + H_2O + CO_3^{-2} \rightarrow 2\,HCO_3^-$$

Ocean Acidification - Effects

- Unfortunately, marine organisms can't extract the carbonate they need from this bicarbonate ion, making it harder for them to build shells and exoskeletons

- If there are enough free H^+ ions around, they can even break apart existing $CaCO_3$ bonds, dissolving shells and skeletons that are already formed

Ocean Acidification – Effects



Source: NOAA.gov

Ocean Acidification – Effects on Coral

- Ocean acidification is harmful to corals because corals need free carbonate ions to form their skeletons

- Corals are the foundation of highly biodiverse reef ecosystems, and provide food and habitat for a variety of marine life. When corals are damaged or die off, ocean biodiversity is severely impacted.

- Combined threats from ocean acidification and ocean warming mean coral reefs are particularly vulnerable to the effects of climate change

Source: Shutterstock.com by Stephan Kerkhofs

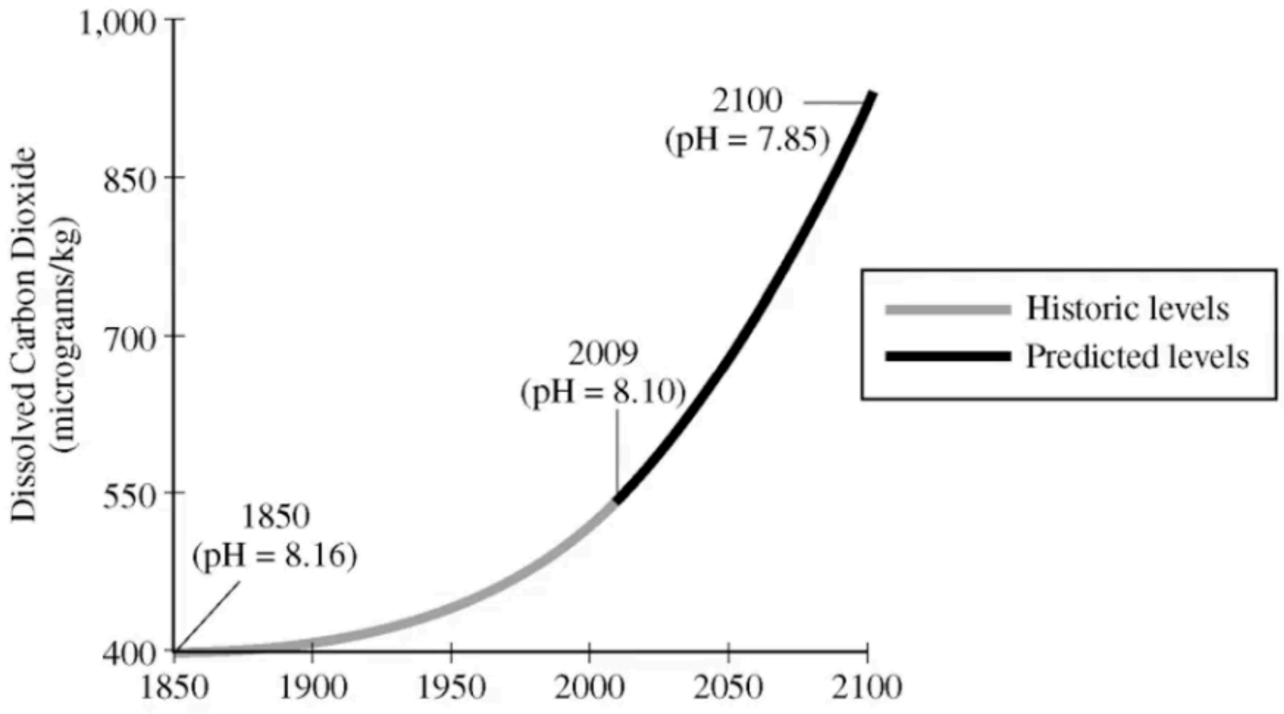
Final Take-Aways

- Increasing levels of atmospheric CO_2 are the cause of ocean acidification. Excess CO_2 is absorbed by the oceans, lowering their pH through a series of chemical reactions.
- Humans increase CO_2 concentrations by burning fossil fuels, driving vehicles, and deforestation
- Organisms that use $CaCO_3$ to build their shells and skeletons are damaged by ocean acidification because it reduces the amount of free CO_3^{-2} ions available for them to use, and may even lead to loss of $CaCO_3$ in existing structures

Source: Shutterstock.com by luca85

Free Response Practice

Coral reefs are produced when corals acquire calcium ions (Ca^{2+}) and carbonate ions (CO_3^{2-}) from seawater and deposit solid $CaCO_3$ to form their exoskeletons. Scientists are concerned that relatively rapid decreases in ocean water pH will hinder the deposition of $CaCO_3$. The graph shows the amount of CO_2 dissolved in ocean water and ocean water pH (shown in parentheses) since 1850 and the predicted changes through 2100.



(a) Explain how an increase in the amount of dissolved CO_2 in ocean water results in a decrease in the pH of ocean water.

(b) Explain why the movement of carbon into the ocean has been increasing since 1850.

(c) In order to model the effects of ocean acidification on coral reefs, some simplifying assumptions can be made. Use the assumptions in the table below to perform the calculations that follow.

Assume that the total global area of corals growing in reefs is 2.5×10^{11} m^2.
Assume that corals grow only vertically and that the average vertical growth rate of corals is 3 mm/year.
Assume that the average density of $CaCO_3$ in corals is 2×10^3 kg/m^3.

(i) Calculate the current annual global increase in volume, in m^3, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

(ii) Calculate the current annual global increase in mass, in kg, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

(iii) Because of ocean acidification, it is expected that in 2050 the mass of $CaCO_3$ deposited annually in coral reefs will be 20 percent less than is deposited currently. Calculate how much less $CaCO_3$, in kg, is expected to be deposited in 2050 than would be deposited if ocean water pH were to remain at its current value.

(d) Identify and describe one likely negative environmental impact of the loss of coral reefs.

(e) Identify one environmental problem (other than one due to ocean acidification or loss of coral reefs) that affects marine ecosystems on a global scale.

(a) Explain how an increase in the amount of dissolved CO_2 in ocean water results in a decrease in the pH of ocean water.

As the amount of CO_2 in the atmosphere increases, so does the amount of CO_2 that is absorbed by ocean water. CO_2 combines with water to create carbonic acid, H_2CO_3. Carbonic acid dissociates into free hydrogen ions and bicarbonate ions. The greater the amount of hydrogen ions the lower the pH of the water, since pH is a measure of the concentration of hydrogen ions.

$$CO_2 + H_2O \rightarrow H_2CO_3 \qquad H_2CO_3 \rightarrow H^+ + HCO_3^-$$

(b) Explain why the movement of carbon into the ocean has been increasing since 1850.

Since 1850, there has been an increase in the burning of fossil fuels, vehicle emissions and rates of deforestation. All of these contribute to a rise in concentrations of atmospheric CO_2.

(c) In order to model the effects of ocean acidification on coral reefs, some simplifying assumptions can be made. Use the assumptions in the table below to perform the calculations that follow.

Assume that the total global area of corals growing in reefs is 2.5×10^{11} m^2.
Assume that corals grow only vertically and that the average vertical growth rate of corals is 3 mm/year.
Assume that the average density of $CaCO_3$ in corals is 2×10^3 kg/m^3.

(i) Calculate the current annual global increase in volume, in m^3, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

$$2.5 \times 10^{11}\ m^2 \times \frac{3\ mm}{year} \times \frac{1\ m}{1.0 \times 10^3\ mm} = \frac{7.5 \times 10^8\ m^3}{year}$$

(ii) Calculate the current annual global increase in mass, in kg, of $CaCO_3$ in coral reefs. Show all steps in your calculation.

$$\frac{7.5 \times 10^8\ m^3}{year} \times \frac{2.0 \times 10^3\ kg}{m^3} = \frac{1.5 \times 10^{12}\ kg}{year}$$

(iii) Because of ocean acidification, it is expected that in 2050 the mass of $CaCO_3$ deposited annually in coral reefs will be 20 percent less than is deposited currently. Calculate how much less $CaCO_3$, in kg, is expected to be deposited in 2050 than would be deposited if ocean water pH were to remain at its current value.

$$1.5 \times 10^{12}\ \text{kg} \times 0.2 = 3.0 \times 10^{11}\ \text{kg}$$

(d) Identify and describe one likely negative environmental impact of the loss of coral reefs.

Loss of habitat for species

- *Elimination of a food source for marine organisms*
- *Loss of breeding grounds for fish/birds*
- *Loss of shelter/hiding spaces*

Loss of biodiversity

- *Extinction or decreased populations of marine organisms*

Loss of critical carbon sink

- *Less carbon storage in coral reefs*

Decreased protection of coastal areas from waves/storm surges

- *Destruction of coastal habitats*
- *Accelerated erosion of shoreline/loss of shoreline habitat*

(e) Identify one environmental problem (other than one due to ocean acidification or loss of coral reefs) that affects marine ecosystems on a global scale.

- ***Overfishing***
- ***Destructive fishing practices***
- ***INCREASED OCEAN TEMPERATURES***
- ***Invasive species***
- ***Nutrient pollution/eutrophication***
- ***Hypoxia/dead zones***
- ***Garbage and plastic debris/pollution***
- ***Oil spills***
- ***Mercury pollution***

TOPIC 9.8

Invasive Species

Required Course Content

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.A

Explain the environmental problems associated with invasive species and strategies to control them.

ESSENTIAL KNOWLEDGE

EIN-4.A.1

Invasive species are species that can live, and sometimes thrive, outside of their normal habitat. Invasive species can sometimes be beneficial, but they are considered invasive when they threaten native species.

EIN-4.A.2

Invasive species are often generalist, r-selected species and therefore may outcompete native species for resources.

EIN-4.A.3

Invasive species can be controlled through a variety of human interventions.

What is an Invasive Species?

- An invasive species is "an ***alien species*** whose ***introduction*** does or is likely to ***cause economic or environmental harm*** or ***harm to human health***" (USDA, Federal Invasive Species Advisory Committee, 2006)

- Invasive species CAN sometimes be beneficial, but they are considered invasive when they threaten native species in some manner

- Non-native species may be introduced into ecosystems accidentally or purposefully

Yep, it's a Cane Toad

Source: Pixabay.com by G John

Characteristics of Invasive Species

- Invasive species tend to be niche ***generalist, r-selected species***

- Characteristics of these types of species include
  - The ability to withstand a wide variation of abiotic conditions
  - A varied diet/ability to survive on different types of food
  - Production of numerous offspring
  - Short gestation times
  - Little parental care
  - Rapid maturation and early reproductive age
  - Exponential population growth

Characteristics of Invasive Species

- Not every species that is introduced into an ecosystem becomes invasive

- The trophic relationships and abiotic conditions of the native ecosystem tend to keep native species' numbers in balance. Introduced species disrupt this balance and compete with natives for niche space.

- Since they are generalists and not subject to the "checks and balances" of the native ecosystem, invasives have a competitive advantage over endemic (native) species

Feral Hogs in a Forest

Source: Shutterstock.com by Slatan

How Are Invasive Species Spread?

- Once introduced, species can be spread through a variety of means, including
  - The transport of lumber or firewood
  - Ballast water in ships
  - Movement of boats and boat trailers
  - Through the movement of international shipping containers
  - On the fur of animals or the clothing/shoes of humans
  - Through the movement of wind and water

Kudzu Vines Overtake a Building in Florida

How Can We Control Invasive Species?

- Drain, clean and dry your boat prior to moving it to help prevent the spread of aquatic invasives

- Prevent the dumping of aquariums and release of exotic pets

- Clean your boots/shoes and change your pants/socks before hiking into a new area to help prevent the spread of invasive seeds

- Keep firewood where it was cut to help prevent the spread of wood-borne pathogens

Source: Shutterstock.com by Amelia Martin

How Can We Control Invasive Species?

- Introduction of a competitor species to the invasive species
- Introduction of a predator species to the invasive species
- Introduction of a species-specific pathogen into an invasive population
- Physical removal and controlled burns help control invasive plants
- Application of a pesticide specific to the invasive species

Final Take-Aways

- Invasive species are non-native species accidentally or purposefully introduced into an ecosystem that threaten or harm native populations
- They are often r-selected, generalist species that can survive in a wide range of abiotic conditions and habitats
- Invasives often out-compete native species
- Invasive species can be spread in a variety of ways
- Invasive species and the damage they cause can be controlled through a variety of human interventions

A Leaping Asian Silver Carp

Source: Shutterstock.com by SandmanPhotography

TOPIC 9.9

Endangered Species

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.B

Explain how species become endangered and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.B.1

A variety of factors can lead to a species becoming threatened with extinction, such as being extensively hunted, having limited diet, being outcompeted by invasive species, or having specific and limited habitat requirements.

EIN-4.B.2

Not all species will be in danger of extinction when exposed to the same changes in their ecosystem. Species that are able to adapt to changes in their environment or that are able to move to a new environment are less likely to face extinction.

EIN-4.B.3

Selective pressures are any factors that change the behaviors and fitness of organisms within an environment.

EIN-4.B.4

Species in a given ecosystem compete for resources like territory, food, mates, and habitat, and this competition may lead to endangerment or extinction.

EIN-4.B.5

Strategies to protect animal populations include criminalizing poaching, protecting animal habitats, and legislation.

Factors that May Lead to Extinction

- As habitats are lost or altered globally, many species are threatened with extinction.
- Certain factors may make a species more likely to become extinct.
- Some of these include:
  - Being ***extensively hunted***
  - Having a ***limited diet***
  - Being ***outcompeted by invasive species***
  - Having ***specific, limited habitat requirements***

Source: Shutterstock.com by FloridaStock

Hunting

- Obviously, extensive hunting can lead to the loss of a species.

- ***Poaching*** is the ***illegal hunting***, killing or capturing of animals for sale or profit.

- Animals may be hunted for:
  - Food
  - Prized body parts
  - Traditional medicinal uses
  - Medical research purposes
  - Sport

Limited Diet and Habitat

- Species who are niche specialists are generally at greater risk of extinction.
- Organisms with specialist traits, such as:
  - Specific habitat requirements
  - Limited diet
  - Low reproductive rates/long gestation times
  - Few offspring with high parental care

  …may fare poorly under altered conditions.
- ***As global change intensifies, ecosystems are at risk and specialist species may be less able to adapt to rapid environmental changes.***

Source: Pixabay.com by Jose R. Cabello

Competition from Invasive Species

- Invasive species are usually r-selected niche generalists (Topic 9.8).
- Generalists who can tolerate a broad range of abiotic conditions and have a varied diet may outcompete native species with more specific requirements.
- This can lead to the increased risk of extinction of the native species.

Source: Shutterstock.com by Slatan

Adapt…or Perish!

- The biological and behavioral traits of a species will determine their risk of extinction when exposed to environmental change.
- Species that are better able to adapt to changes in their environment will fare better under changing or disrupted conditions.
- Adaptation requires genetic diversity, so species with low genetic diversity will have less ability to adapt.
- Species that can migrate to move favorable environmental conditions are also less likely to face extinction. However, migration may also raise competitive pressures in the new environment.

Selective Pressures and Adaptation

- A ***selective pressure*** is any external factor that changes the behavior and fitness of organisms within an environment.
- Examples of selective pressures include:
  - **Resource availability**
    - Food
    - Water
    - Habitat
    - Mates
  - **Abiotic environmental conditions**
    - Temperature
    - Humidity
    - Tree cover
    - Salinity
  - **Biological Factors**
    - Pathogens (viruses, bacteria, fungi, etc.)
    - Disease
- Selective pressures determine which genetic/behavioral traits are favorably adapted to the environment…and which aren't!
- Selective ***pressures will change in changing environments***, so traits that were once advantageous in an environment may not continue to be so.

Competition

- In Topic 1.1, we discussed how the availability of resources influences species interactions.
- Competition can occur within or between species in an ecosystem where there are limited resources.
- Competition consumes important metabolic resources, so competitive strategies generally evolve to limit resource conflicts through ***resource partitioning.***
- Organisms may compete within their own species or between species resources, such as:
  - ***Territory***
  - ***Food***
  - ***Mates***
  - ***Habitat***

Competition

- Although competition is “normal,” species seek to limit competition because it’s biologically costly.
- But, in ecosystems in which:
  - Trophic relationships are disrupted
  - There is increased competition invasive species
  - Resources have become increasingly scare due to habitat loss or climate change

…competition can become intense enough to lead to a species’ endangerment or extinction.

Invasive Species and Competition

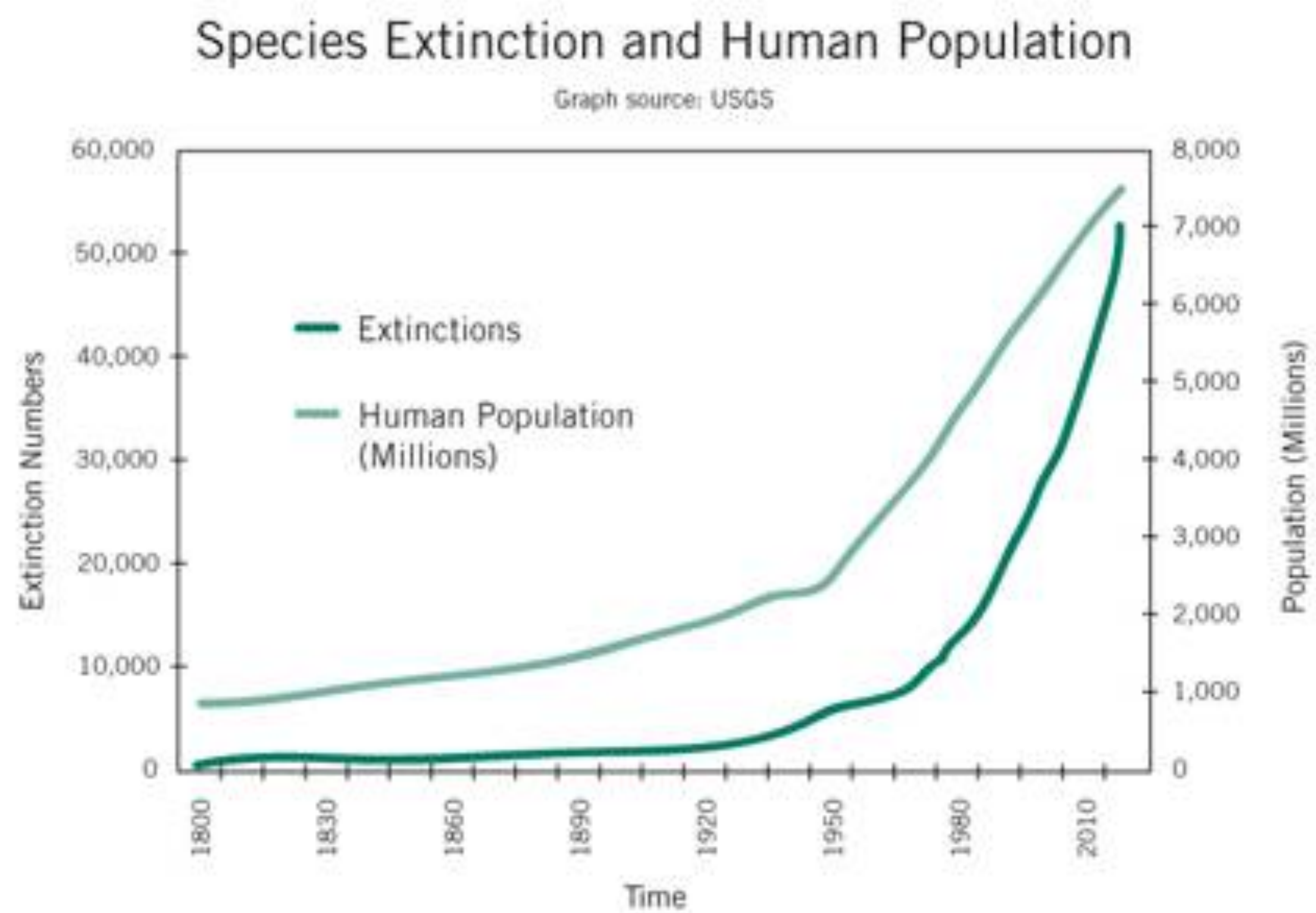
- Thinking back to Topic 9.8…remember that ***invasive species often out-compete native species.***

- This is because of the biological/behavioral adaptations of the invasive species (r-selected/generalists), as well as the fact that they lack natural predators in the new ecosystem.

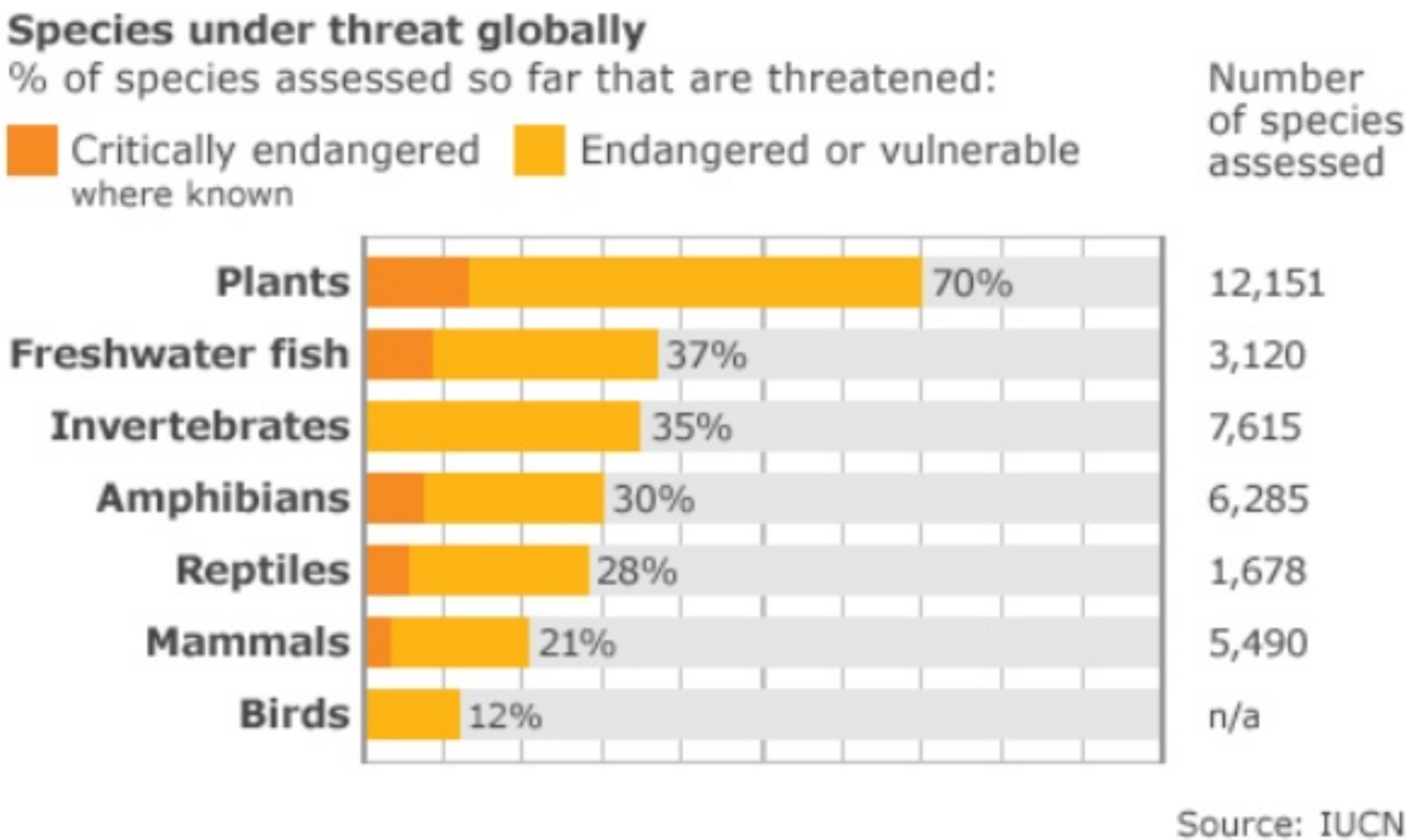
- ***Under changing environmental conditions, generalist invasives will have a competitive advantage over specialist natives, and may drive the native species to extinction.***

Biodiversity

Species extinction and the degradation of ecosystems are proceeding rapidly and the pace is accelerating. The world is losing species at a rate that is 100 to 1000 times faster than the natural extinction rate.



The biodiversity crisis



The number of wild animals living on Earth is set to fall by two-thirds by 2020, according to a new report, part of a mass extinction that is destroying the natural world upon which humanity depends.

The analysis, the most comprehensive to date, indicates that animal populations plummeted by 58% between 1970 and 2012, with losses on track to reach 67% by 2020.

Researchers from WWF and the Zoological Society of London compiled the report from scientific data and found that the **destruction of wild habitats**, **hunting** and **pollution** were to blame.

The biggest cause of tumbling animal numbers is the **destruction of wild areas for farming and logging**: the majority of the Earth's land area has now been impacted by humans, with just 15% protected for nature.

Strategies to Protect Species

- ***Legislation*** (with enforcement) is one primary way to help protect endangered species.

- Criminalizing poaching and instituting steep fines and/or punishment for poachers can help curb this practice.

Source: Pixabay.com by Clker-Free-Vector-Images

- Laws prohibiting the harming of endangered species and their habitats, or the trade in endangered species:
  - The Lacey Act
  - The Endangered Species Act
  - The Marine Mammal Protection Act
  - CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora)

Strategies to Protect Species

- The establishment of protected areas for species, such wildlife refuges or national parks
- Enforcement of conservation practices within protected habitat areas can help, too.

Source: Shutterstock.com by Robert Mutch

The Endangered Haleakala Silversword in Haleakala NP, Maui, Hawai’i

Source: Shutterstock.com by Vincent K Ho

Source: National Park Service, NPS.gov

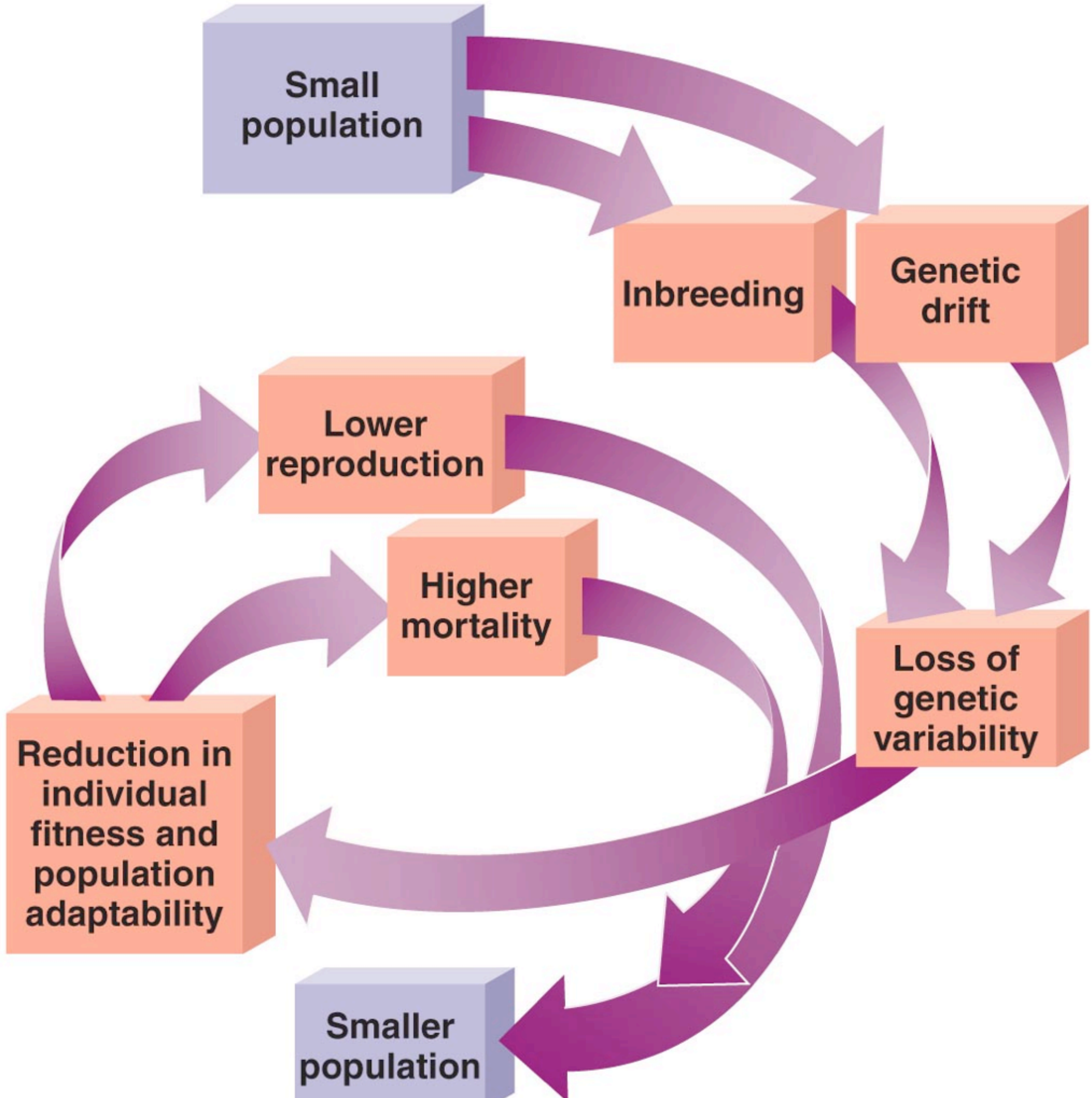
POPULATION CONSERVATION FOCUSES ON POPULATION SIZE, GENETIC DIVERSITY AND CRITICAL HABITAT

Small Population Approach

- Particularly vulnerable to over harvesting and habitat loss
- study processes that cause extinctions of small populations

The Extinction Vortex: Evolution Implications

- Small populations suffer from Inbreeding and Genetic Drift which result in a loss of genetic variation.


Small population
Inbreeding
Genetic drift
Lower reproduction
Higher mortality
Loss of genetic variability
Reduction in individual fitness and population adaptability
Smaller population

Minimum Viable Population Size

- Minimal population size at which a species is able to sustain its numbers..(MVP)
- Depends on the organism and other factors

Effective Population Size

- Population size by itself can be misleading, Effective population size is based on breeding potential.
  - Consider a population of 1000 with only 5 females and a population of 100 with 40 females. See a difference?

TOPIC 9.10

Human Impacts on Biodiversity

ENDURING UNDERSTANDING

EIN-4

The health of a species is closely tied to its ecosystem, and minor environmental changes can have a large impact.

LEARNING OBJECTIVE

EIN-4.C

Explain how human activities affect biodiversity and strategies to combat the problem.

ESSENTIAL KNOWLEDGE

EIN-4.C.1

HIPPCO (habitat destruction, invasive species, population growth, pollution, climate change, and over exploitation) describes the main factors leading to a decrease in biodiversity.

EIN-4.C.2

Habitat fragmentation occurs when large habitats are broken into smaller, isolated areas. Causes of habitat fragmentation include the construction of roads and pipelines, clearing for agriculture or development, and logging.

EIN-4.C.3

The scale of habitat fragmentation that has an adverse effect on the inhabitants of a given ecosystem will vary from species to species within that ecosystem.

EIN-4.C.4

Global climate change can cause habitat loss via changes in temperature, precipitation, and sea level rise.

EIN-4.C.5

Some organisms have been somewhat or completely domesticated and are now managed for economic returns, such as honeybee colonies and domestic livestock. This domestication can have a negative impact on the biodiversity of that organism.

continued on next page

ESSENTIAL KNOWLEDGE

EIN-4.C.6

Some ways humans can mitigate the impact of loss of biodiversity include creating protected areas, use of habitat corridors, promoting sustainable land use practices, and restoring lost habitats.

HIPPCO!

- ***HIPPCO*** is a useful acronym that helps you remember the main factors leading to ***decreases in biodiversity***
  - **H** – ***Habitat destruction***
  - **I** – ***Invasive species***
  - **P** – ***Population growth (human)***
  - **P** – ***Pollution***
  - **C** – ***Climate change***
  - **O** – ***Over exploitation***

During the scope of AP Environmental Science, we've discussed each of these factors. Be sure you can ***make the connections between the specifics you learned in earlier topics to HOW each of these impacts biodiversity*** in ecosystems. This is how you'll be assessed on the exam!

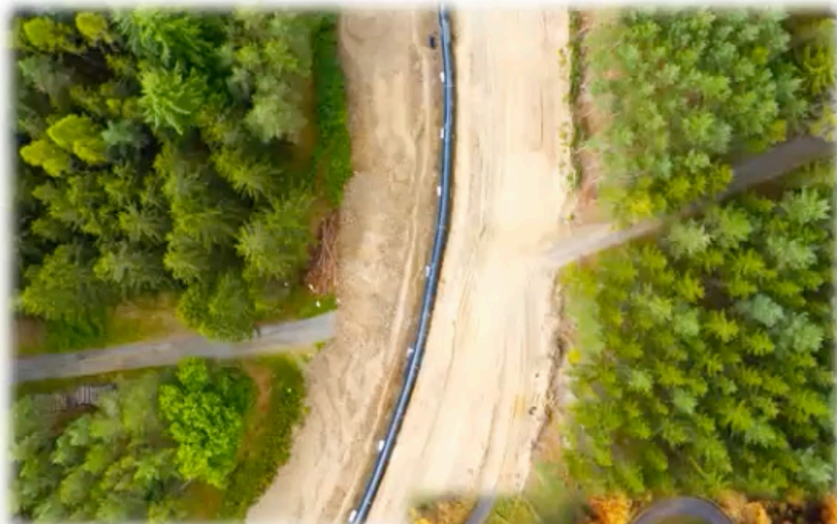
HIPPCO

Habitat Loss

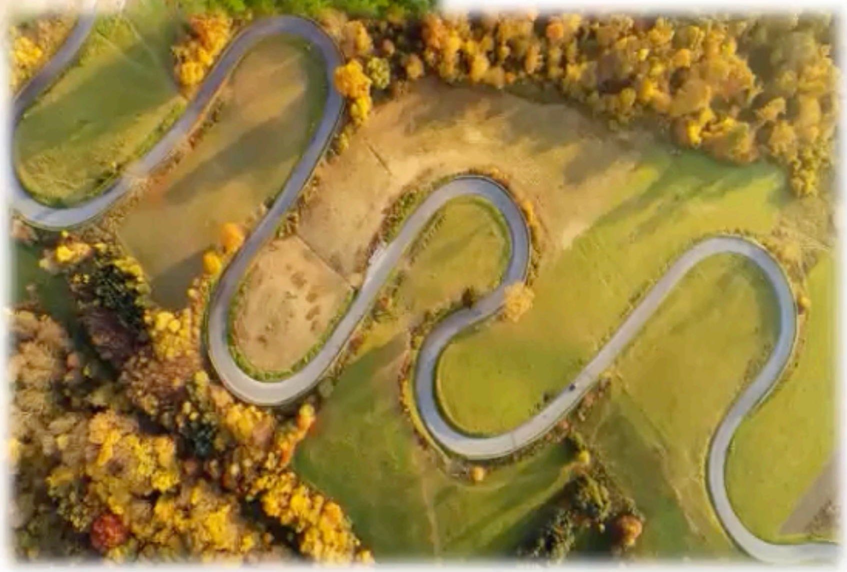
Habitat Fragmentation - Causes

- Habitat fragmentation occurs when large habitats are broken up into smaller, isolated areas.
- Causes of habitat fragmentation include:
  - ***Construction of roads and pipelines***
  - ***Clearing of land for agriculture or development***
  - ***Logging***
- Some species may actually benefit from increased fragmentation, such as species that thrive in edge habitats, but generally, habitat fragmentation has a ***negative impact biodiversity***.

Construction of Pipelines and Roads



Source: Shutterstock.com by Kletr



Source: Shutterstock.com by Piotr Krzeslak

Clearing of Land for Agriculture and Logging

Source: Shutterstock.com by PRILL

Source: Shutterstock.com by Rich Carey

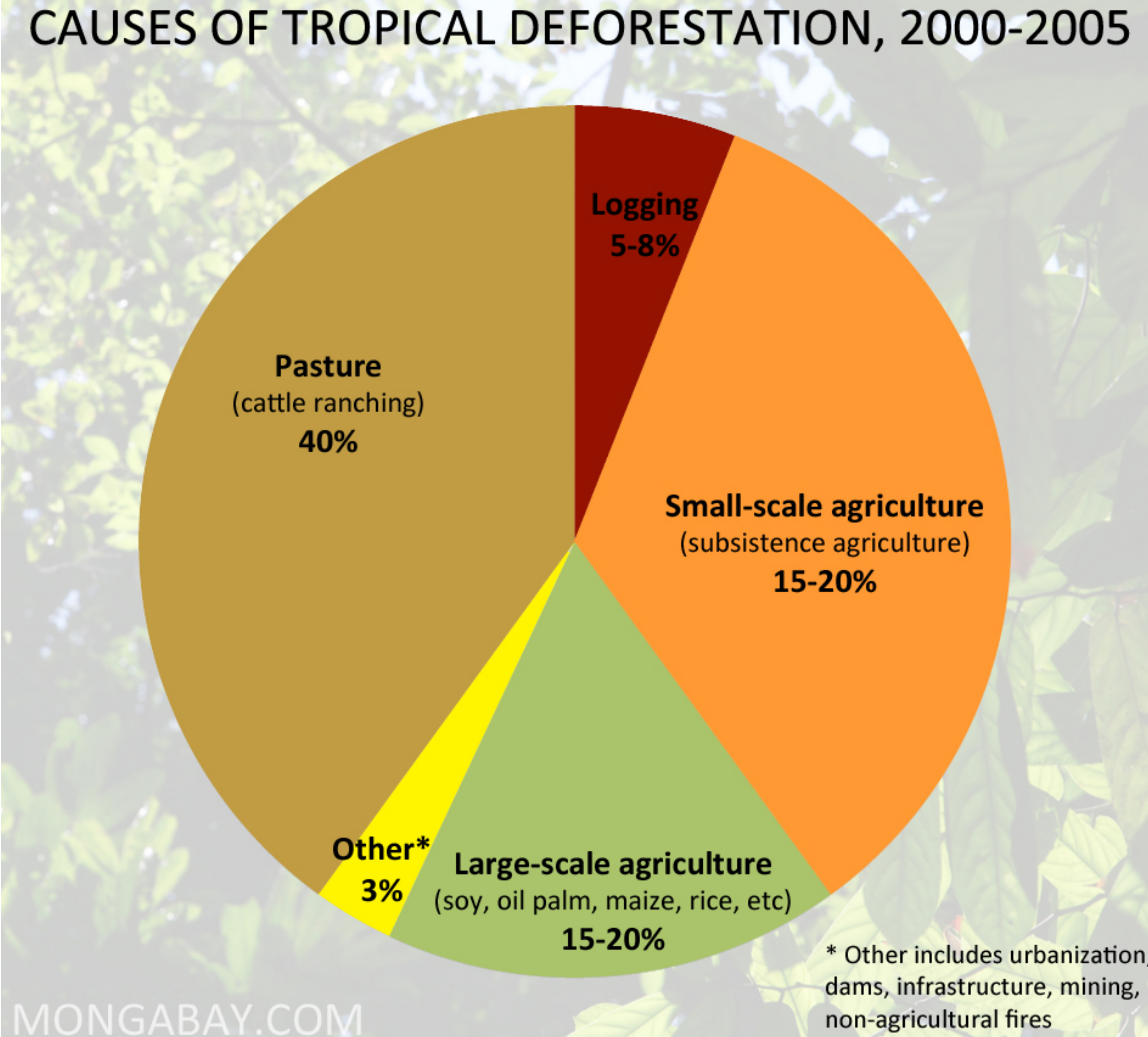
Habitat Fragmentation – Differential Effects

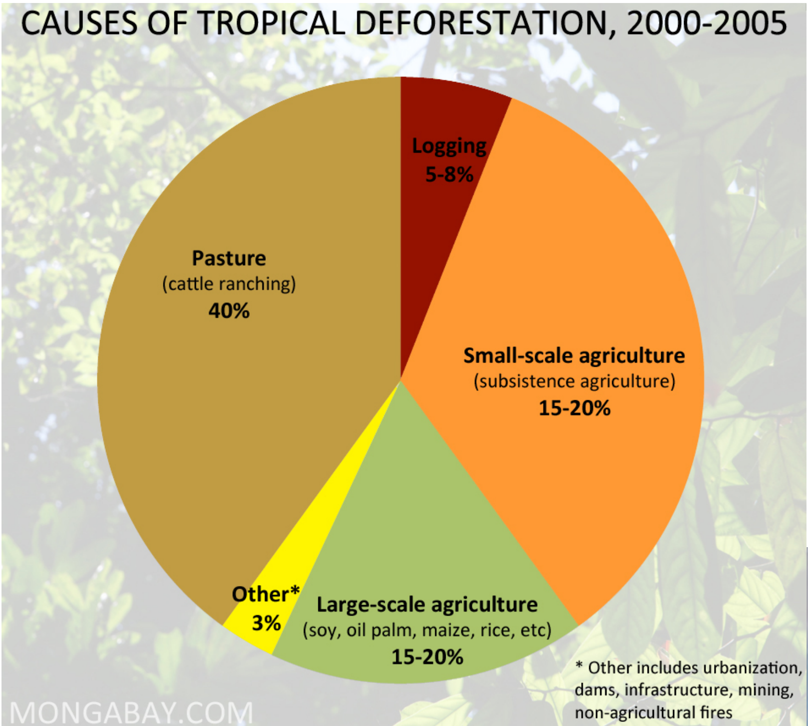
- ***Not all species are equally impacted by the adverse effects of habitat fragmentation.***
- Generalists who can thrive in a range of abiotic conditions, or species that thrive in “edge” habitats may actually increase in number when an intact habitat becomes fragmented, and can tolerate much greater fragmentation than specialists.
- Specialist species who have specific habitat requirements, as well as migratory and territorial organisms, are usually adversely affected by habitat fragmentation.
- Fragmentation generally ***decreases overall ecosystem biodiversity***, even if it increases the relative numbers of certain species.

Deforestation

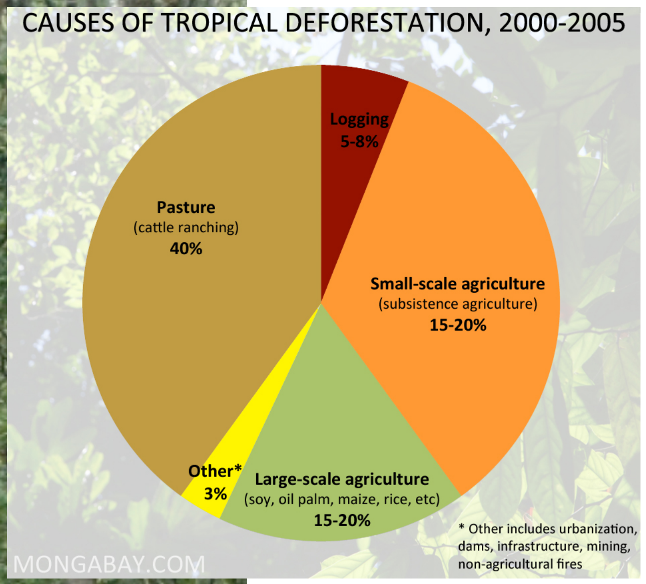
Deforestation is clearing Earth's forests on a massive scale, often resulting in damage to the quality of the land. Forests still cover about 30 percent of the world's land area, but swaths half the size of England are lost each year.

The world's rain forests could completely vanish in a hundred years at the current rate of deforestation.


CAUSES OF TROPICAL DEFORESTATION, 2000-2005
Logging
5-8%
Small-scale agriculture
(subsistence agriculture)
15-20%
Large-scale agriculture
(soy, oil palm, maize, rice, etc)
15-20%
Other*
3%
Pasture
(cattle ranching)
40%
* Other includes urbanization, dams, infrastructure, mining, non-agricultural fires
MONGABAY.COM



The biggest driver of deforestation is agriculture. Farmers cut forests to provide more room for planting crops or grazing livestock. Often, small farmers will clear a few acres by cutting down trees and burning them in a process known as slash and burn agriculture.



Logging operations, which provide the world's wood and paper products, also cut countless trees each year. Loggers, some of them acting illegally, also build roads to access more and more remote forests—which leads to further deforestation. Forests are also cut as a result of growing urban sprawl as land is developed for dwellings.

Effects of Deforestation

Deforestation can have a negative impact on the environment. The most dramatic impact is a loss of habitat for millions of species. Eighty percent of Earth’s land animals and plants live in forests, and many cannot survive the deforestation that destroys their homes.

Effects of Deforestation

Deforestation also drives climate change. Forest soils are moist, but without protection from sun-blocking tree cover, they quickly dry out. Trees also help perpetuate the water cycle by returning water vapor to the atmosphere. Without trees to fill these roles, many former forest lands can quickly become barren deserts.

Removing trees deprives the forest of portions of its canopy, which blocks the sun's rays during the day, and holds in heat at night. This disruption leads to more extreme temperature swings that can be harmful to plants and animals.

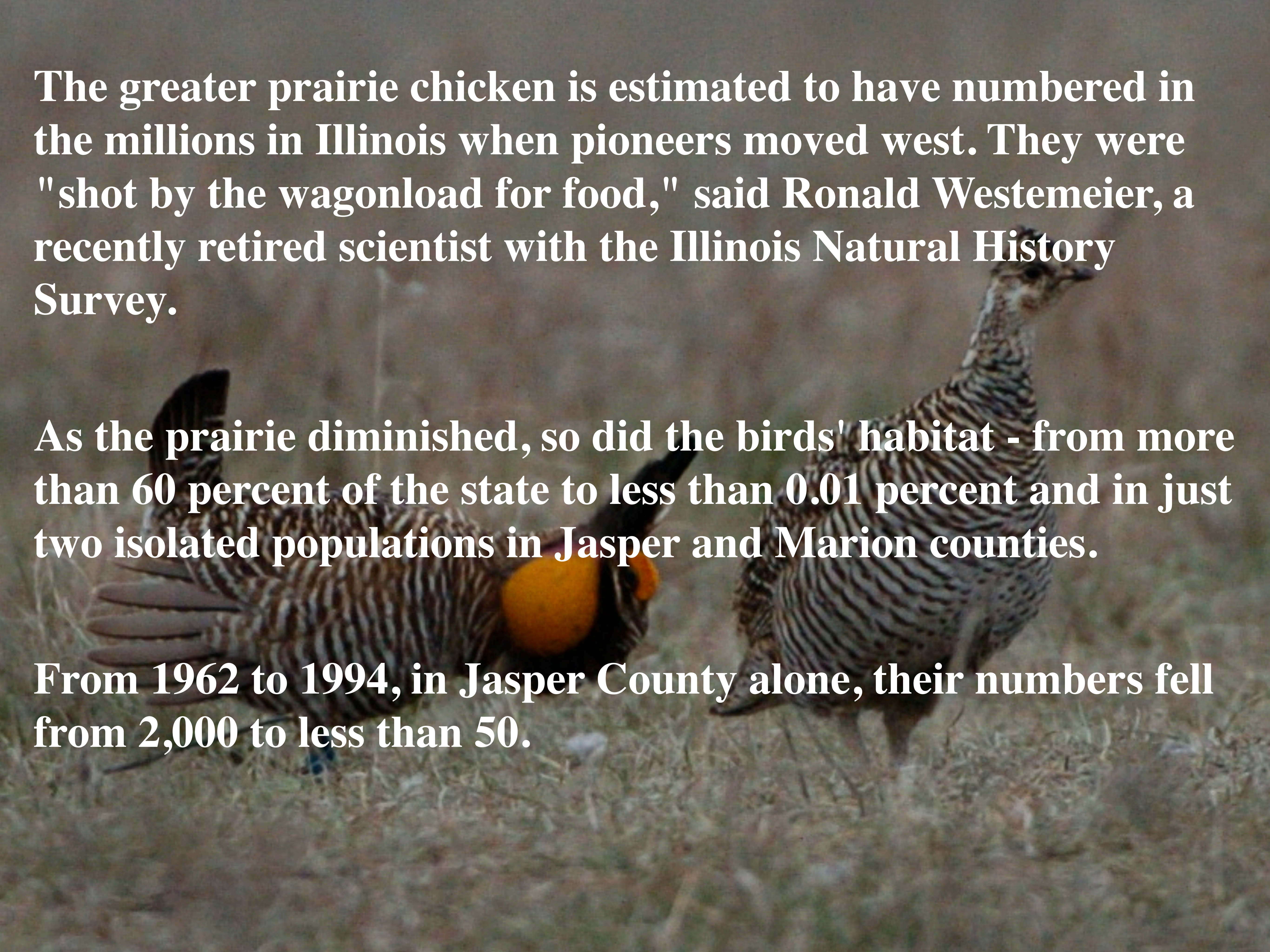
Trees also play a critical role in absorbing the greenhouse gases that fuel global warming. Fewer forests means larger amounts of greenhouse gases entering the atmosphere—and increased speed and severity of global warming.

Habitat Loss

- **98% of tropical dry forests in Mexico and Central America have been cleared.**
- **90% of tropical rain forests in Veracruz, Mexico have been cleared.**
- **93% of Coral Reefs worldwide are damaged.**
    - **At the current rate 40-50% of all coral reefs could disappear by 2050.**

Case Study: Greater Prairie Chicken

Booming mating calls rocked the Illinois prairie in the mid-1800s, announcing that colorful greater prairie chickens were near and abundant. As pioneers moved west, the birds were hunted for food. They fell to predators, their habitats shrank, and, scientists say, even the birds' declining genetic diversity brought their near extinction. In the Nov. 27 issue of the journal Science, nine researchers report that an isolated group of the birds is making a comeback.

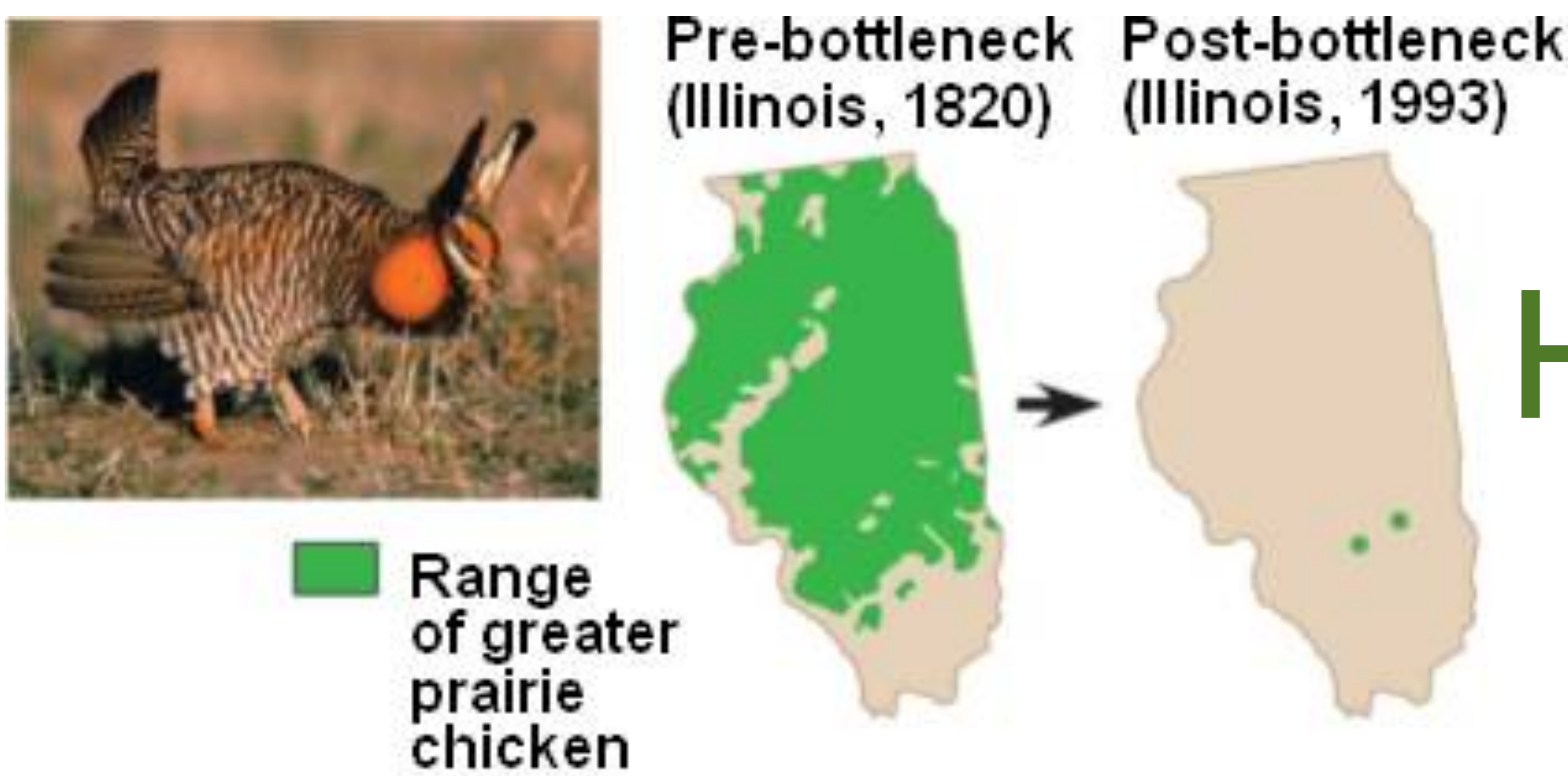


The greater prairie chicken is estimated to have numbered in the millions in Illinois when pioneers moved west. They were "shot by the wagonload for food," said Ronald Westemeier, a recently retired scientist with the Illinois Natural History Survey.

As the prairie diminished, so did the birds' habitat - from more than 60 percent of the state to less than 0.01 percent and in just two isolated populations in Jasper and Marion counties.

From 1962 to 1994, in Jasper County alone, their numbers fell from 2,000 to less than 50.

"The message is that fragmentation and habitat loss can really lead to a number of problems in conserving species.

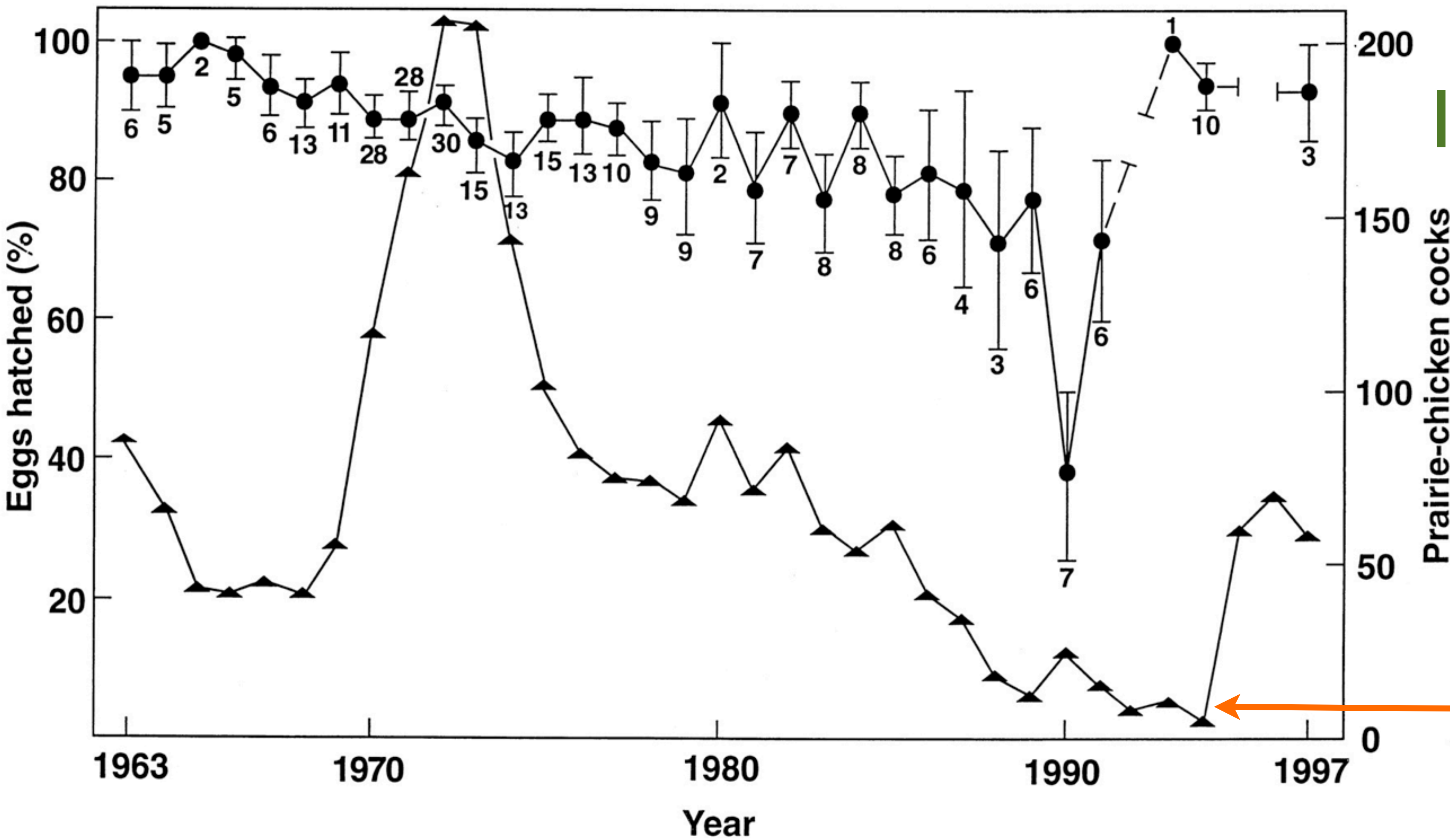


Habitat Loss

The Problem

In this case, these factors led to genetic problems.

What was interesting is that the people who manage the population did their best, going to extraordinary measures to preserve this population over the years, yet it kept going down and down, owing to the fact that it was just a small relic population that had low genetic diversity.



Imported birds from a larger population elsewhere

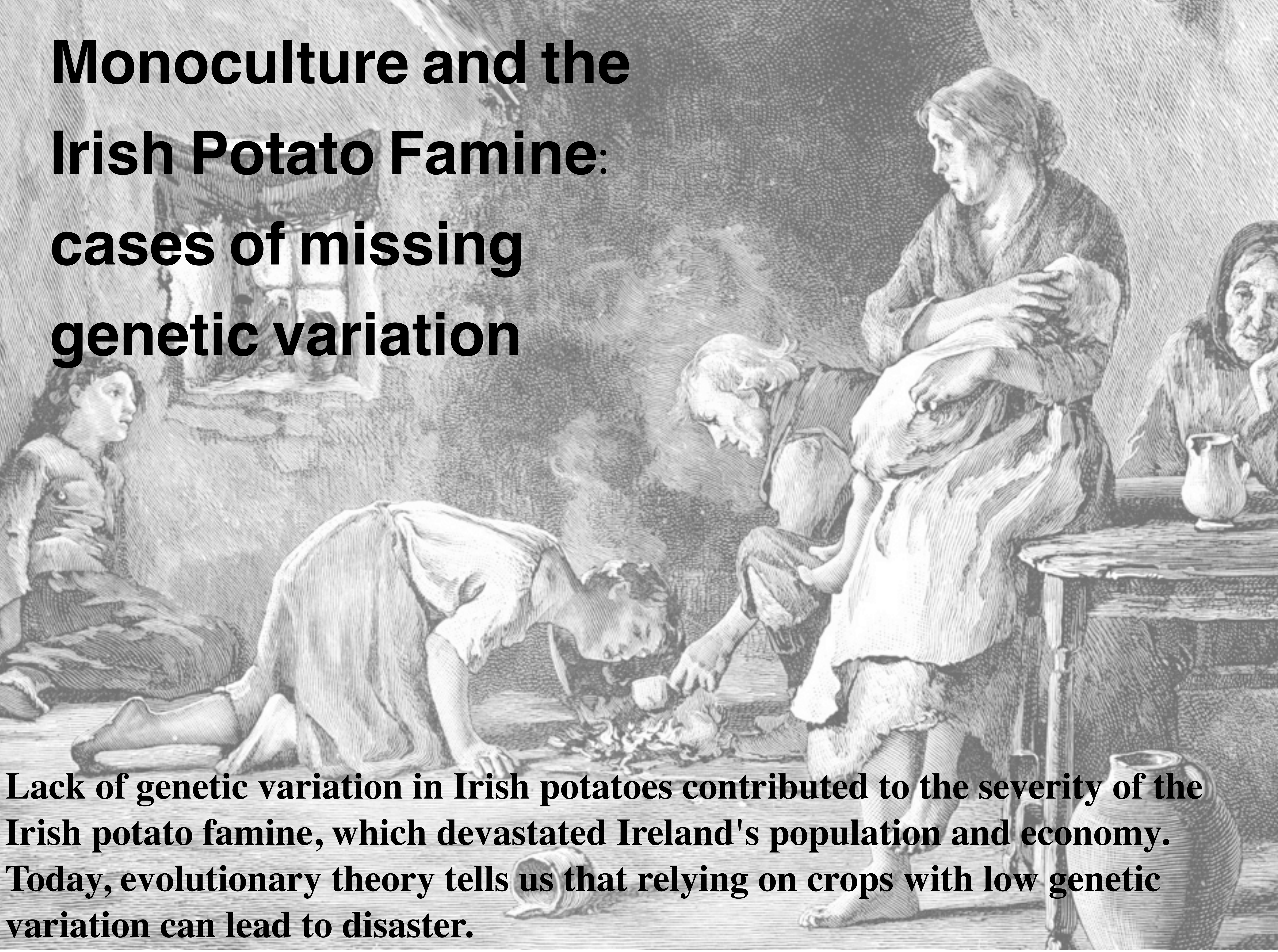
Transfusion of genetic variability

The success - in which more than 500 birds were brought in beginning in 1992 from larger populations in Minnesota, Kansas and Nebraska - could serve as a model to save dwindling populations of wild species from extinction, the researchers say. The 35 years of data represent one of the most detailed sets of data ever collected from an isolated and declining wildlife population.

Far Reaching Effects

Sometimes the lack of genetic diversity effects more than one species...for example

Potato Blight



Monoculture and the Irish Potato Famine: cases of missing genetic variation

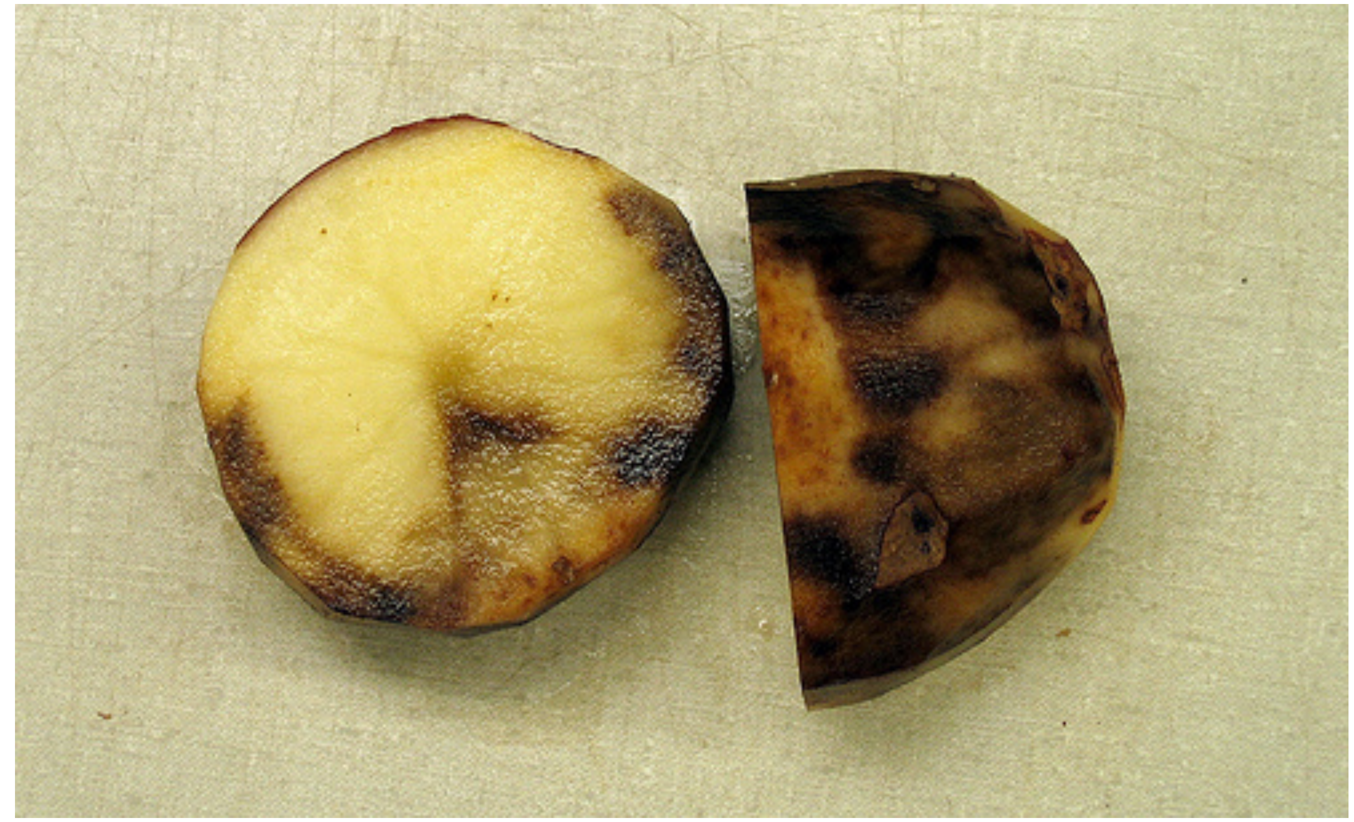
Lack of genetic variation in Irish potatoes contributed to the severity of the Irish potato famine, which devastated Ireland's population and economy. Today, evolutionary theory tells us that relying on crops with low genetic variation can lead to disaster.

Lumpers

In the 1800s, the Irish solved their problem of feeding a growing population by planting potatoes. Specifically, they planted the "lumper" potato variety. And since potatoes can be propagated vegetatively, all of these lumpers were clones, genetically identical to one another.

The lumper fed Ireland for a time, but it also set the stage for human and economic ruin. Evolutionary theory suggests that populations with low genetic variation are more vulnerable to changing environmental conditions than are diverse populations. The Irish potato clones were certainly low on genetic variation, so when the environment changed and a potato disease swept through the country in the 1840s, the potatoes (and the people who depended upon them) were devastated.

The importance of diversity

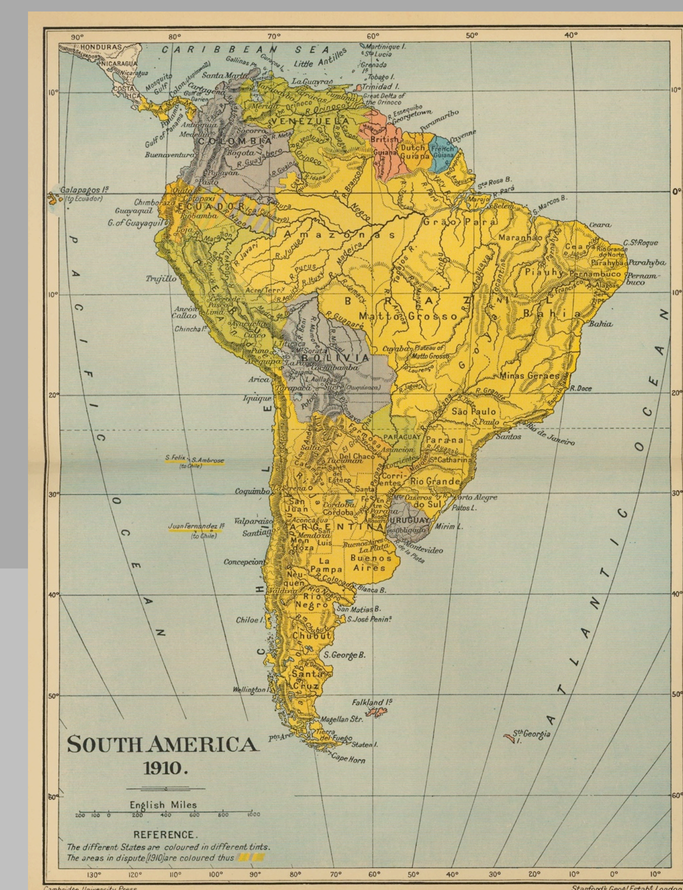


The genetically identical lumpers were all susceptible to a rot caused by *Phytophthora infestans*, which turns non-resistant potatoes to inedible slime.

Because Ireland was so dependent on the potato, one in eight Irish people died of starvation in three years during the Irish potato famine of the 1840s.

Over 1 million people died

Although the famine ultimately had many causes, the disaster would likely not have been so terrible had more genetically variable potatoes been planted. Some potatoes would have carried the right genes to make it through the epidemic, and more of the resistant varieties could have been planted in the years following the first epidemic.



Later, scientists identified resistance genes in a potato from South America, where farmers have preserved the genetic variation of potatoes by growing many cultivated varieties alongside the potato's wild cousins.

Ignoring history

Despite the warnings of evolution and history, much agriculture continues to depend on genetically uniform crops. The widespread planting of a single corn variety contributed to the loss of over a billion dollars worth of corn in 1970, when the U.S. crop was overwhelmed by a fungus. And in the 1980s, dependence upon a single type of grapevine root forced California grape growers to replant approximately two million acres of vines when a new race of the pest insect, grape phylloxera (*Daktulosphaira vitifoliae*, shown at right) attacked in the 1980s.

Although planting a single, genetically uniform crop might increase short term yields, evolutionary theory and the lessons of history highlight an undesirable side effect. Planting genetically uniform crops increases the risk of "losing it all" when environmental variables change: for example, if a new pest is introduced or rainfall levels drop.

HIPPCO

Invasive Species

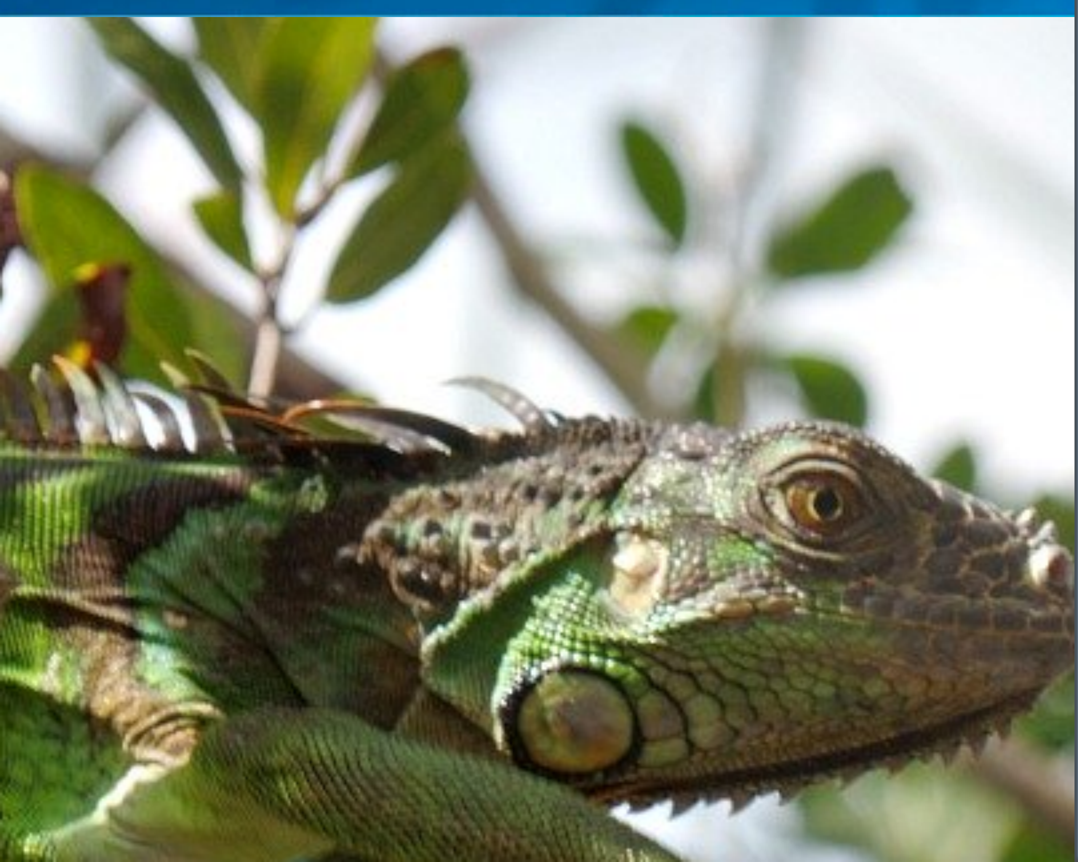
Invasive Species

An **invasive species** is a plant, fungus, or animal species that is not native to a specific location (an introduced **species**), and which has a tendency to spread to a degree believed to cause damage to the environment, human economy or human health.

What are some negative effects of invasive species?

- Invasive species do not provide food
- They out-compete our native species for limited resources such as food and habitat
- They explode in population because they do not have a natural **predator**
- They are a threat to our ecosystems, economy or society

Florida Invasives



In a nutshell:

- Invasive species and infectious diseases are becoming more prevalent and widespread with increased connectedness and globalization
- Alien species are the second leading cause of extinction in the US and cost approximately $120 billion annually
- Disease vectors and pathogens are spreading across continents due to human transport, land-use change, and climate change
- To adequately understand and predict the spread of invasive species and disease, we must coordinate the many existing networks at local, regional, continental, and global scales
- Both observational and experimental approaches are required to fully understand the effects and impacts of invasive species and diseases and, more importantly, to understand the biotic and abiotic factors that enhance or diminish their effects

Invasive Species

- Non-native species disrupt community interactions by preying on native species or by out competing them.
  - Invasive species have contributed to 40% of all extinctions since 1750.
  - They are costly and worldwide problem.
    - Examples include: Kudzu, Brown Tree Snake, Zebra Mussel

HIPPCO

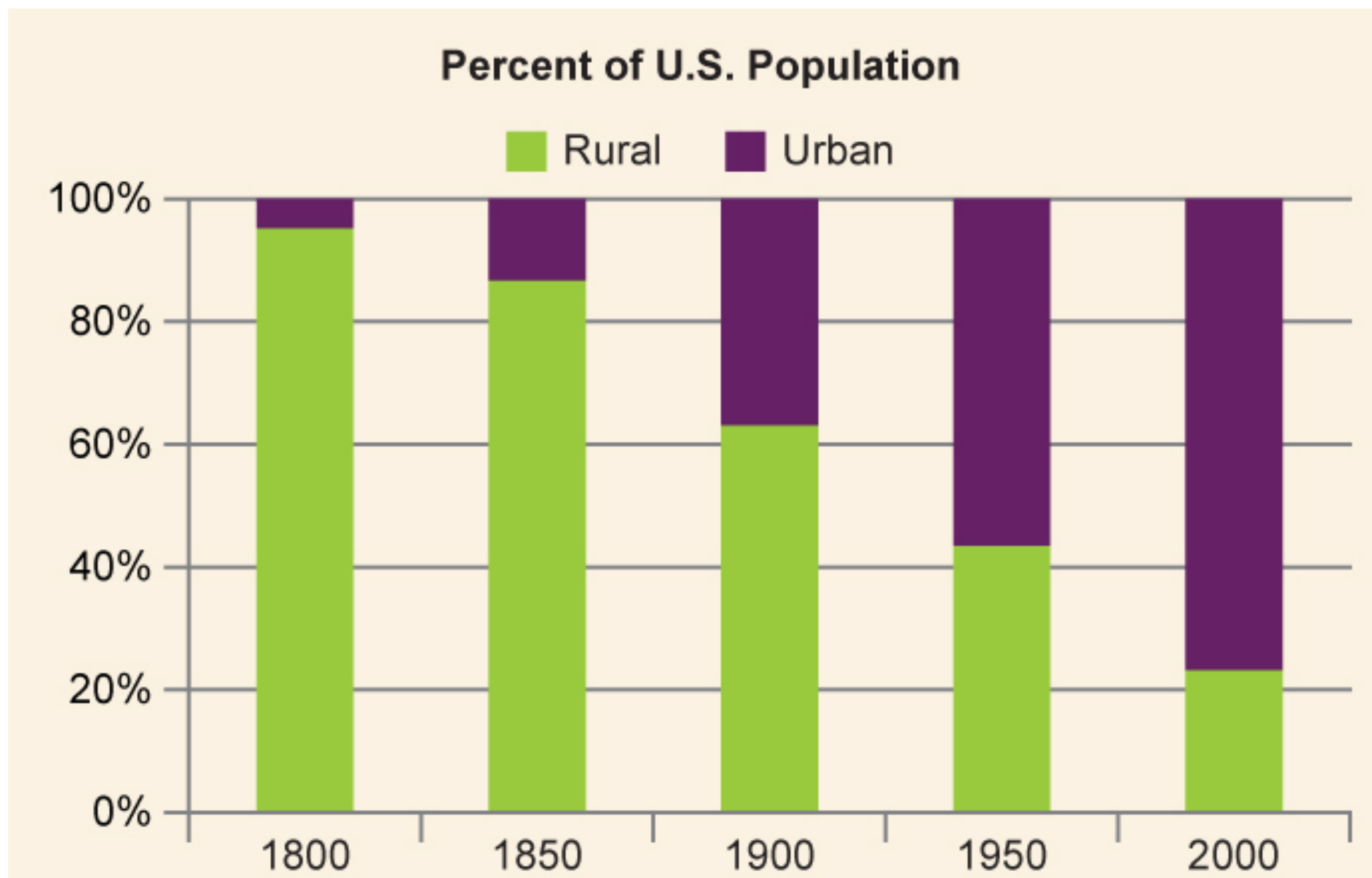
Population Growth

Urbanization

Urbanization is a population shift from rural to urban areas, "the gradual increase in the proportion of people living in urban areas", and the ways in which each society adapts to the change. It is predominantly the process by which towns and cities are formed and become larger as more people begin living and working in central areas.

Trends

Nearly all urban areas are growing, having added 58,000 square kilometers in built-up land since 1970, an area equivalent to the size of Lake Michigan. While we find some global trends of rapid development near coastal and ecologically sensitive areas, urban areas also vary widely in their spatial patterns, rates, and types of growth.



Urbanization

1900 | 2 out of every 10 people lived in an urban area

1990 | 4 out of every 10 people lived in an urban area

2010 | 5 out of every 10 people lived in an urban area

2030 | 6 out of every 10 people will live in an urban area

2050 | 7 out of every 10 people will live in an urban area

Defined by UN HABITAT as a city with a population of more than 10 million

Forecast...

In 2008, the global urban population exceeded the rural population for the first time, and it is estimated that by 2050, 70% of the world population will live in urban areas (UN DESA, 2012). Furthermore, mid-range forecasts show an increase of around 1.5 million square kilometers of new urban land area by 2030, an area nearly equal to the land area of Mongolia, and nearly tripling the global urban land area in 2000 (Seto et al. 2011; Seto et al. 2012) These forecasts suggest an important—and limited—window of opportunity to shape future urbanization.

Environmental Impacts

The conversion of Earth's land surface to urban uses is one of the most irreversible human impacts on the global biosphere.

It hastens the loss of...

-highly productive farmland,
-affects energy demand,
-alters the climate,
-modifies hydrologic and biogeochemical cycles,
-fragments habitats,
-and reduces biodiversity (Seto et al., 2011)

We see these effects on multiple levels. Future urbanization will, for example, pose direct threats to high-value ecosystems: the highest rates of land conversion over the next few decades will likely take place in biodiversity hotspots that were relatively undisturbed by urban development in 2000 (Seto et al., 2012).

Environmental Impacts

The environmental impacts of urban expansion reach far beyond urban areas themselves.

In rapidly urbanizing areas, agriculture intensifies on remaining undeveloped land and is likely to expand to new areas, **putting pressure on land resources** (Jiang et al., 2013).

Furthermore, urban areas **change precipitation patterns** at scales of hundreds of square kilometers (Kaufman et al., 2007) .

Urban expansion **will affect global climate** as well.

Direct **loss in vegetation biomass** from areas with high probability of urban expansion is predicted to contribute about 5% of total emissions from tropical deforestation and land-use change (Seto et al., 2012).

Infrastructure: Dams

Impacts of Dams

Downstream Impacts

reduced biodiversity; poor water quality; lower crop production; decreased fish populations

Dam

blocked fish migration; distrupted flow of sediments and water; hazards from ageing dams

Reservoir

contributes to global warming; displaces communities; increases water-borne illnesses; triggers earthquakes

HIP**P**CO

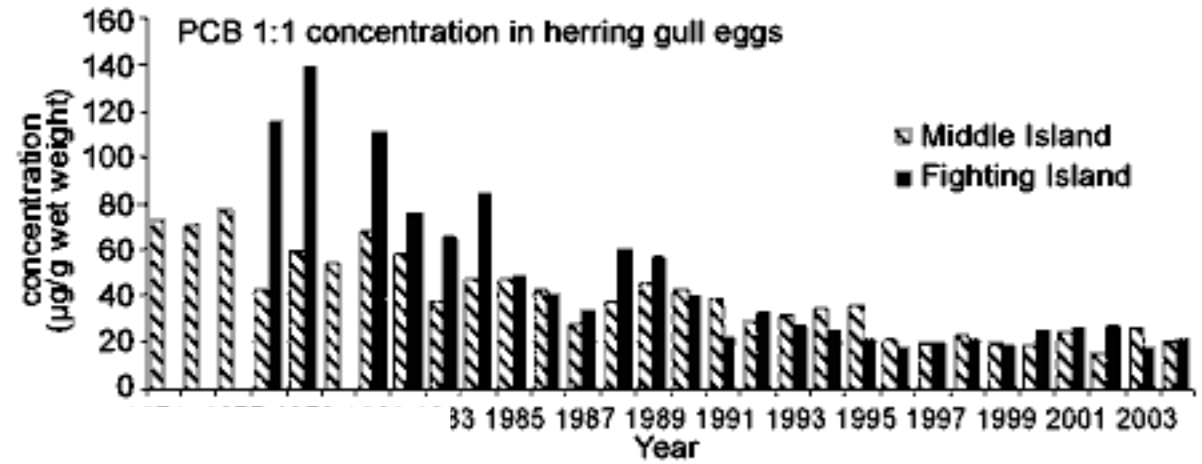
Pollution

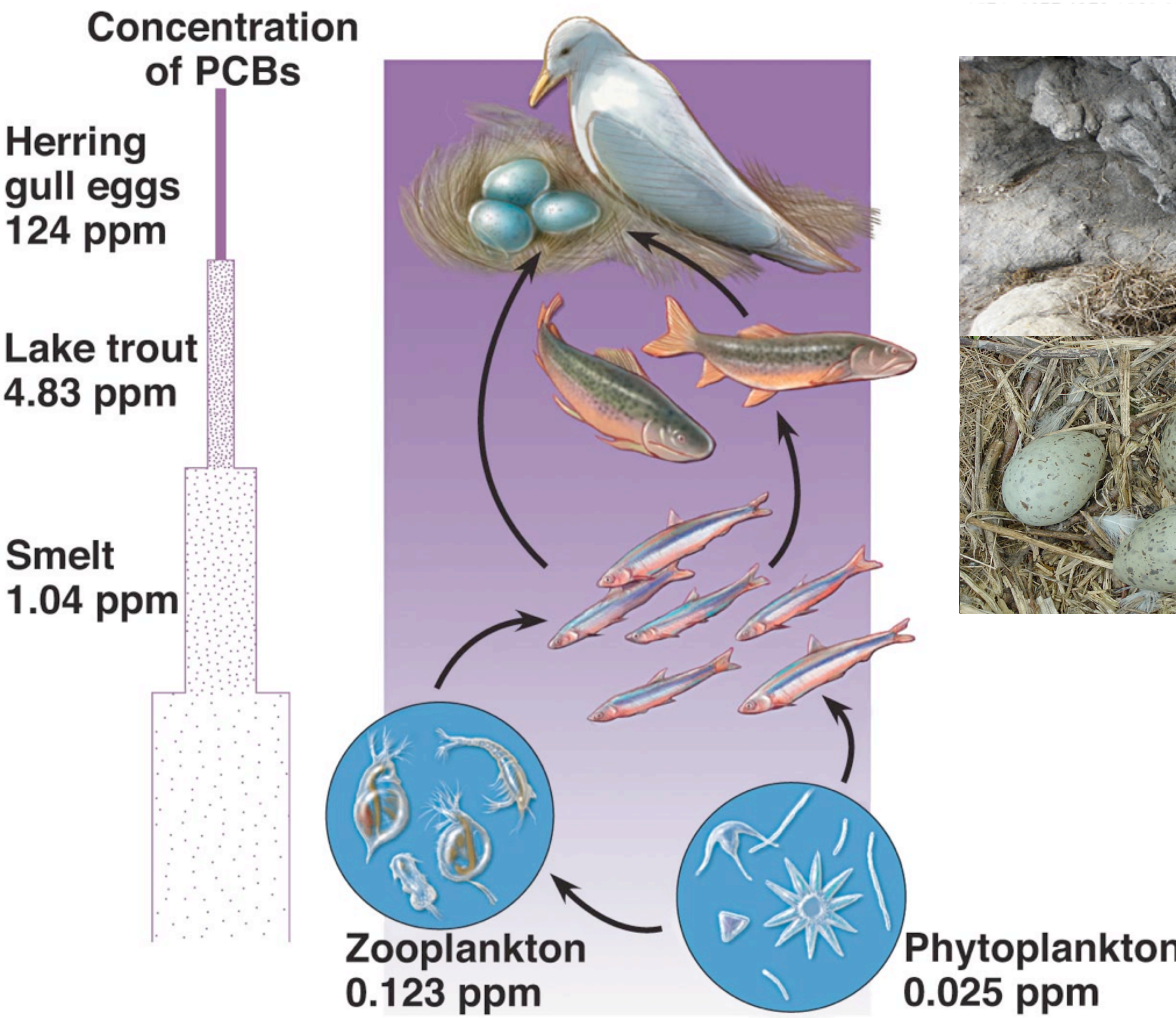
Pollution is also a significant problem with, for example, killer whales and dolphins in European seas being seriously harmed by long-lived industrial pollutants. Vultures in south-east Asia have been decimated over the last 20 years, dying after eating the carcasses of cattle dosed with an anti-inflammatory drug. Amphibians have suffered one of the greatest declines of all animals due to a fungal disease thought to be spread around the world by the trade in frogs and newts.

Toxins in the Environment

- Humans release a variety of toxins, often times synthetic (novel to organisms) into the environment.
- Many toxins can't be degraded by microorganisms and persist in the environment for years.
- Some toxins are excreted by organisms but many accumulate in the fatty tissue.
    - These toxins become more concentrated with each successive trophic level. ***(biological magnification)***
    - Two well documented examples illustrate this process, industrial compound <u>PCB's</u> & the pesticide <u>DDT</u>

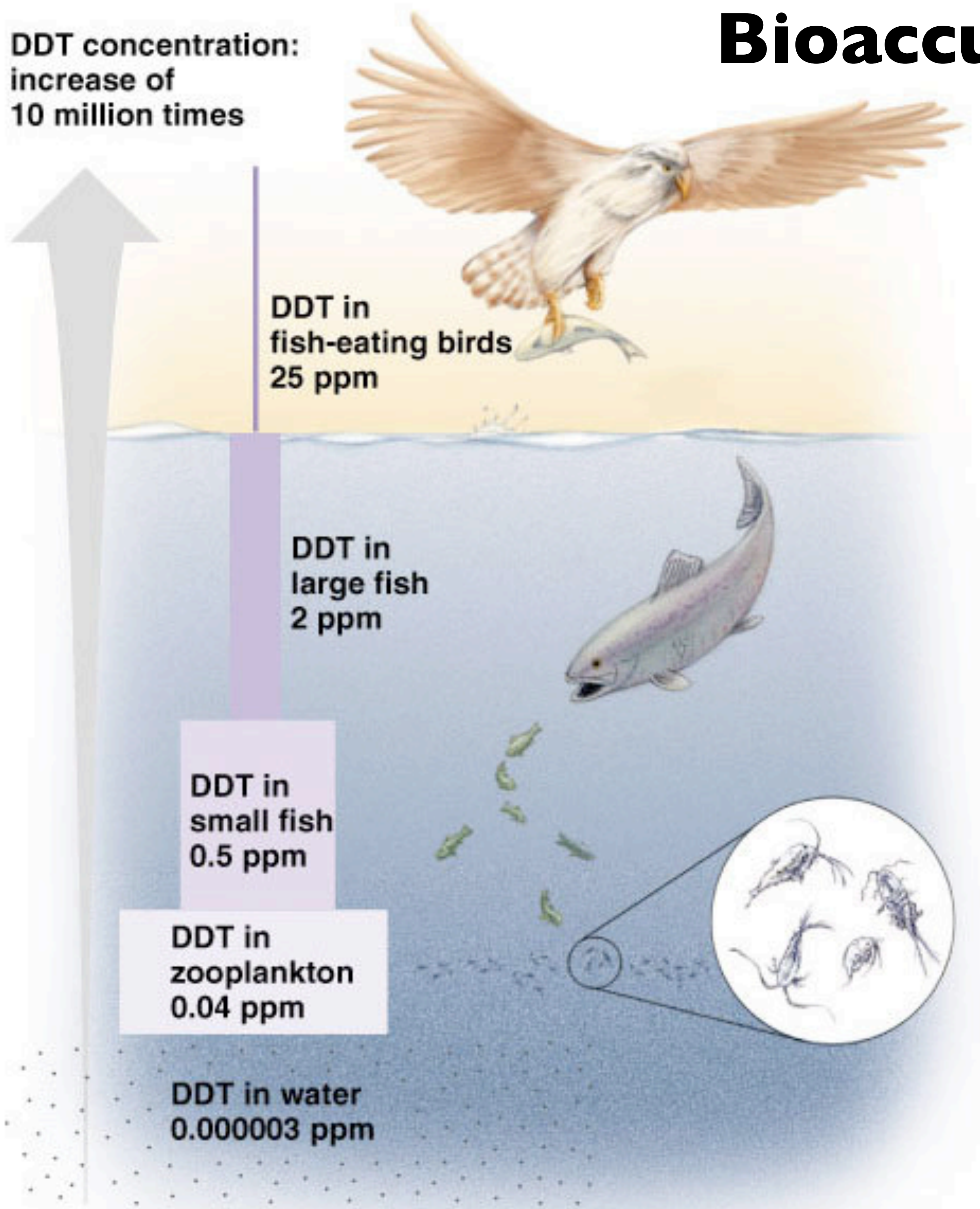
Bioaccumulation: PCB's





PCB's prevented calcium deposition in egg shells

Bioaccumulation: DDT



Then, in 1939, Swiss chemist Paul Hermann Müller (1899–1965) discovered that DDT was highly poisonous to insects. The discovery was very important because of its potential for use in killing insects that cause disease and eat agricultural crops. For his work, Müller was awarded the Nobel Prize in medicine in 1948.

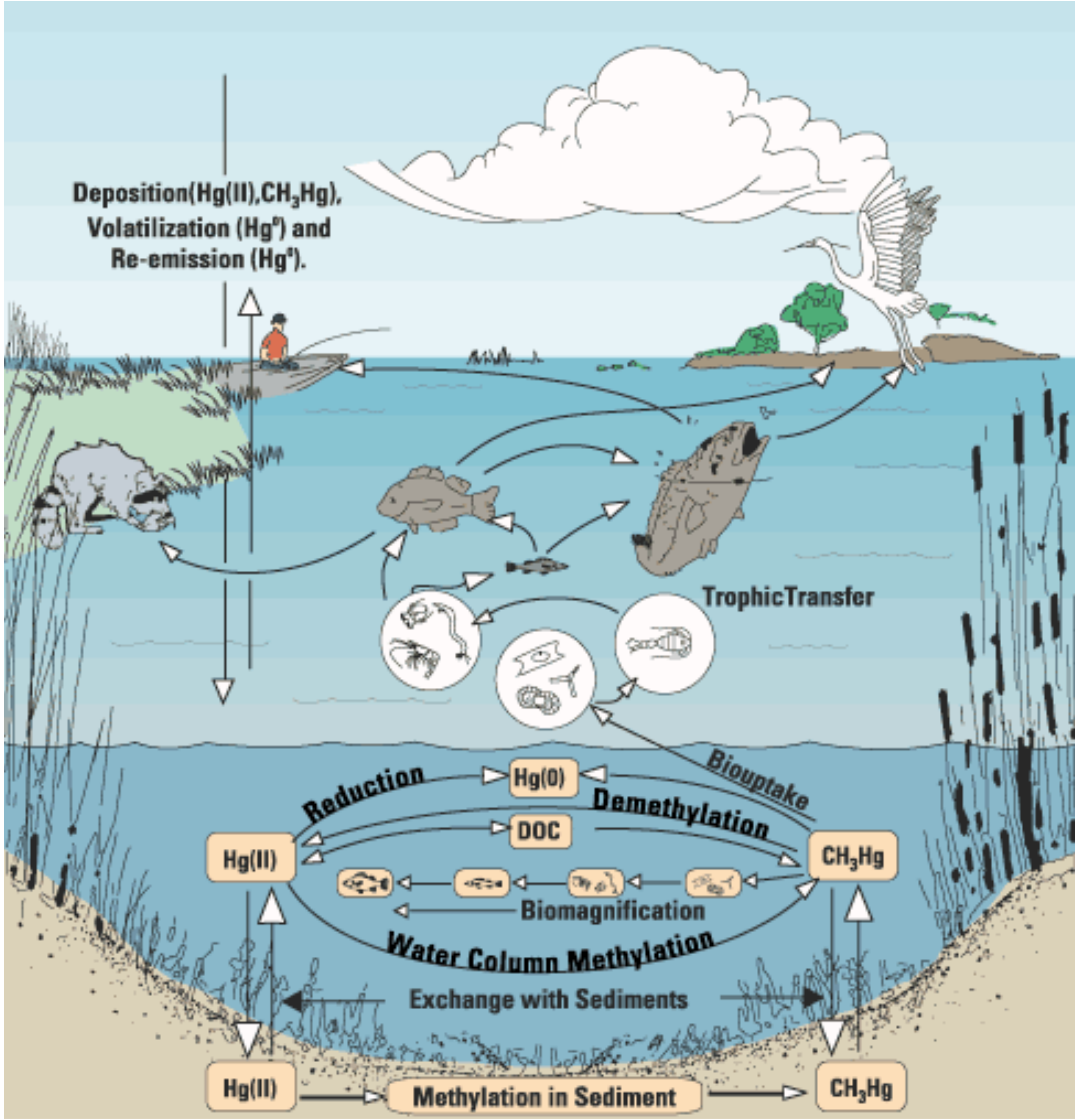
During and after World War II (1939–45), DDT became extremely popular among public health workers, farmers, and foresters. Peak production of the compound reached 386 million pounds (175 million kilograms) globally in 1970. Between 1950 and 1970, 22,204 tons (20,000 metric tons) of DDT was used annually in the former Soviet Union. The greatest use of DDT in the United States occurred in 1959, when 79 million pounds (36 million kilograms) of the chemical were sprayed.

By the early 1970s, however, serious questions were being raised about the environmental effects of DDT. Reports indicated that harmless insects (such as bees), fish, birds, and other animals were being killed or harmed as a result of exposure to DDT. The pesticide was even blamed for the near-extinction of at least one bird, the peregrine falcon. Convinced that the environmental damage from DDT was greater than the compound's possible benefits, the U.S. Environmental Protection Agency banned the use of DDT in the United States in 1973. Its use in certain other countries has continued, however, since some nations face health and environmental problems quite different from those of the United States.

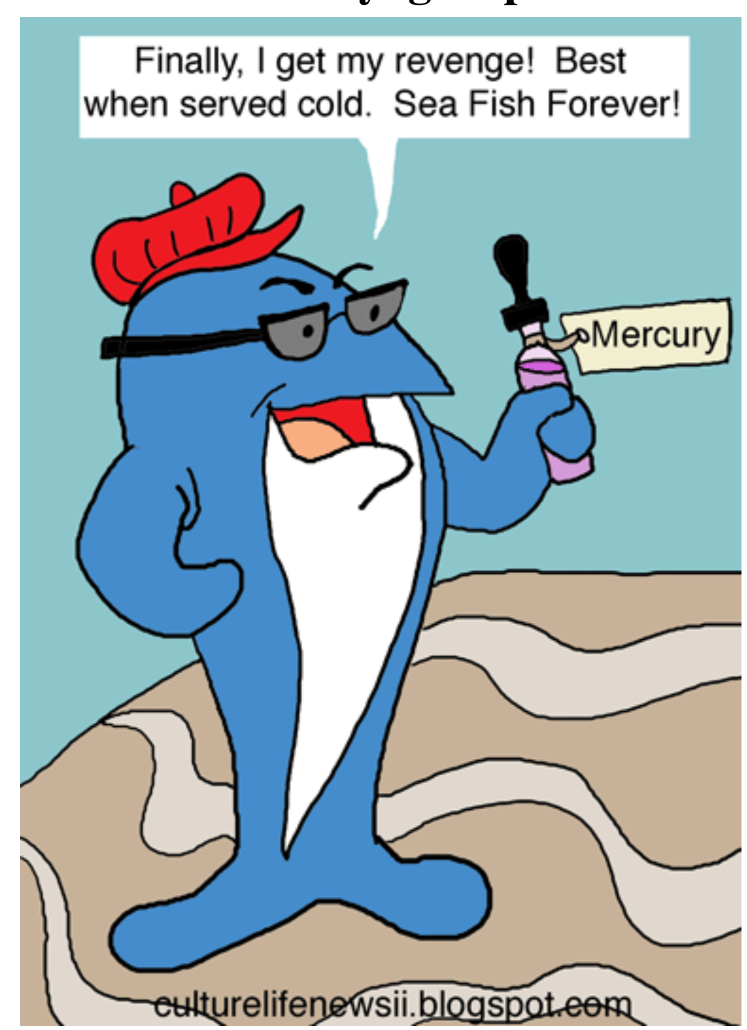
In December 2000, in a convention organized by the United Nations Environment Program, 122 nations agreed to a treaty banning twelve very toxic chemicals. Included among the twelve was DDT. However, the treaty allowed the use of DDT to combat malaria until other alternatives become available. Before it can take effect, the treaty must be ratified by 50 of the nations that agreed to it in principle.

What is an endocrine disrupter?

"DDT is good for me-e-e!"
The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.
Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.
GOOD FOR FRUITS—Bigger apples, juicier fruits that are free from unsightly worms . . . all benefits resulting from DDT dusts and sprays.
GOOD FOR STEERS—Beef grows meatier nowadays . . . for it's a scientific fact that—compared to untreated cattle—beef-steers gain up to 50 pounds extra when protected from horn flies and many other pests with DDT insecticides.
Knox Out FOR THE HOME—helps to make healthier, more comfortable homes . . . protects your family from dangerous insect pests. Use Knox-Out DDT Powders and Sprays as directed . . . then watch the bugs "bite the dust"!
Knox Out FOR DAIRIES—Up to 20% more milk . . . more butter . . . more cheese . . . tests prove greater milk production when dairy cows are protected from the annoyance of many insects with DDT insecticides like Knox-Out Stock and Barn Spray.
KILLING SALT
CHEMICALS
97 Years' Service to Industry • Farm • Home
GOOD FOR ROW CROPS—25 more barrels of potatoes per acre . . . actual DDT tests have shown crop increases like this! DDT dusts and sprays help truck farmers pass these gains along to you.
Knox Out FOR INDUSTRY—Food processing plants, laundries, dry cleaning plants, hotels . . . dozens of industries gain effective bug control, more pleasant work conditions with Pennsalt DDT products.



In the environment, sulfate-reducing bacteria take up mercury in its inorganic form and through metabolic processes convert it to methylmercury. Sulfate-reducing bacteria are found in anaerobic conditions, typical of the well-buried muddy sediments of rivers, lakes, and oceans where methylmercury concentrations tend to be highest. Sulfate-reducing bacteria use sulfur rather than oxygen as their cellular energy-driving system. One hypothesis is that the uptake of inorganic mercury by sulfate-reducing bacteria occurs via passive diffusion of the dissolved complex HgS. Once the bacterium has taken up this complex, it utilizes detoxification enzymes to strip the sulfur group from the complex and replaces it with a methyl group:



Pollution

California Condor

Another Case of Organisms Endangered by low Genetic Diversity

The spectacular but endangered California Condor is the largest bird in North America. The population fell to just 22 birds in the 1980s, but there are now some 230 free-flying birds in California, Arizona, and Baja California with another 160 in captivity. **Lead** poisoning remains a severe threat to their long-term prospects.

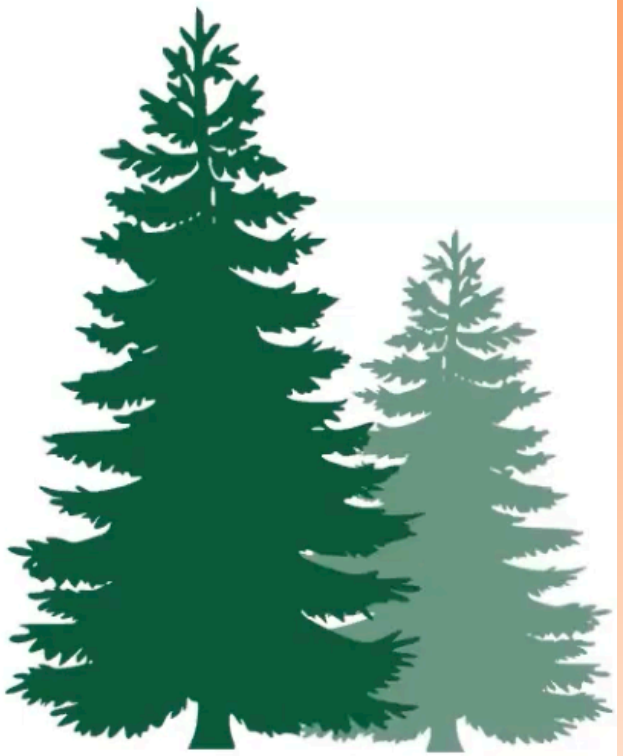
Rivers and lakes are the hardest hit habitats, with animals populations down by 81% since 1970, due to excessive water extraction, pollution and dams. All the pressures are magnified by global warming, which shifts the ranges in which animals are able to live.

HIPPCO

Climate Change

Climate Change and Habitat Loss

- Global climate change plays a large role in habitat loss.
- As average global temperatures rise, habitats may be lost due to…
  - ***Coastal inundation from melting land ice and permafrost***
  - ***Rising sea levels due to thermal expansion***
  - ***Changes in precipitation patterns due to changing atmospheric and oceanic circulation patterns***
- Climate change has been most intense in northern latitudes; as warming trends continue, these areas will be at most risk for habitat loss and loss of biodiversity.



Source: Pixabay.com by Clkr-Free-Vector-Images

EARTH IS CHANGING RAPIDLY AS A RESULT OF HUMAN ACTIONS

Nutrient Enrichment

- Human activity removes nutrients from one part of the biosphere and adds them to another! Consider the following..
  - Small scale: Floridian consumes corn grown in Iowa.
  - Large scale: Fertilizer runs off from that same farm in Iowa into the Mississippi River.
  - Additionally humans are adding synthetic, novel and some toxic nutrients to ecosystems as well

Lets take a closer look at "farming"...

- **Farming** removes nutrients from the soil.
    - Despite variations nutrients will eventually be depleted and *nitrogen* is often the first to go.

- Recent studies indicate that 3 human activities have more than doubled the amount of fixed nitrogen available to producers.

1. industrial fertilizers, 2. fossil fuel consumption and 3. increased cultivation of legumes.

- Unfortunately problems arise when nutrient load exceeds, the critical load, the amount of nutrients that plants can absorb without damaging the ecosystems.
    - Excess nutrients run-off into bodies of water and groundwater leading to...

1. contamination, 2. eutrophication 3. dead zones

*Lake Erie was nearly wiped out in the 1960's due to eutrophication and over-fishing. Since then *REGULATIONS have helped the recovery efforts but some organisms have yet to recover.*

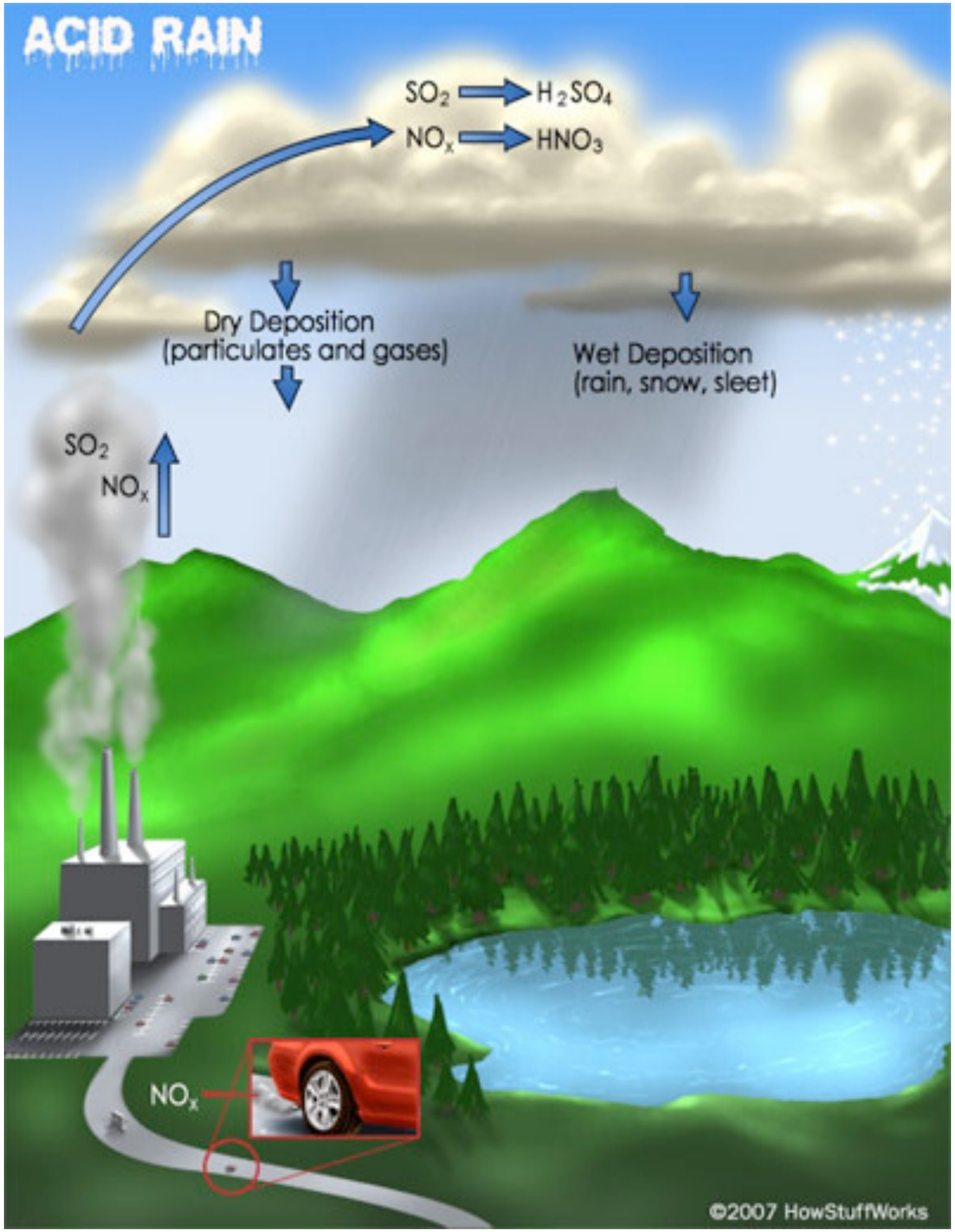
Dead zones are areas of water so devoid of oxygen that sea life cannot live there.

If phytoplankton productivity is enhanced by fertilizers or other nutrients, more organic matter is produced at the surface of the ocean. The organic matter sinks to the bottom, where bacteria break it down and release carbon dioxide. Bacteria thrives off excessive organic matter and absorb oxygen, the same oxygen that fish, crabs and other sea creatures rely on for life.

Recent reports indicate that the large region of low oxygen water often referred to as the 'Dead Zone' has spread across nearly 5,800 square miles of the Gulf of Mexico again in what appears to be an annual event. NASA satellites monitor the health of the oceans and spots the conditions that lead to a dead zone. These images show how ocean color changes from winter to summer in the Gulf of Mexico. Summertime satellite observations of ocean color from MODIS Aqua show highly turbid waters which may include large blooms of phytoplankton extending from the mouth of the Mississippi River all the way to the Texas coast. When these blooms die and sink to the bottom, bacterial decomposition strips oxygen from the surrounding water, creating an environment very difficult for marine life to survive in. Reds and oranges represent high concentrations of phytoplankton and river sediment. The National Oceanic and Atmospheric Administration (NOAA) ships measured low oxygen water in the same location as the highly turbid water in the satellite images. Most studies indicate that fertilizers and runoff from human sources is one of the major stresses impacting coastal ecosystems. In the third image using NOAA data, reds and oranges represent low oxygen concentrations. For additional information, see: http://www.gsfc.nasa.gov/topstory/2004/0810deadzone.html

Global Change

- Global Change includes changing *climates* and *atmospheric chemistry*.
- *Acid Precipitation* is one of the first examples of global change.
  - rain, sleet, fog, snow, etc with a pH less than 5.2
- Burning wood releases sulfur and nitrogen that react with water to from acids
- Acid precipitation harms both aquatic and terrestrial ecosystems
  - Regulations have reduced sulfur emissions by 40% between 1993 and 2008 however nitrogen emissions are still increasing

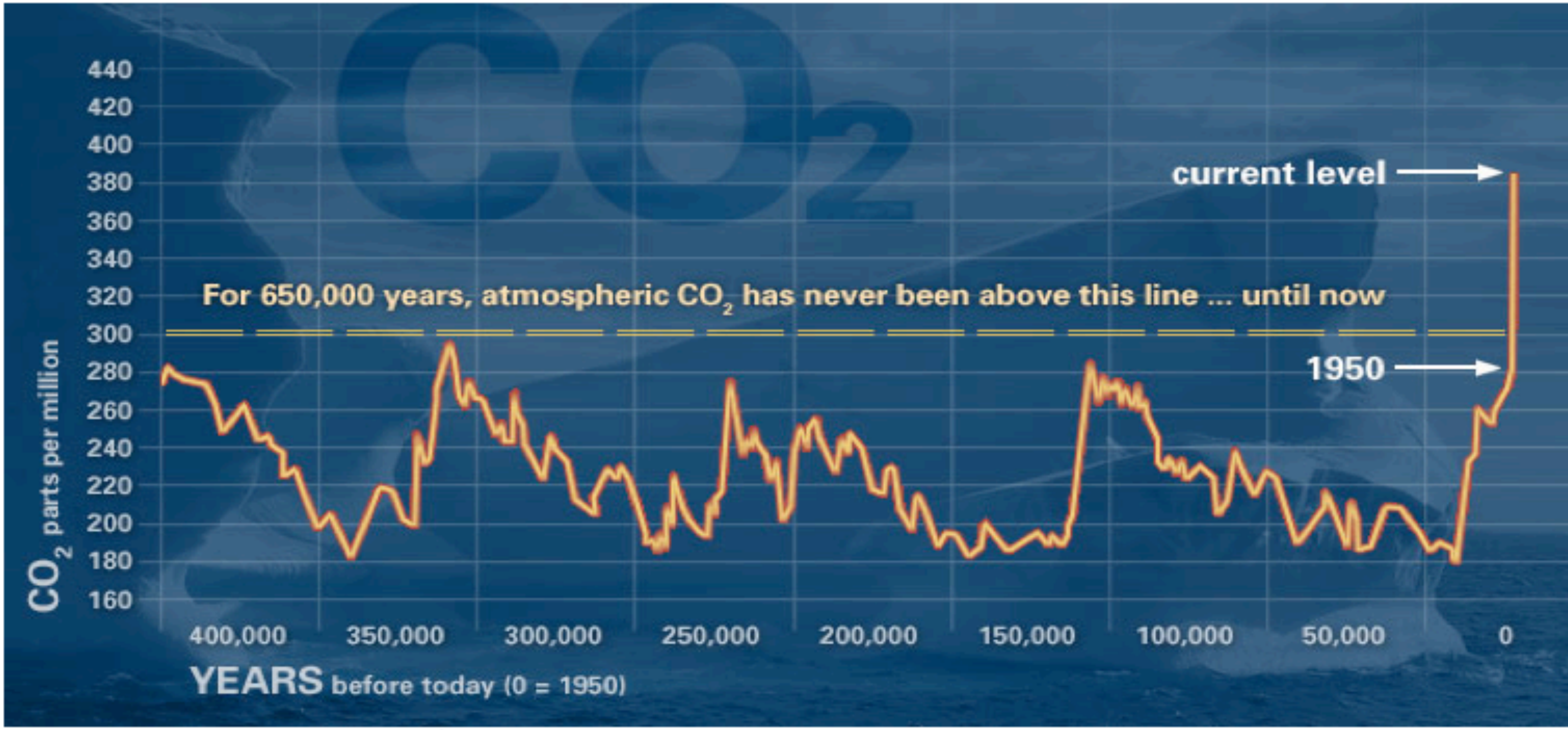

ACID RAIN
SO2 → H2SO4
NOx → HNO3
Dry Deposition
(particulates and gases)
Wet Deposition
(rain, snow, sleet)
SO2
NOx
NOx
©2007 HowStuffWorks

Greenhouse Gases & Global Warming

1. Rising atmospheric CO_2 levels

- Since the industrial revolution the levels of CO_2 in atmosphere have been increasing. (estimates of 274 ppm in 1850)
- Since 1958 we have been able to accurately measure CO_2 levels in the atmosphere. (1958 = 316ppm), (today it exceeds 385 ppm)
- Computer models estimate that in 60 years the amount of CO_2 in the atmosphere will be double what it was in the 19th century.
    - These rising levels are not questioned by even the skeptics.

Climate change: How do we know?

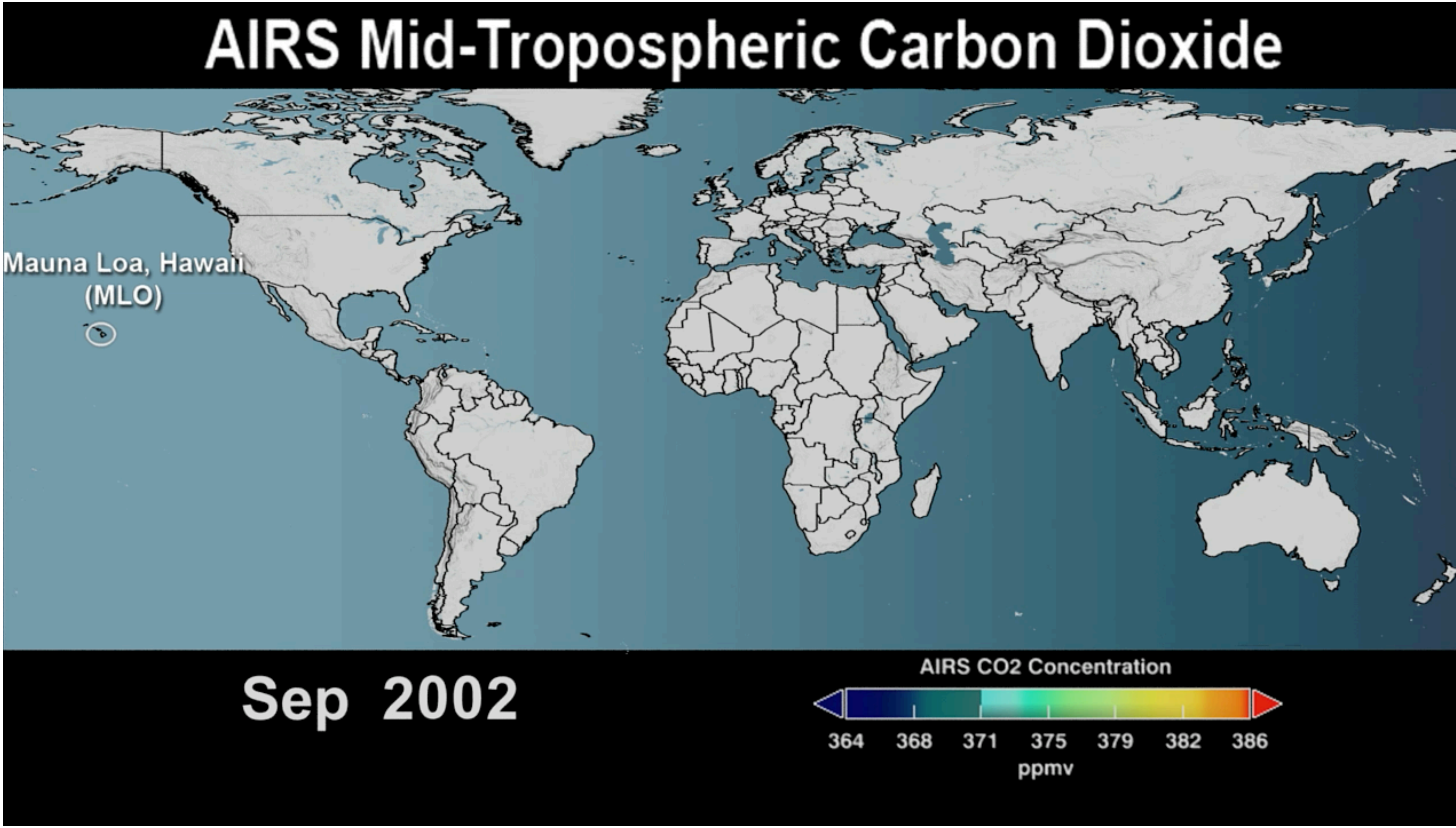


This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

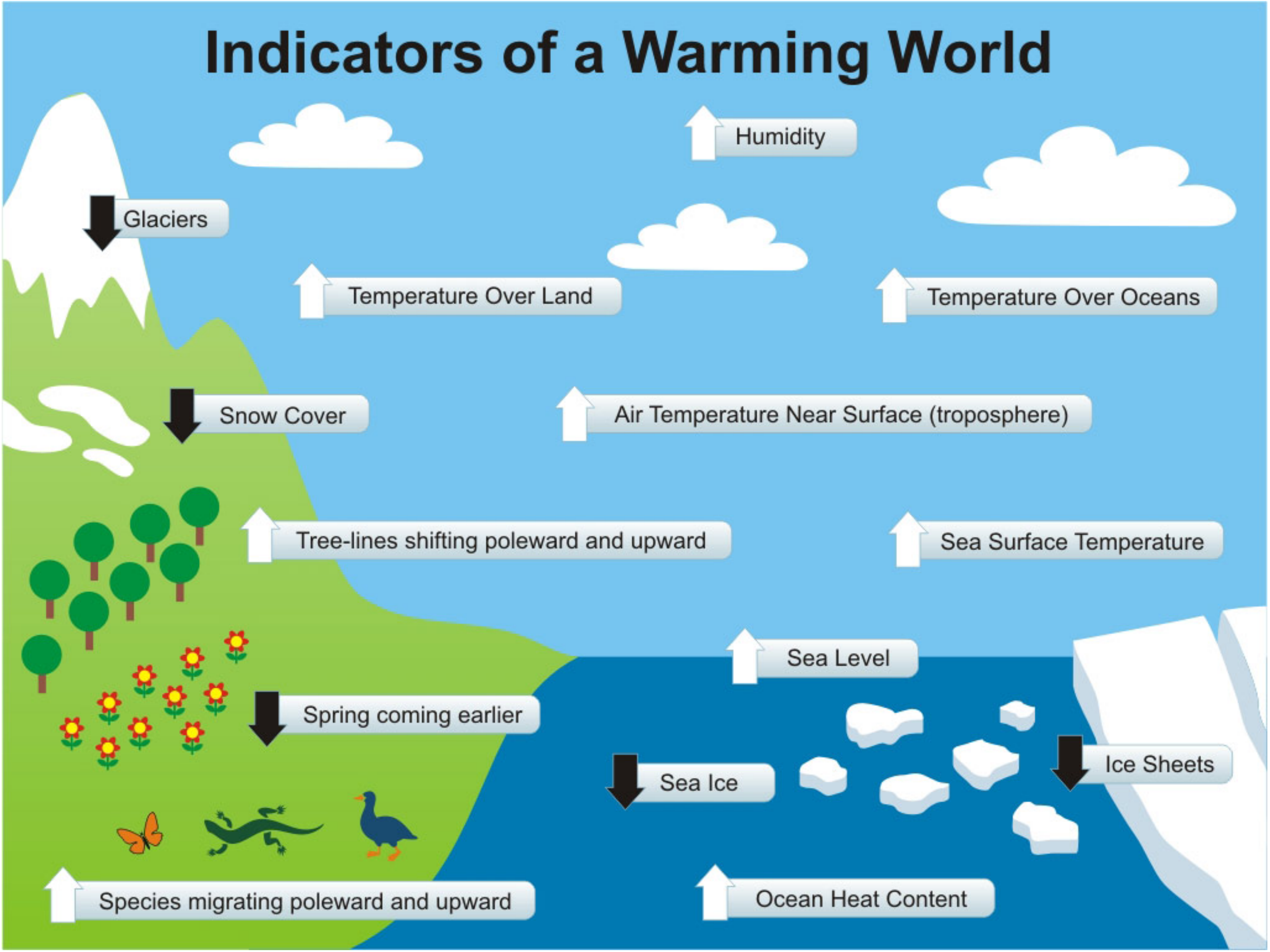
What do the skeptics say about the rising CO_2 levels in the atmosphere?

"Yes, our climates change. They've been changing ever since the earth was formed."

17 August 2011 (Source)



Why do the carbon dioxide levels rise and fall?


Indicators of a Warming World
Humidity
Glaciers
Temperature Over Land
Temperature Over Oceans
Snow Cover
Air Temperature Near Surface (troposphere)
Tree-lines shifting poleward and upward
Sea Surface Temperature
Sea Level
Spring coming earlier
Sea Ice
Ice Sheets
Species migrating poleward and upward
Ocean Heat Content

Global Surface Temperature

⬇ download data

Data updated 4.18.11

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Source: NASA/GISS. This research is broadly consistent with similar constructions prepared by the Climatic Research Unit and the National Atmospheric and Oceanic Administration. Credit: NASA/GISS

Politician	Objective Data	Politician
"the last 4 or 5 years, have they been cooler or warmer?" 31 March 2011 (Source)	Global temperature is still rising and 2010 was the hottest recorded.	"we've actually had global cooling in the last ten years" 7 December 2009 (Source)
"would it be fair to say then that there has been a cooling of global temperatures at least over the last 13 years compared to 1998?" 31 March 2011 (Source)	The last decade 2000-2009 was the hottest on record.	"What the science says is that temperatures peaked out globally in 1998. So we've gone for 10 plus years where the temperatures have gone down." 14 April 2009 (Source)

Sea Level

download data

Data updated 8.5.11

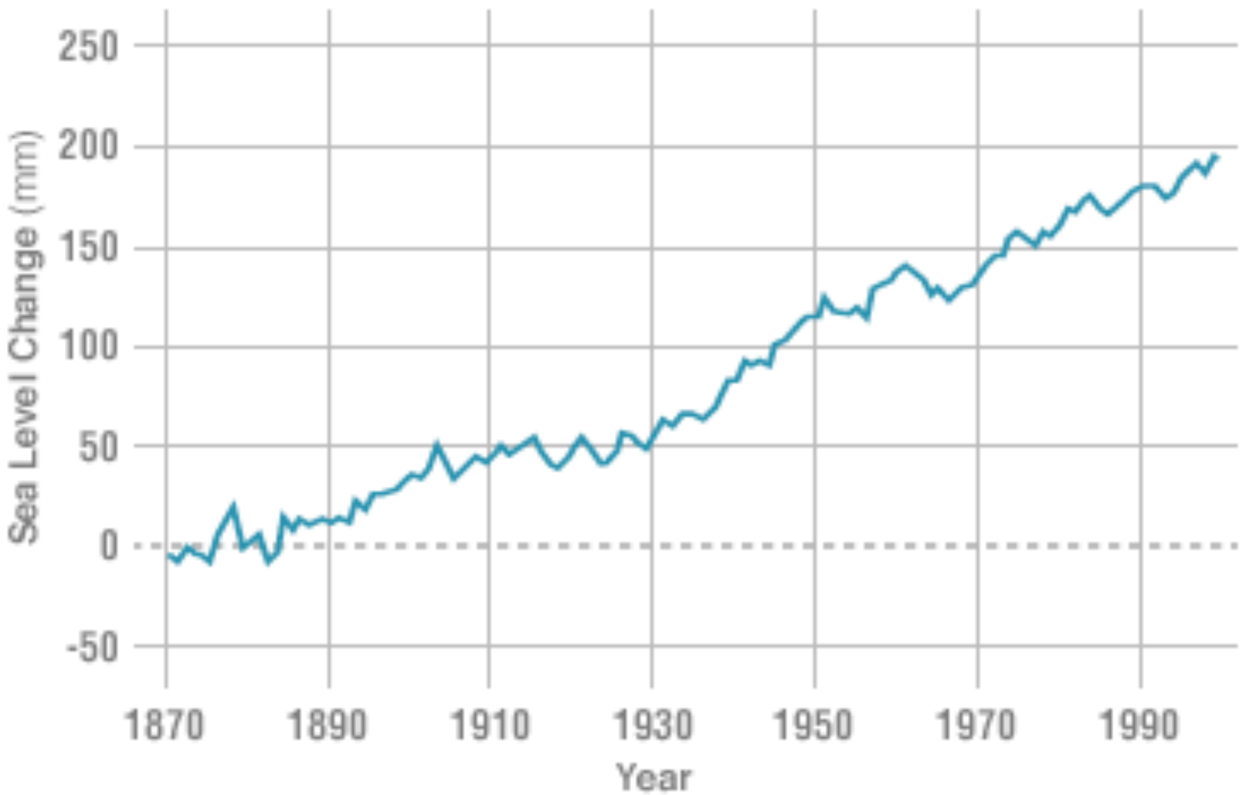
GROUND DATA: 1870-2000

RATE OF CHANGE

Data source: Coastal tide gauge records.

Credit: CSIRO

↑ 1.70 mm per yr*



*estimate for 20th century

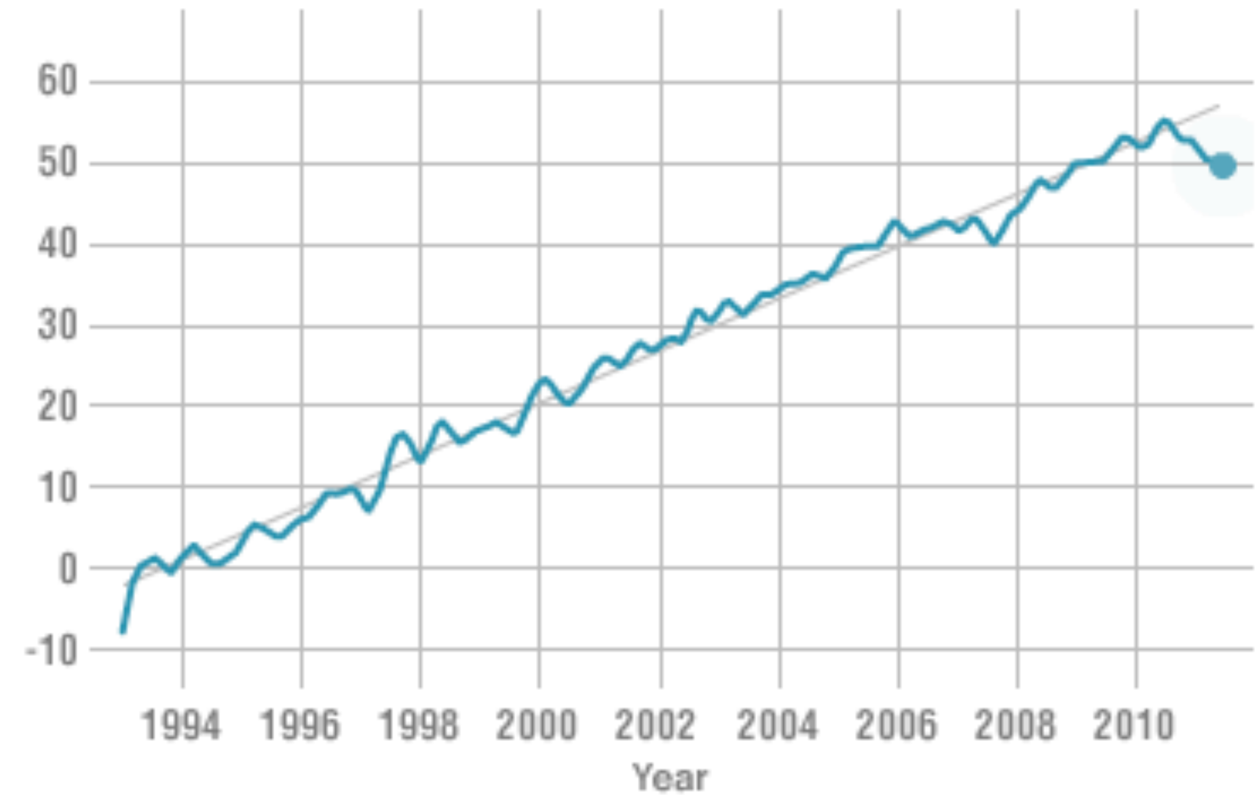
SATELLITE DATA: 1993-PRESENT

RATE OF CHANGE

Data source: Satellite sea level observations.

Credit: CLS/Cnes/Legos

↑ 3.27 mm per yr*



Inverse barometer applied and seasonal signals removed.

*estimate for 1993-2010

Arctic Sea Ice

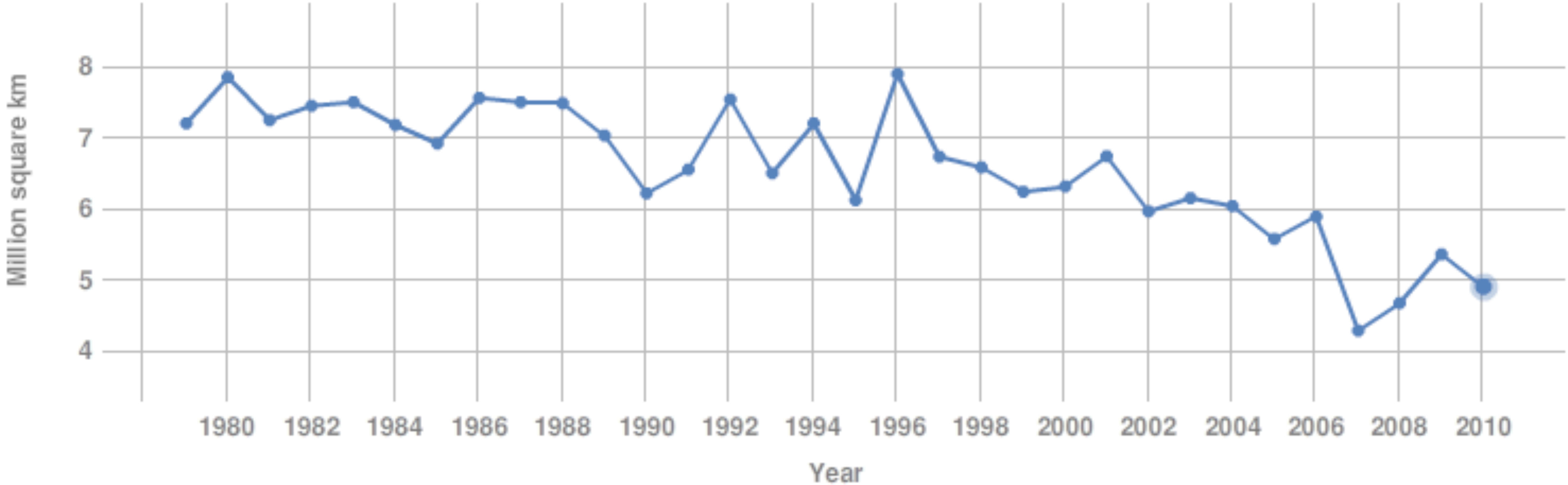
download data

Data updated 2.23.11

AVERAGE SEPTEMBER EXTENT

Data source: Satellite observations

Credit: NSIDC



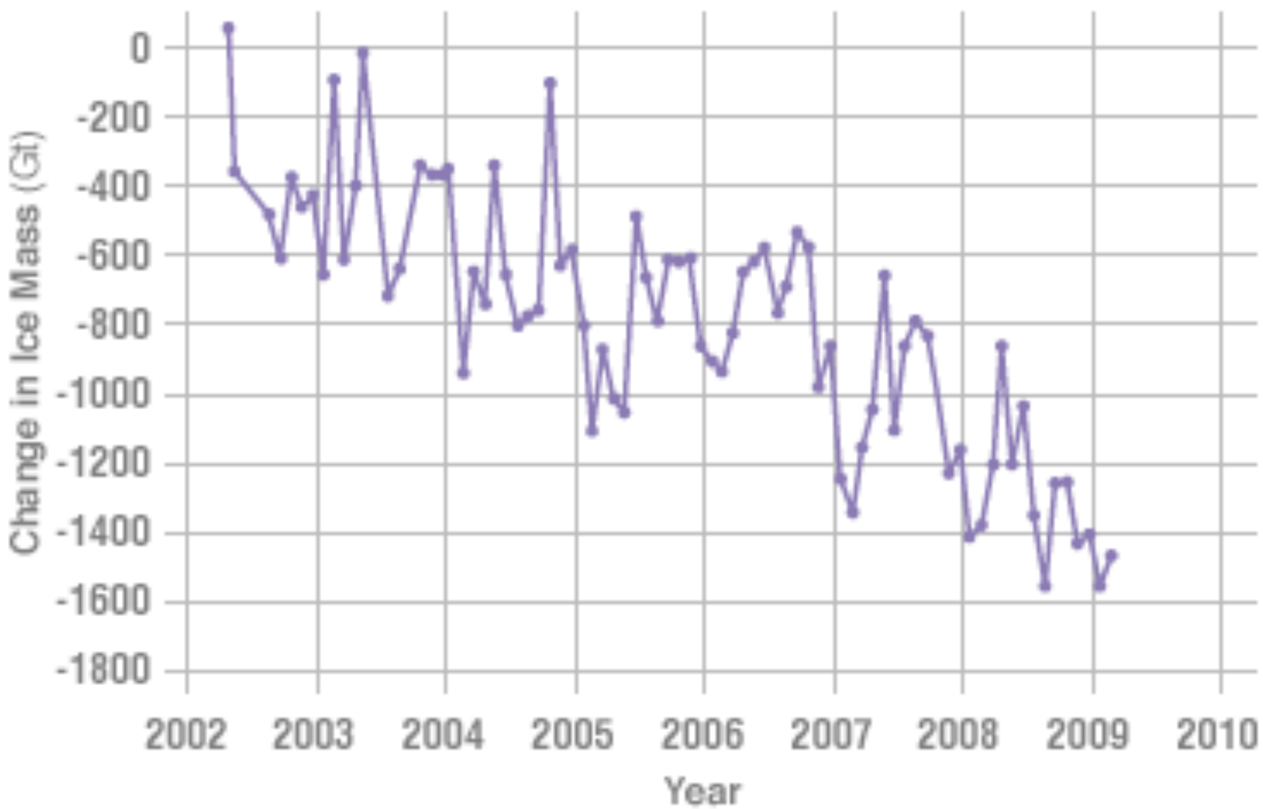
Land Ice

Data updated 2.23.11

download data

ANTARCTICA MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.
Credit: NASA/University of California, Irvine



GREENLAND MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.
Credit: NASA/University of California, Irvine

Note: In the above charts, negative numbers indicate mass loss; positive numbers indicate mass gain. (Reference)

Really?

"in the Antarctic, where the penguins are, there is a buildup of ice."

18 March 2009 (Source)

"the ice in the Antarctic is growing"

8 March 2011 (Source)

Further Evidence of Climate Change

Ocean acidification

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent.[12,13] This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.[14,15]

Warming oceans

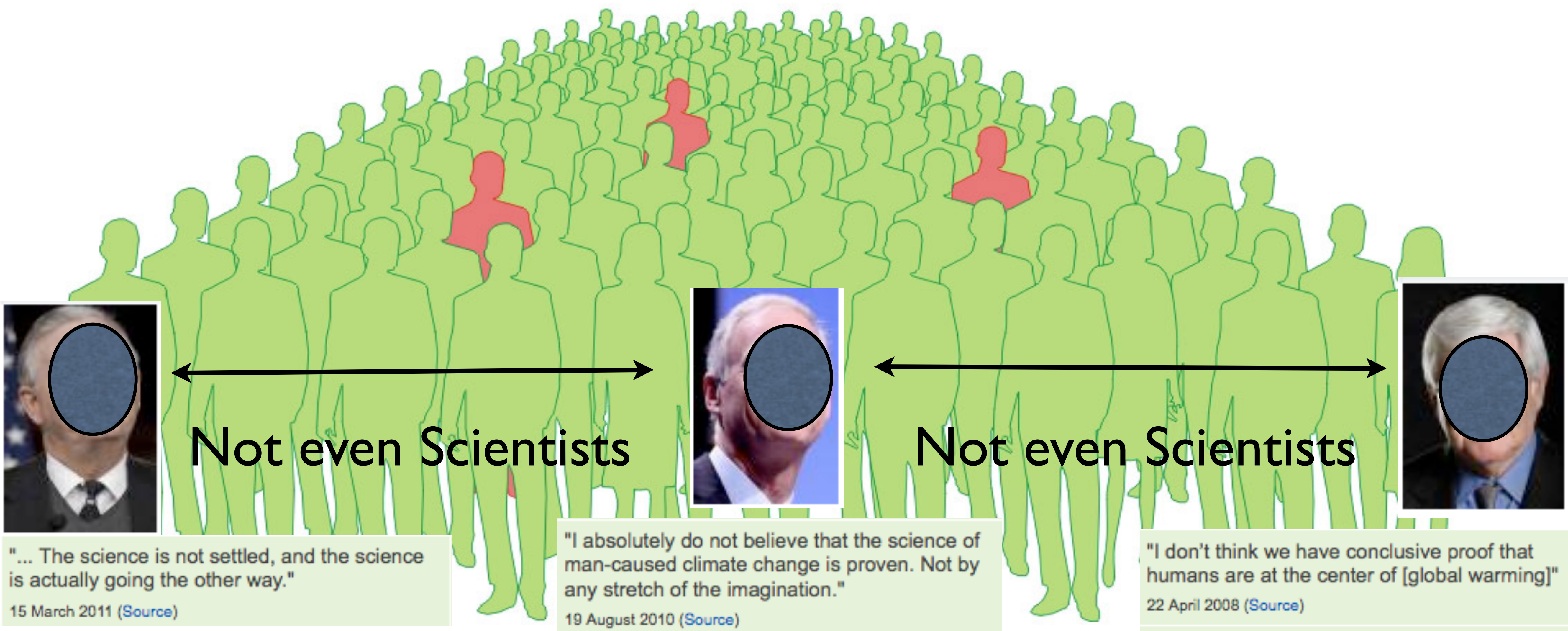
The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969.[8]

Extreme events

The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.[11]

Despite Evidence of Climate Change Some Want Us to Believe that there is Debate Among Scientists…NO

97 out of 100 climate experts think humans are changing global temperature



Despite Evidence of Climate Change Skeptics continue to make statements that illustrate their ignorance of science

"The idea that carbon dioxide is a carcinogen that is harmful to our environment is almost comical. Every time we exhale, we exhale carbon dioxide. Every cow in the world—you know when they do what they do—you've got more carbon dioxide."

[redacted] / ABC's *This Week* / April 2010

Despite Evidence of Climate Change Skeptics continue to make statements that fly in the face of data

[redacted]

"There are just as many glaciers that are growing that are shrinking."

THE SHRINKING PUNCAK JAYA

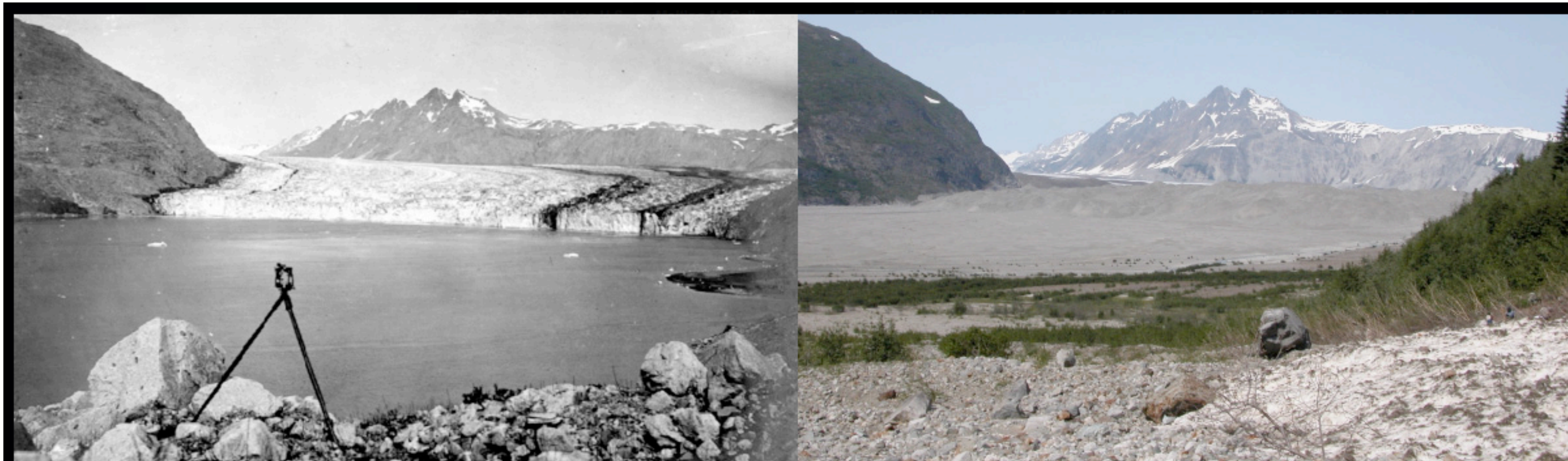
Puncak Jaya Glacier in the Irian Jaya province of Indonesia. Left: 1936. Middle: 1972. Right: 2005. Click here to download image.

BAKED ALASKA

McCarty Glacier, Alaska. Left: July 30, 1909. Right: August 11, 2004. Click here to download image.

PERU VIEW

Qori Kalis Glacier in Peru. Left: July 1978. Right: July 2004. Click here to download image.



RETREAT OF CARROLL GLACIER, ALASKA

Left: August 1906. Right: June 21, 2004. Click here to download image.

BEAR GLACIER, ALASKA, THEN AND NOW

Bear Glacier in Alaska, photographed by Ulysses Sherman Grant on July 20, 1909 (left) and by Bruce F. Molnia on August 5, 2005 (right). Click here to download image.

IMJA GLACIER, HIMALAYAS

Imja Glacier in the Himalayas, as seen from a point above Amphu Lake and from the upper slopes of Island Peak. Left: Autumn, circa 1956. Right: October 18, 2007. The latter image shows pronounced retreat and collapse of the lower tongue of the glacier and the formation of new melt ponds. Click here to download image.

LESS IS MUIR

Muir Glacier, Alaska. Left: September 2, 1892. Right: August 8, 2005. Click here to download image.

THE MELTING OF HOLGATE GLACIER

Holgate Glacier, Alaska. Left: July 24, 1909. Right: August 13, 2004. Click here to download image.

PEDERSEN PAST AND PRESENT

The retreat of Pedersen Glacier, Alaska. Left: summer 1917. Right: summer 2005. Click here to download image.

OKPILAK GLACIER, ALASKA

Left: June 1907. Right: August 5, 2004. Click here to download image.

SLIPPERY SLOPE, COLORADO

Arapaho Glacier, Colorado. Left: 1898. Right: 2003. Click here to download image.

MELTING MCCALL

McCall Glacier, Alaska. Left: July 1958. Right: August 14, 2003. Click here to download image.

MIGHTY MATTERHORN

The nearly 15,000-ft-high Matterhorn mountain, located in the Alps on the border between Italy and Switzerland. Left: August 16, 1960 at 9.00 am. Right: August 18, 2005 at 9.10 am. Click here to download image.

MOUNT KILIMANJARO, AFRICA

Kilimanjaro Glacier top view and side view, photographed by NASA's Landsat satellite on 17 February, 1993 (left) and again on 21 February, 2000 (right). Click here to download image.

That makes 14 examples of shrinking ones (there are more) do you think he can find that many that are growing?

That politician must have talking about sea ice?!@#?

NO?!@#? How about the ice covering Greenland?

NO! Again ?!@#?, What about icebergs?

OK I Give Up! What hypothesis would draw from these observations?

As a footnote consider this...

GLOBAL CLIMATE CHANGE | NASA's Eyes on the Earth

GLOBAL ICE VIEWER

Northwest Passage

The Northwest Passage is a sea route through the Arctic Ocean north of Canada connecting the Atlantic and Pacific Oceans. In the past, ice pack in the Arctic prevented commercial shipping throughout most of the year, but climate change is reducing the ice pack and making the waterways more navigable. In August 2007, ships were able to sail through the Northwest Passage without needing an icebreaker, which was the first time the passage has been clear since records have been kept. Being able to sail through the passage cuts thousands of miles off shipping routes. In August 2008, the Northwest Passage opened again. Thawing oceans and melting ice simultaneously opened up a Northeast Passage, making it possible to sail around the Arctic ice cap north of Russia.

11.2 % per decade – approximate decrease in annual Arctic minimum [2]

about Arctic sea ice

HIPPC**O**

Overharvesting

Poaching and exploitation for food is another major factor, due to **unsustainable fishing and hunting**: more than 300 mammal species are being eaten into extinction, according to recent research.

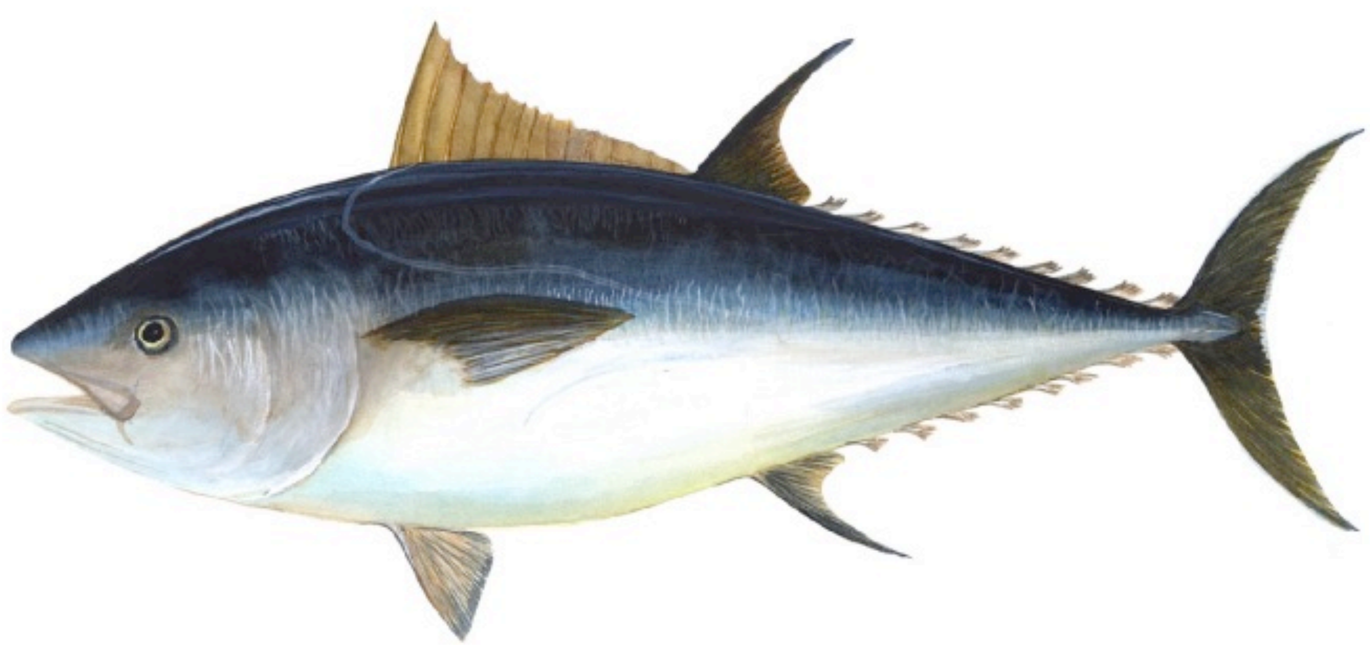
Overharvesting

- Harvesting organisms at a rate that exceeds the populations ability to rebound.
  - Species with small habitats and/or low reproductive rates are especially vulnerable.
    - Ex. Great Auk now extinct, Elephants once decimated

When the giant flightless birds called moa were overexploited to the point of extinction,[4] the giant Haast's eagle that preyed on them also became extinct[5]

Overharvesting (over fishing)

- Blue Fin Tuna and Northern Cod are classic examples of overharvesting.
- Prior to 1980 Blue Fins had little commercial value (0.03$/lb) and valued mostly for cat food and sportfishing.
- Then in the 1980's Blue Fin's were introduced into the sashimi and sushi market, today valued at over 100$/lb
- From 1980 to 1990 the Blue Fin population was reduced by 80%



Domestication and Loss of Biodiversity

- Humans have been domesticating organisms for thousands of years
- Domestication involves ***artificial selection***, in which organisms with the most desirable traits for humans are crossbred to enhance the occurrence of that in the species.
- Many domesticated species are managed for economic returns, and provide humans with
  - Food
  - Labor
  - Medicine
  - Pollination services

Source: Pixabay.com by Pexels

Domestication and Loss of Biodiversity

- When humans assume responsibility for the reproduction and selection of traits in another species, ***genetic diversity will be reduced***

- Genetic diversity is one facet of biodiversity, so ***domestication for economic return leads to a loss of biodiversity***

- Examples of this can be seen in domestic livestock (cattle, sheep, goats, pigs), honeybees, and the agricultural practice of monocropping.

Source: Pixabay.com by Peggy und Marco Lachmann-Anke

Monoculture

Monocultures, the agricultural practice of producing or growing genetically similar, or essentially identical plants, over a large areas (stands), year after year, is widely used in modern industrial agriculture. It is often argued that monoculture produces greater yields by utilizing plants' abilities to maximize growth under less pressure from other species and more uniform plant structure.

Of the myriad species of plants and animals available for human consumption, modern agriculture uses only a few. According to the UN's Food and Agriculture Organization, only 12 plant species provide 75% of our total food supply, and only 15 mammal and bird species make up over 90% of livestock production.

The Issues and problems...

However, these plants are selected because of their ability to grow well under the specific conditions of a particular place, and therefore are at greater risk when these conditions change, for instance in extreme weather, than are genetically diverse stands. Genetically diverse crops can better survive in environments in which conditions fluctuate, because some are vulnerable to certain changes and other are not. Thus genetic diversity is likely to reduce the odds of massive crop failure and to contribute to greater stability of production.

The vulnerability of monocultures to disease and insects also illustrates this point. Pathogens spread more readily, and epidemics tend to be more severe, when the host plants (or animals) are more genetically uniform and crowded. The pathogens encounter less resistance to spreading than they do in mixed stands. Outbreaks of disease, invasions of insects, and climatic anomalies have caused many wholesale crop and animal failures in the past.

What is also not appreciated is that modern crops and livestock vitally depend on hundreds of thousands of other species, including insects and birds that pollinate crops and feed on pests, and numerous microbial species that live on and in plants and animals, and that are especially critical to survival.

Species diversity has declined around the world

- **Threatened species** According to the International Union for Conservation of Nature (IUCN), species that have a high risk of extinction in the future.
- **Near-threatened species** Species that are very likely to become threatened in the future.
- **Least concern species** Species that are widespread and abundant.

Declining Species Diversity

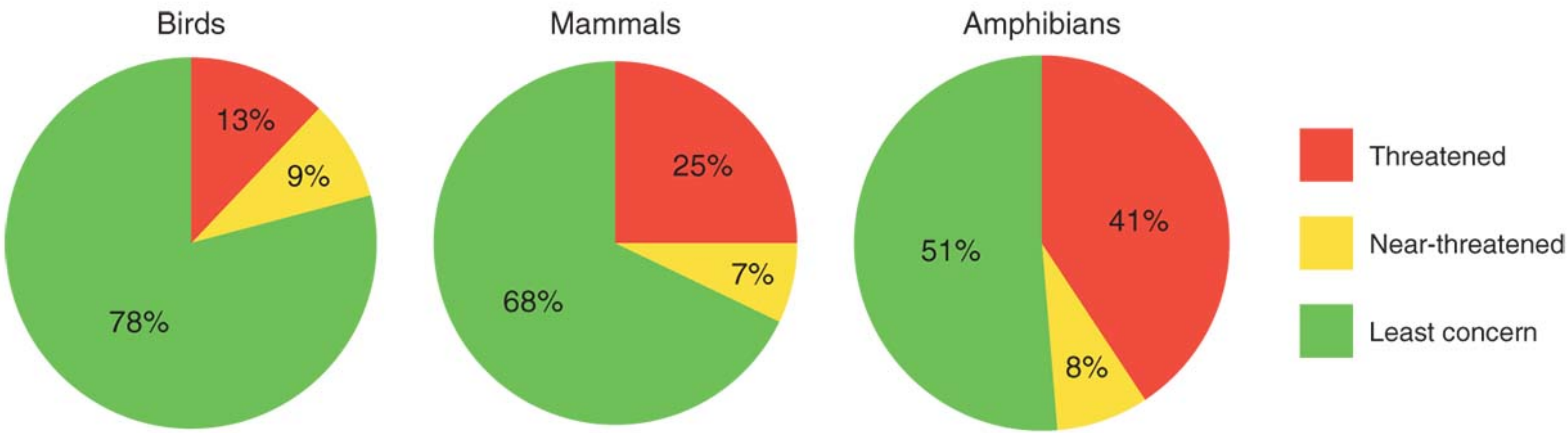


Figure 59.4
Environmental Science for AP®, Second Edition
After International Union for Conservation of Nature, 2009

The decline of birds, mammals, and amphibians. Based on those species for which scientists have reliable data, 21 percent of birds, 32 percent of mammals, and 49 percent of amphibians are currently classified as threatened or near-threatened with extinction.

Ecosystem Services

There are 5 categories of ecosystem services:

- Provisions
- Regulating services
- Support systems
- Resilience
- Cultural services

Provisions

- **Provision** A good that humans can use directly.
- Examples of provisions include lumber, food crops, medicinal plants, natural rubber, and furs.
- Of the top 150 prescription drugs sold in the United States, about 70 percent come from natural sources.

Regulating Services

- Natural ecosystems help to regulate environmental conditions.
- Natural ecosystems, such as tropical rainforests and oceans, remove carbon from the atmosphere.
- Ecosystems also are important in regulating nutrient and hydrologic cycles.

Support Services

- Natural ecosystems provide numerous support services such as pollination of food crops.
- Ecosystems also provide natural pest control services because they provide habitat for predators that prey on agricultural pests.

Resilience

- Resilience depends greatly on species diversity.
- For example, several different species may perform similar functions in an ecosystem, but differ in their susceptibility to disturbance. If a pollutant kills one plant species that contains nitrogen-fixing bacteria, but not all plant species that contain nitrogen-fixing bacteria, the ecosystem can still continue to fix nitrogen.

Cultural Services

- The awe-inspiring beauty of nature has instrumental value because it provides an aesthetic benefit for which people are willing to pay.

- Similarly, scientific funding agencies may award grants to scientists for research that explores biodiversity with no promise of any economic gain.

The Decline of Ecosystem Services

- Of 24 different ecosystem functions, 15 have been found to be declining or used at a rate that cannot be sustained.
- If we want to improve ecosystem functions, we need to improve the fate of the species and ecosystems that provide these services.

Plant and Animal Trade

- The legal and illegal trade in plants and animals represents a serious threat to their ability of some species to persist in nature.
- National and international laws help protect species.
- **Lacey Act** A U.S. act that prohibits interstate shipping of all illegally harvested plants and animals.
- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)** A 1973 treaty formed to control the international trade of threatened plants and animals.
- **Red List** A list of worldwide threatened species.
- Poor enforcement of these regulations and laws presents the biggest obstacle and challenge.

Conservation legislation often focuses on a single species

- **Marine Mammal Protection Act** A 1972 U.S. act to protect declining populations of marine mammals.

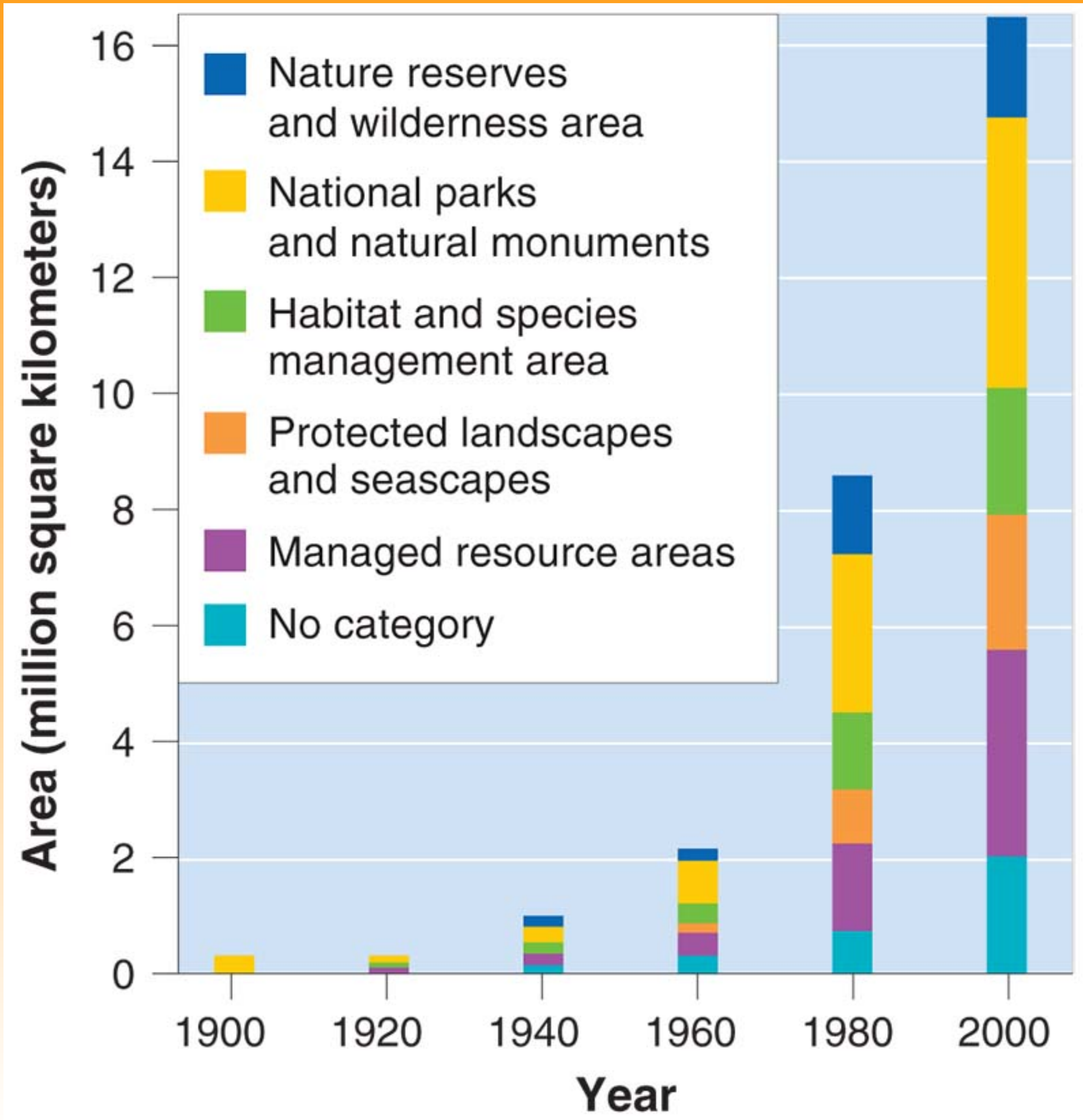
- **Endangered species** A species that is in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

- **Threatened species** According to U.S. legislation, any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Endangered Species Act

- First passed in 1973, it authorizes the U.S. Fish and Wildlife Service to determine which species can be listed as threatened or endangered and prohibits the harming of these species.
- Trading these species is also illegal.
- The act also authorizes the government to purchase habitat that is critical to the species.

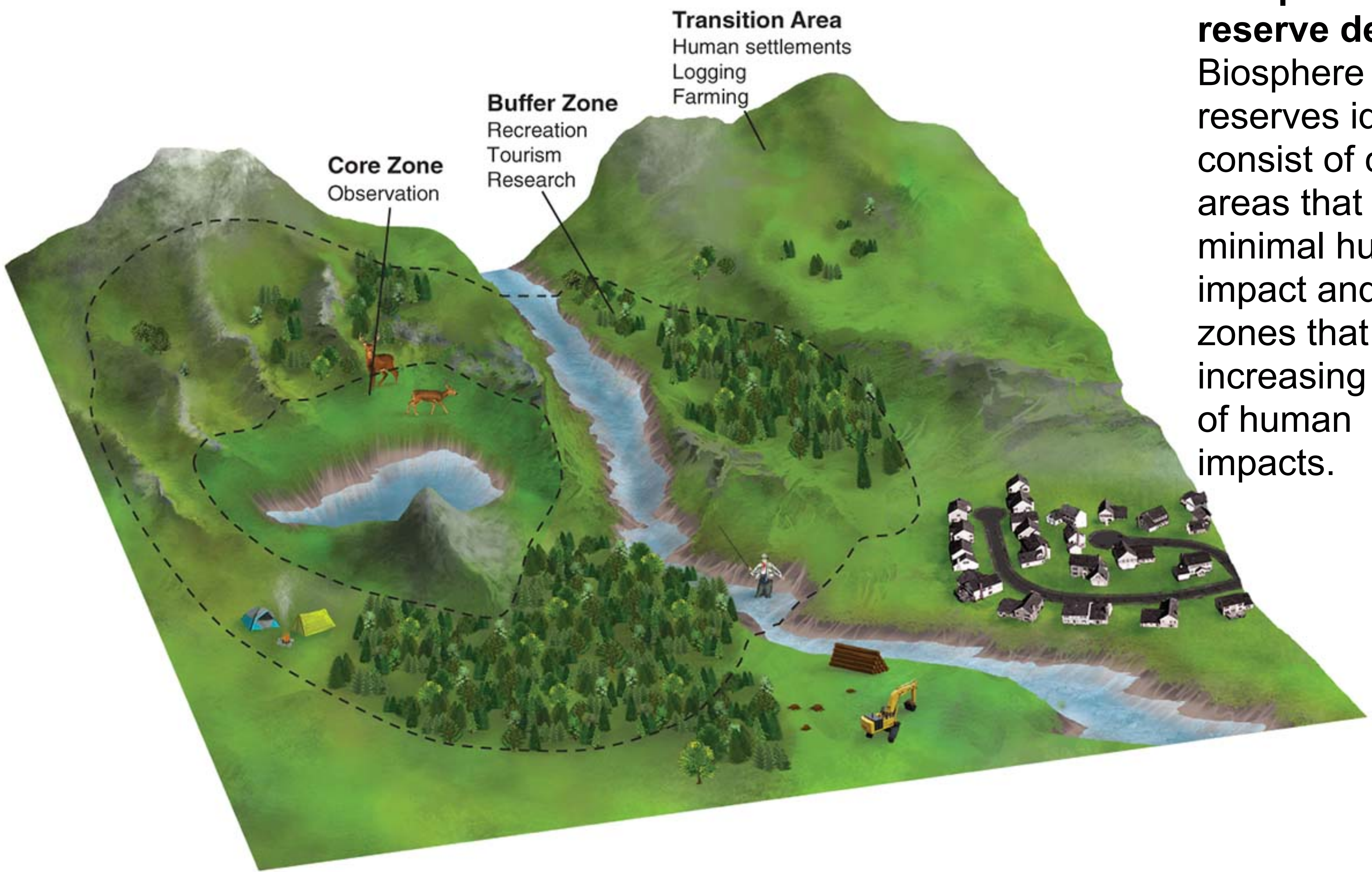
Protecting Entire Ecosystems



Changes in protected land. Since the 1960s, there has been a large increase in the amount of land that is under various types of protection throughout the world.

Biosphere Reserves

- **Biosphere reserve** Protected area consisting of zones that vary in the amount of permissible human impact.



Biosphere reserve design. Biosphere reserves ideally consist of core areas that have minimal human impact and outer zones that have increasing levels of human impacts.

Strategies to Mitigate Biodiversity Loss

- As global change intensifies, it is important that we address current and future losses of biodiversity.

- Some strategies to help with this include:
  - The creation of ***protected areas***, such as wildlife refuges and parks
  - The creation of ***habitat corridors*** to reduce the negative effects of habitat fragmentation
  - ***Restoration*** of lost habitats
  - ***Sustainable land use*** practices

Strategies to Mitigate Biodiversity Loss

Establishing protected areas for wildlife can help preserve biodiversity

Habitat corridors can reduce the negative impact of fragmentation and allow gene flow between populations

Strategies to Mitigate Biodiversity Loss

Source: Shutterstock.com by Jason Finn

Source: Shutterstock.com by MPIX

Habitat restoration and sustainable land use practices, including sustainable agriculture and forestry, are important strategies to reduce the loss of biodiversity

Source: Shutterstock.com by SpeedKingz

RESTORATION ECOLOGISTS HELP RETURN DEGRADED ECOSYSTEMS TO A MORE NATURAL STATE

Bioremediation

- Bioremediation- using organisms (bacteria, fungi or plants) to detoxify polluted ecosystems
- Some plants and lichens can extract and accumulate potentially toxic heavy metals from the soil
  - This can be helpful in cleaning up old mining sites

Biological Augmentation

- Biological Augmentation- uses organisms to add essential materials to a degraded ecosystem.
- Ecologists can use either plants and/or animals to speed up succession and recovery
    - Mycorrhizal symbionts were added to the soil of the tall grass prairies of Minnesota to restore the soil.
    - Lupines have been used in the western United States to increase nitrogen concentration in the soil. SEE NEXT SLIDE


Lupines

Global Restoration Projects

- A very new discipline that is steadily evolving.
- Even still many success stories exist today

Kissimmee River Restoration

Maungatautari, New Zealand

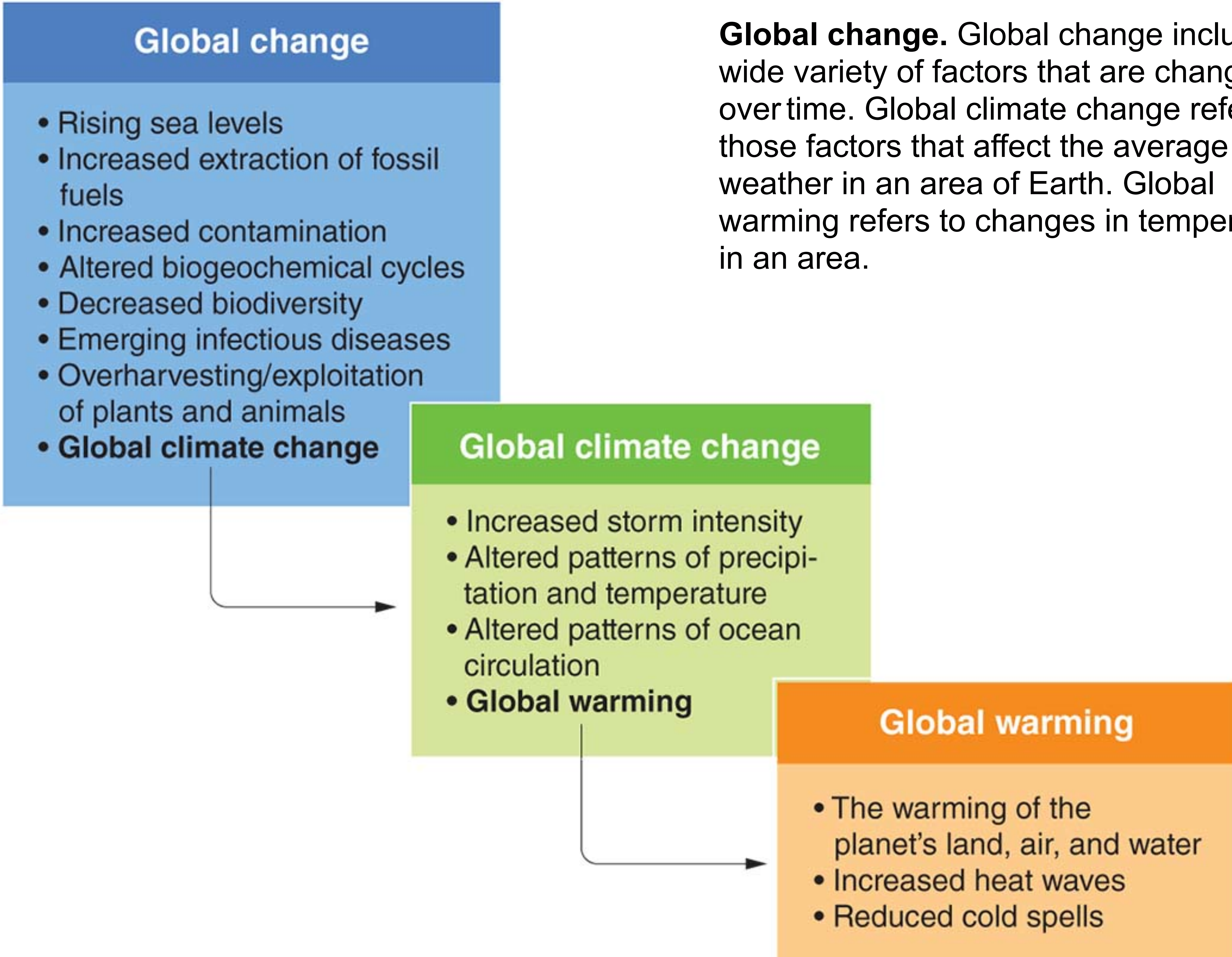

Ducktown, Tennesee 1965


Ducktown, Tennesee 2009

Addendum

Global change includes global climate change and global warming

- **Global change** Change that occurs in the chemical, biological, and physical properties of the planet.
- **Global climate change** Changes in the average weather that occurs in an area over a period of years or decades.
- **Global warming** The warming of the oceans, land masses, and atmosphere of Earth.



Global change. Global change includes a wide variety of factors that are changing over time. Global climate change refers to those factors that affect the average weather in an area of Earth. Global warming refers to changes in temperature in an area.

Greenhouse Gases

TABLE 62.1 The major greenhouse gases

The major greenhouse gases differ in their ability to absorb infrared radiation and in the duration of time that they stay in the atmosphere. The units "ppm" are parts per million.

Greenhouse gas	Concentration in 2010	Global warming potential (over 100 years)	Duration in the atmosphere
Water Vapor	Variable with temperature	<1	9 days
Carbon Dioxide	390 ppm	1	Highly variable (ranging from years to hundreds of years)
Methane	1.8 ppm	25	12 years
Nitrous Oxide	.3 ppm	300	114 years
Chlorofluorocarbons	.9 ppm	1,600 to 13,000	55 to $>$500 years

Sources of greenhouse gases are both natural and anthropogenic

Some greenhouse gases are produced from natural sources:

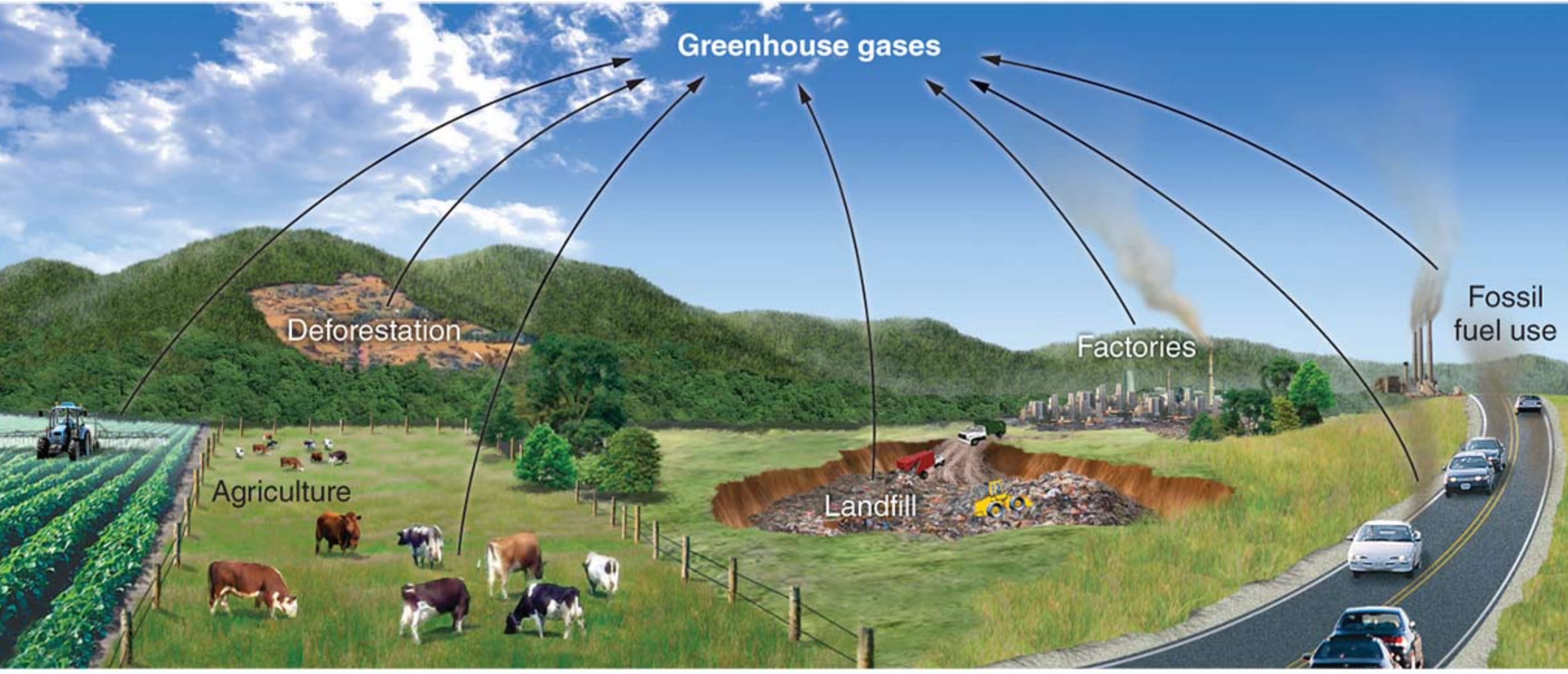
- Volcanic eruptions: ash, carbon dioxide,
- Decomposition and digestion: methane
- Denitrification: nitrous oxide
- Evaporation and evapotranspiration: water vapor

Anthropogenic Causes of Greenhouse Gases

Some greenhouse gasses are produced by human activity:

- Burning of fossil fuels
- Agricultural practices and Livestock
- Deforestation
- Landfills
- Industrial production

Anthropogenic sources of greenhouse gases. Human activities are a major contributor of greenhouse gases including CO_2, methane, and nitrous oxide. These activities include the use of fossil fuels, agricultural practices, the creation of landfills, and the industrial production of new greenhouse gases.

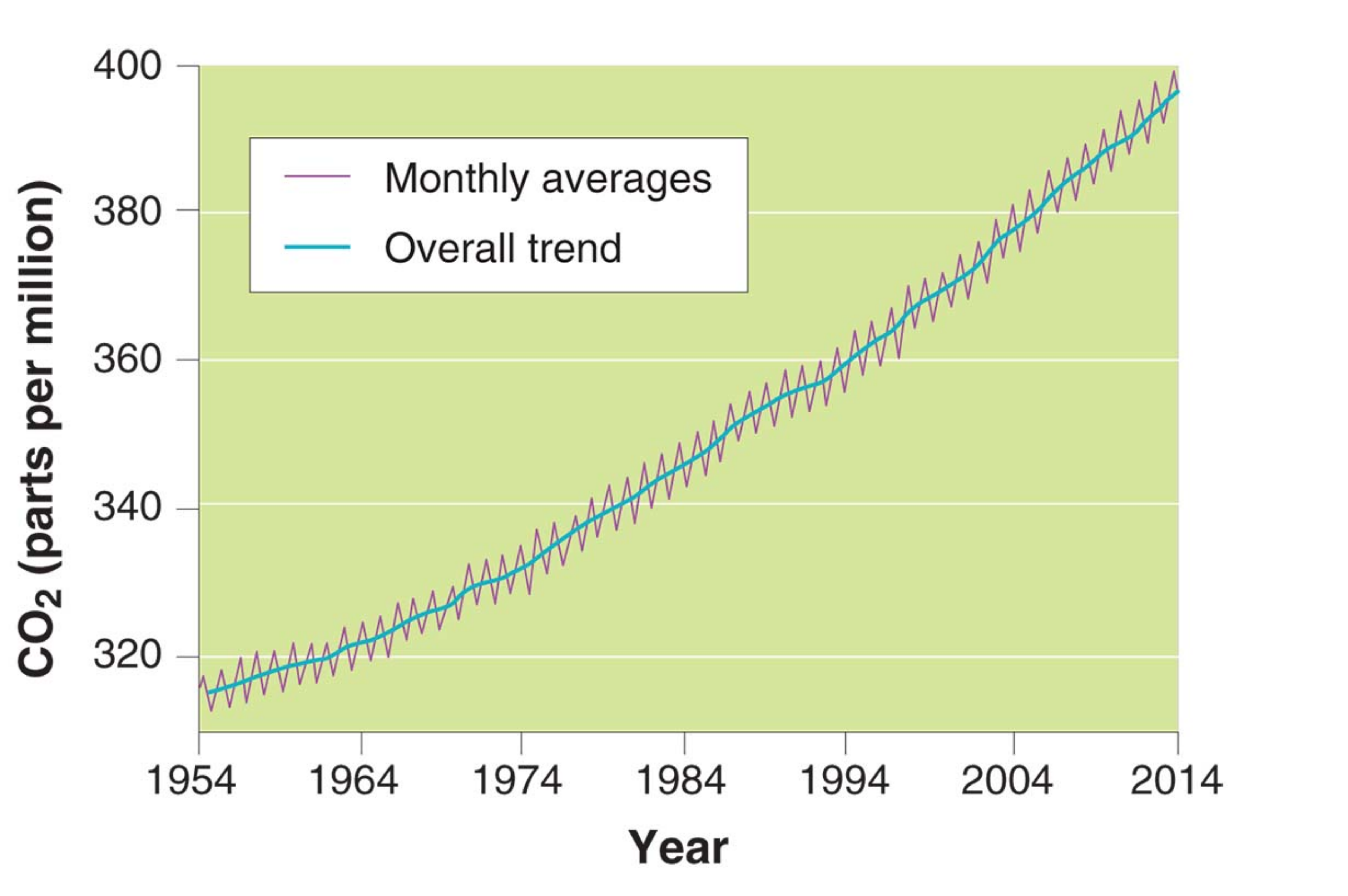


Classwork / HW

Human Activity	Greenhouse Gas Produced
Fossil Fuel Use	
Deforestation	
Agriculture	
Landfills	
Industry	

CO_2 concentrations have been increasing for the past 6 decades

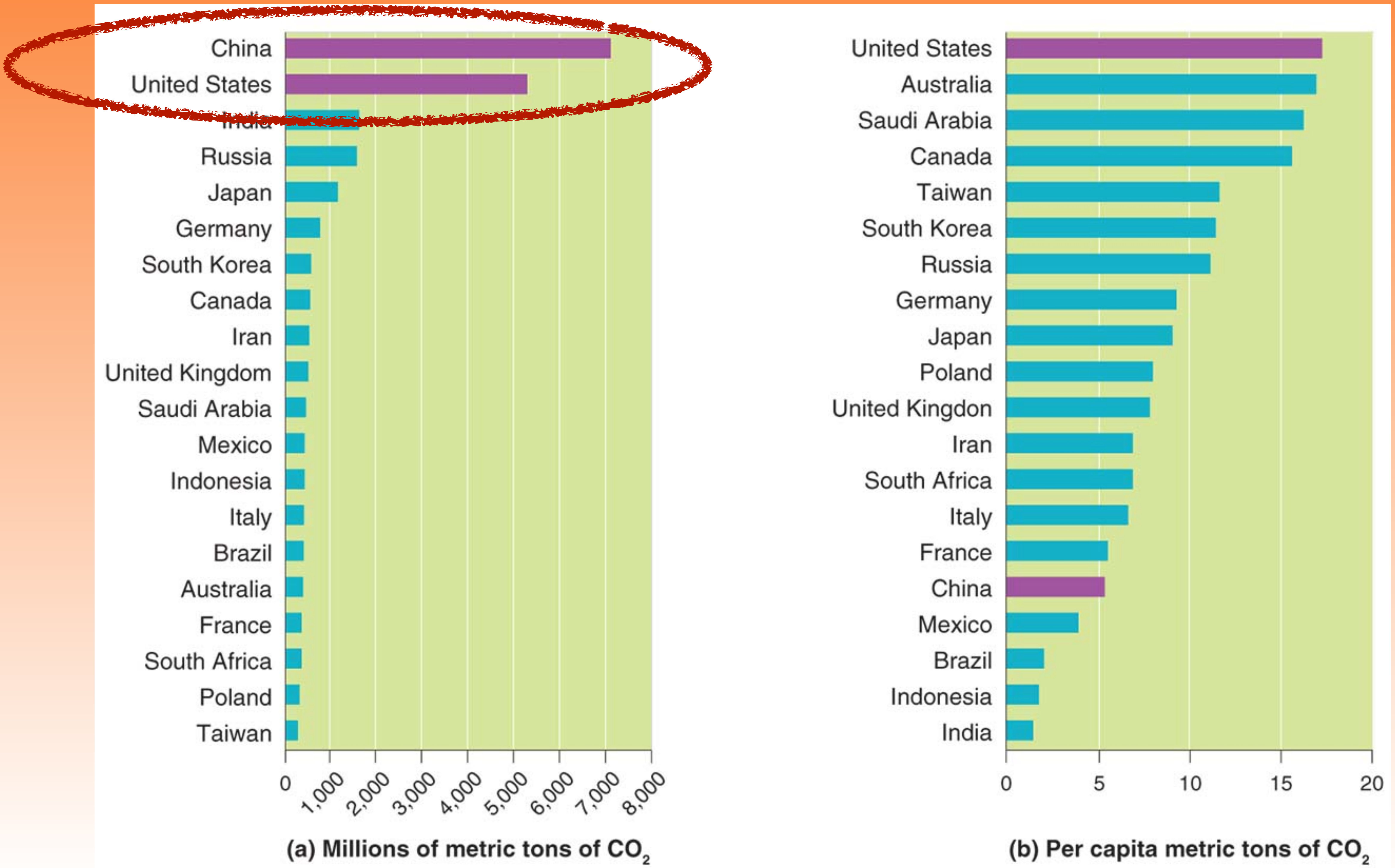
- **Ocean acidification** The process by which an increase in ocean CO_2 causes more CO_2 to be converted to carbonic acid, which lowers the pH of the water.



Changes in atmospheric CO_2 over time. Carbon dioxide levels have risen steadily since measurement began in 1958.

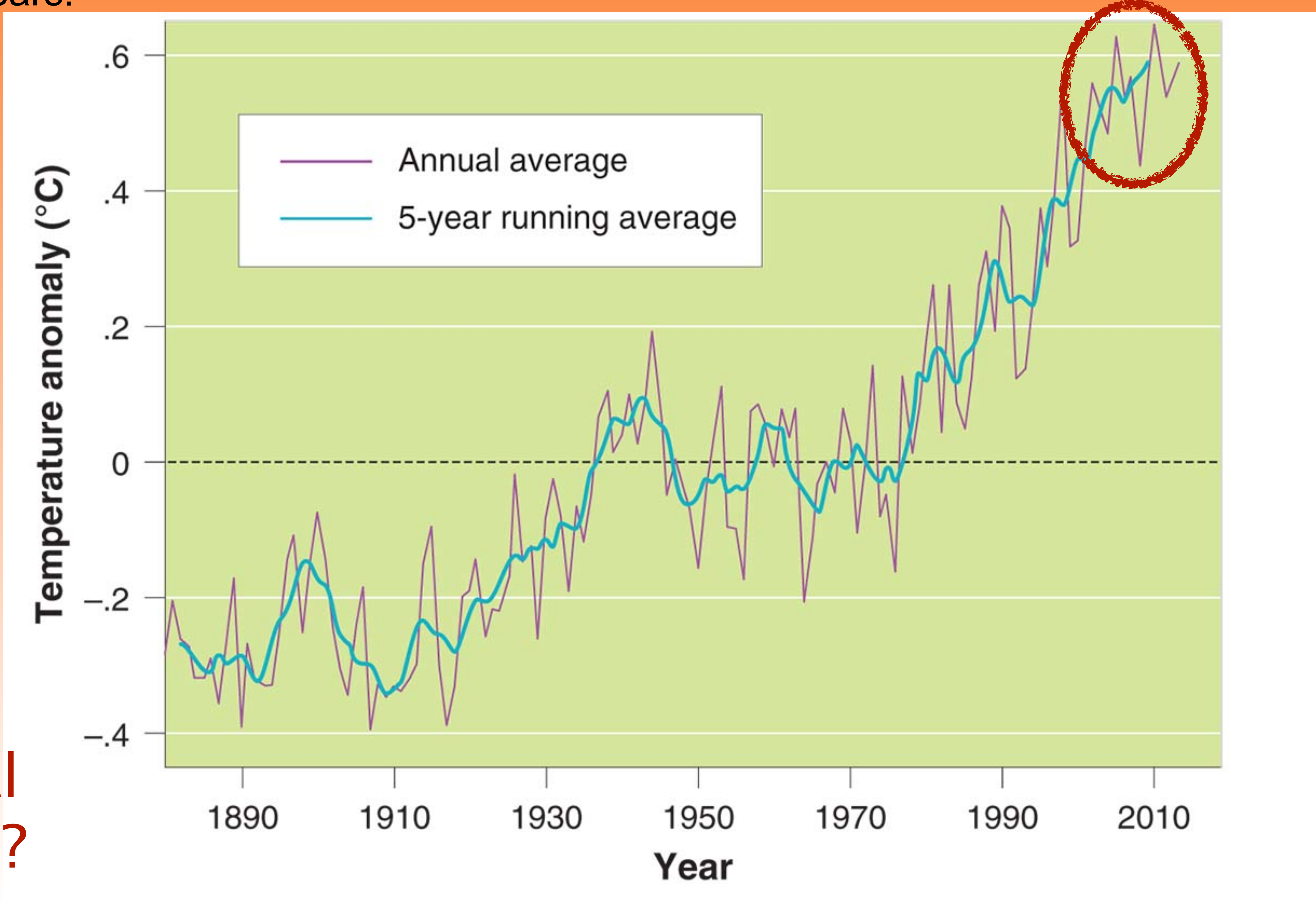
CO_2 emissions differ among nations

CO_2 emissions by country in 2010. (a) When we consider the total amount of CO_2 produced by a country, we see that the largest contributors are the developed and rapidly developing countries of the world. (b) On a per capita basis, some major CO_2 emitters have relatively low per capita CO_2 emissions.



Global temperatures have steadily increased since records began in 1880

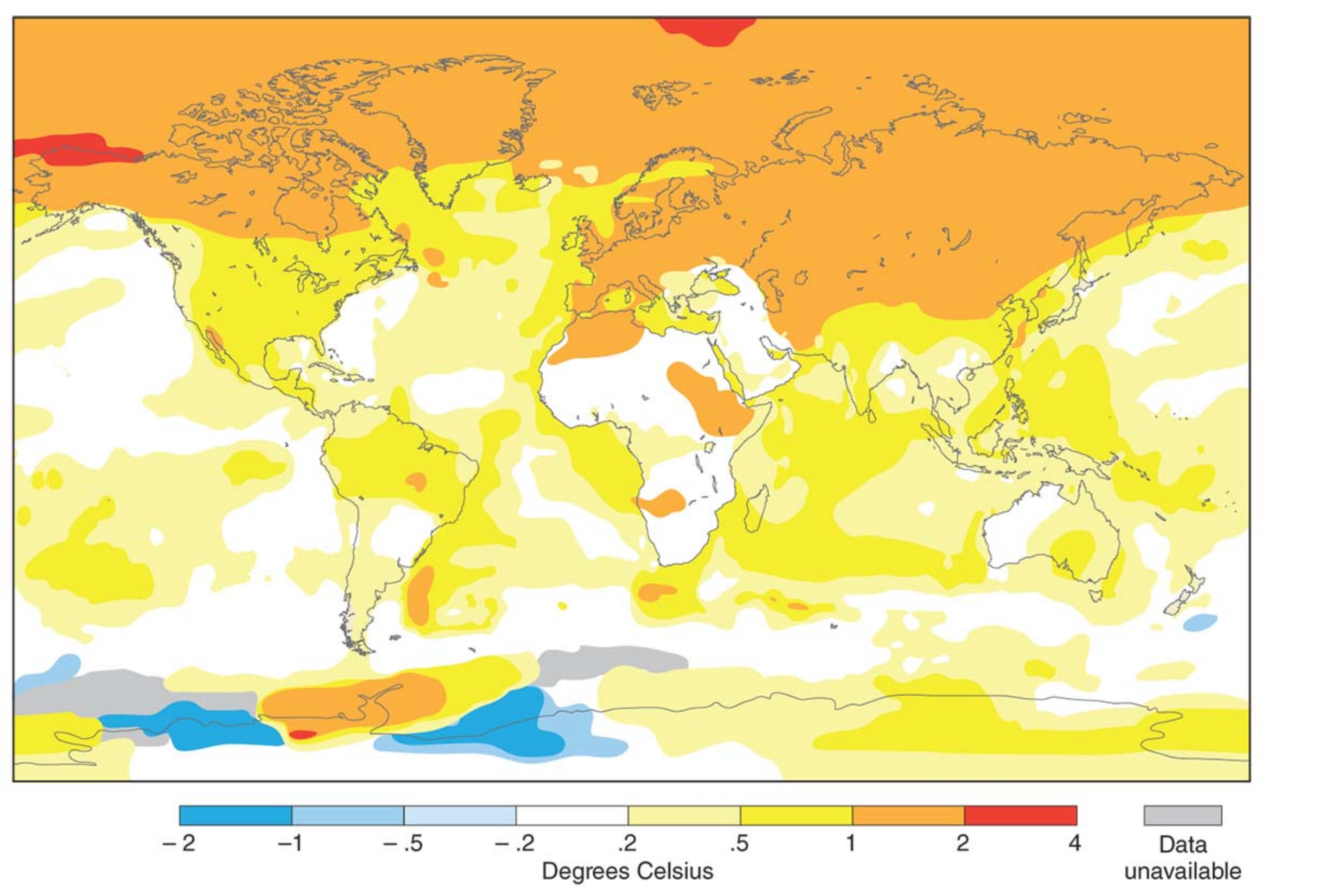
Changes in mean global temperatures over time. Although annual mean temperatures can vary from year to year, temperatures have exhibited a slow increase from 1880 to 2012. This pattern becomes much clearer when scientists compute the average temperature each year for the past 5 years.



Why, Annual fluctuations?

Global Temperatures Since 1880

Changes in mean annual temperature in different regions of the world. In 2010, some regions became cooler, some regions had no temperature change, and the northern latitudes became substantially warmer than the long term average temperature. The surface temperatures plotted on the map represent differences relative to the average temperature from 1951 to 1980.



Scientists can estimate global temperatures and greenhouse gas concentrations for over 5,000 years

Historic CO_2 concentrations. Using a variety of indirect indicators including air bubbles trapped in ancient ice cores, scientists have found that for more than 400,000 years CO_2 concentrations never exceeded 300 ppm. After 1950, CO_2 concentrations have sharply increased to their current level of nearly 400 ppm.

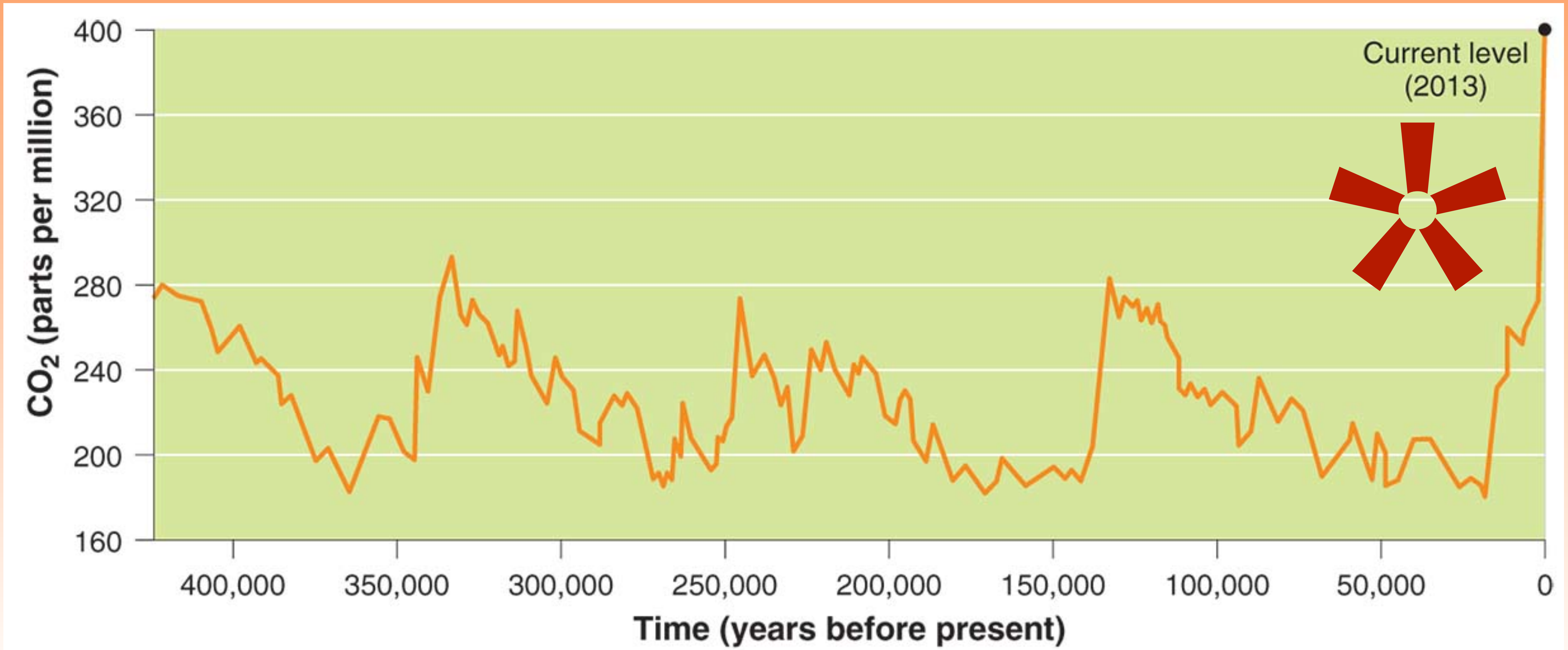
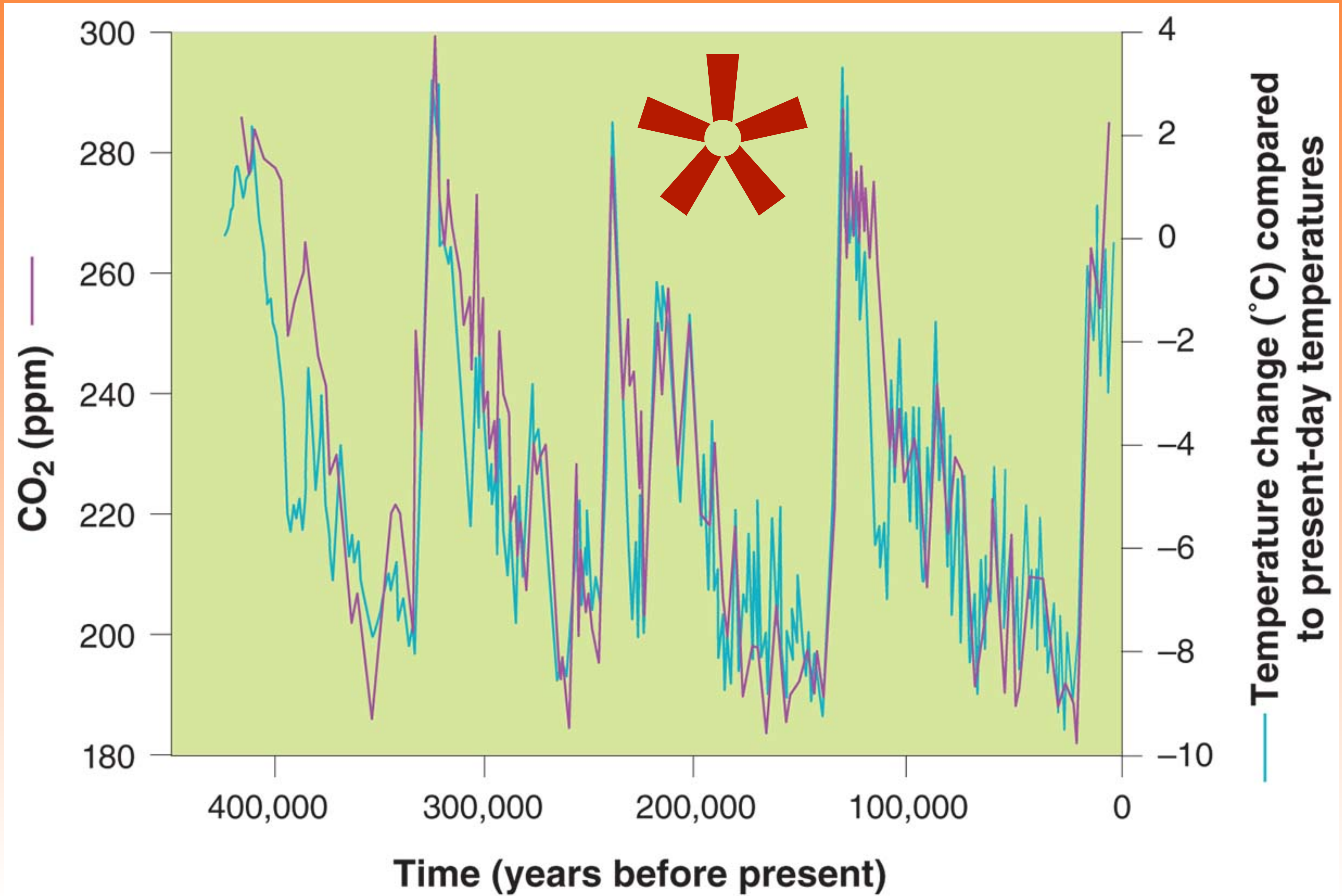


Figure 63.7

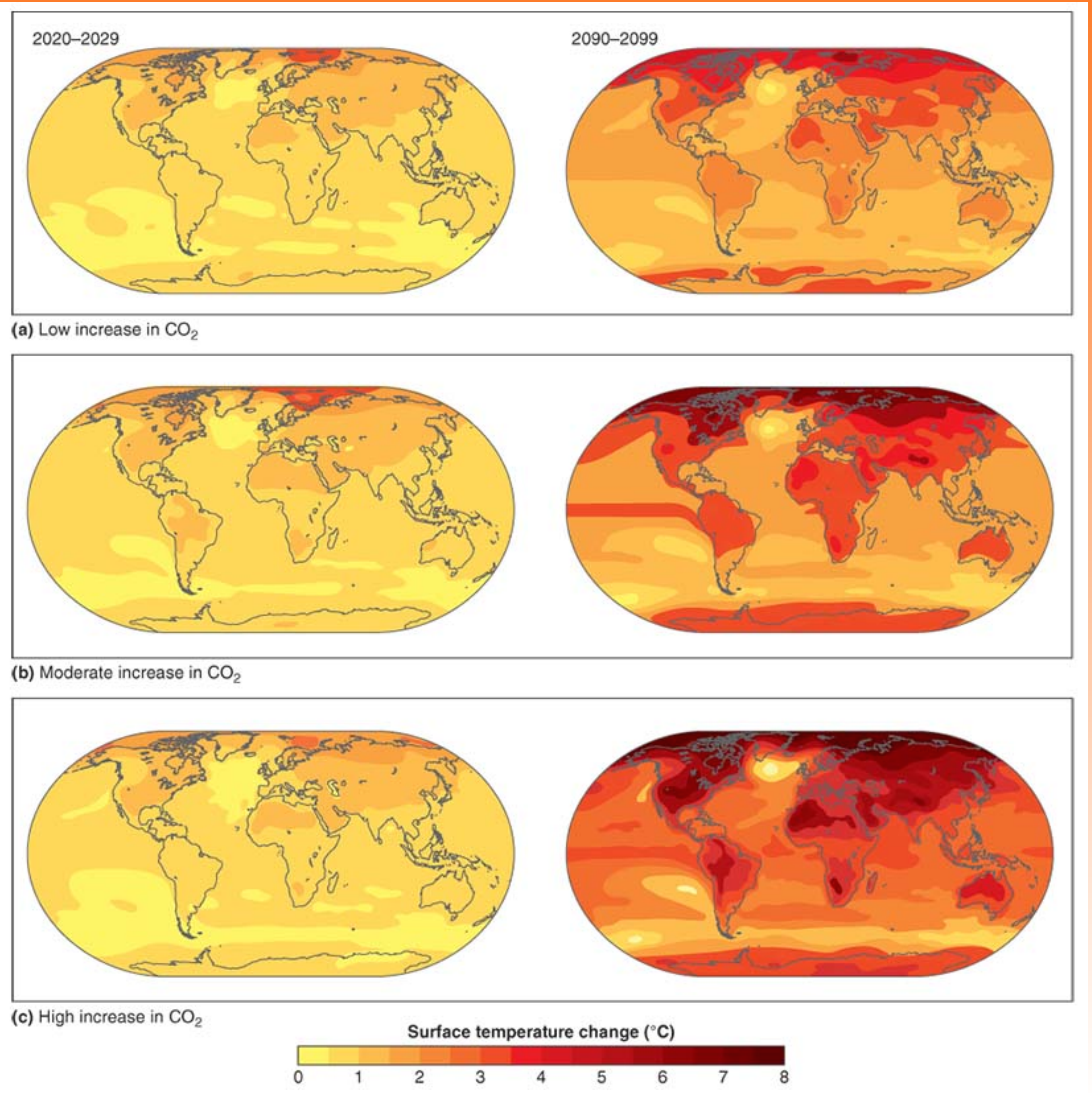
Historic Greenhouse Gas Concentrations

Historic temperature and CO_2 concentrations. Ice cores used to estimate historic temperatures and CO_2 concentrations indicate that the two factors vary together. Ice formed during warmer times will have a higher percentage of heavy oxygen

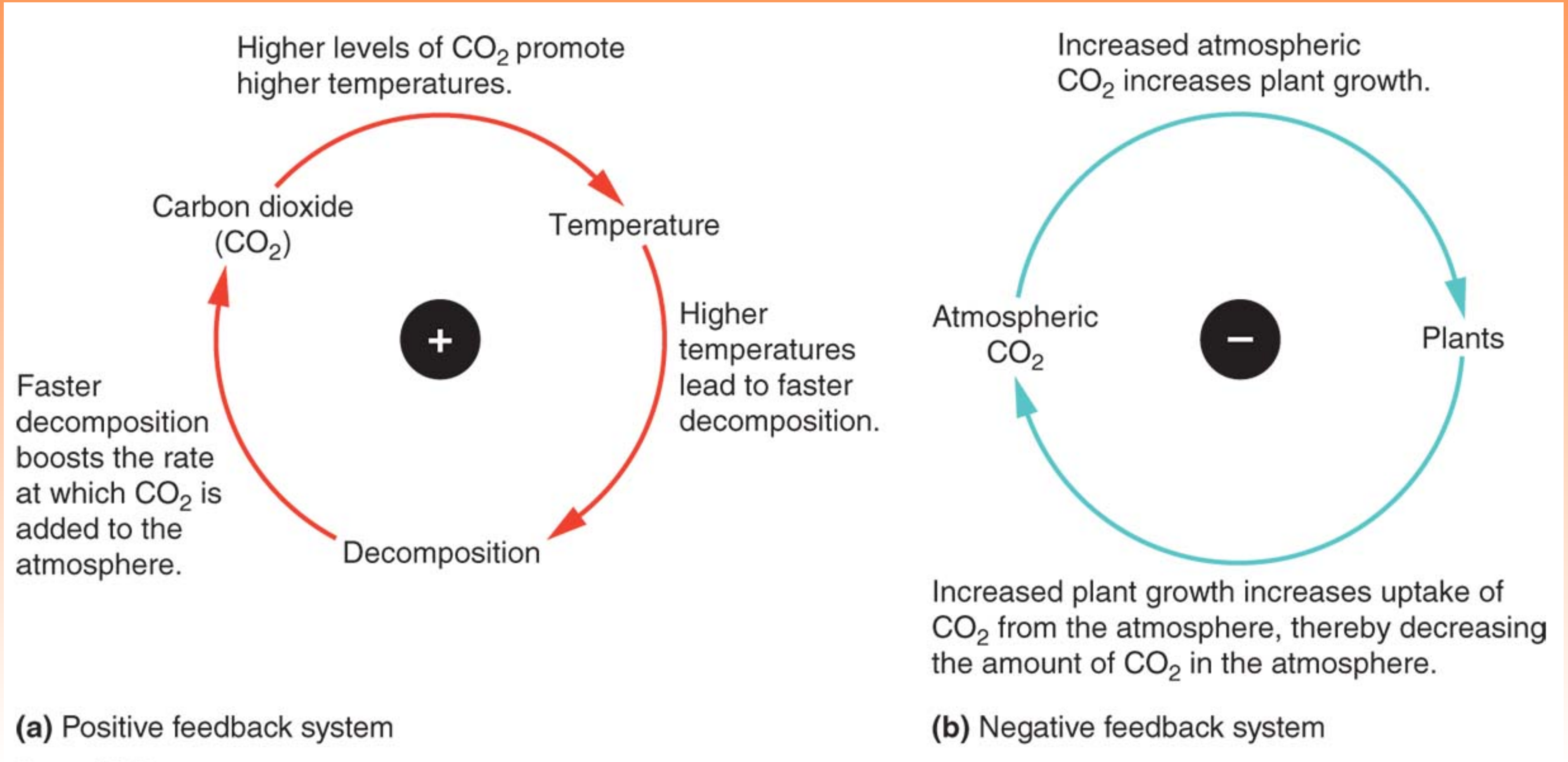


Climate Models and the Prediction of Future Global Temperatures

Predicted increase in global temperatures by 2100.
The predictions depend on whether we expect (a) low, (b) moderate, or (c) high increases in how much CO_2 the world emits during the current century. These changes in temperature are relative to the mean temperatures from 1961 to 1990.



Feedbacks can increase or decrease the impact of climate change

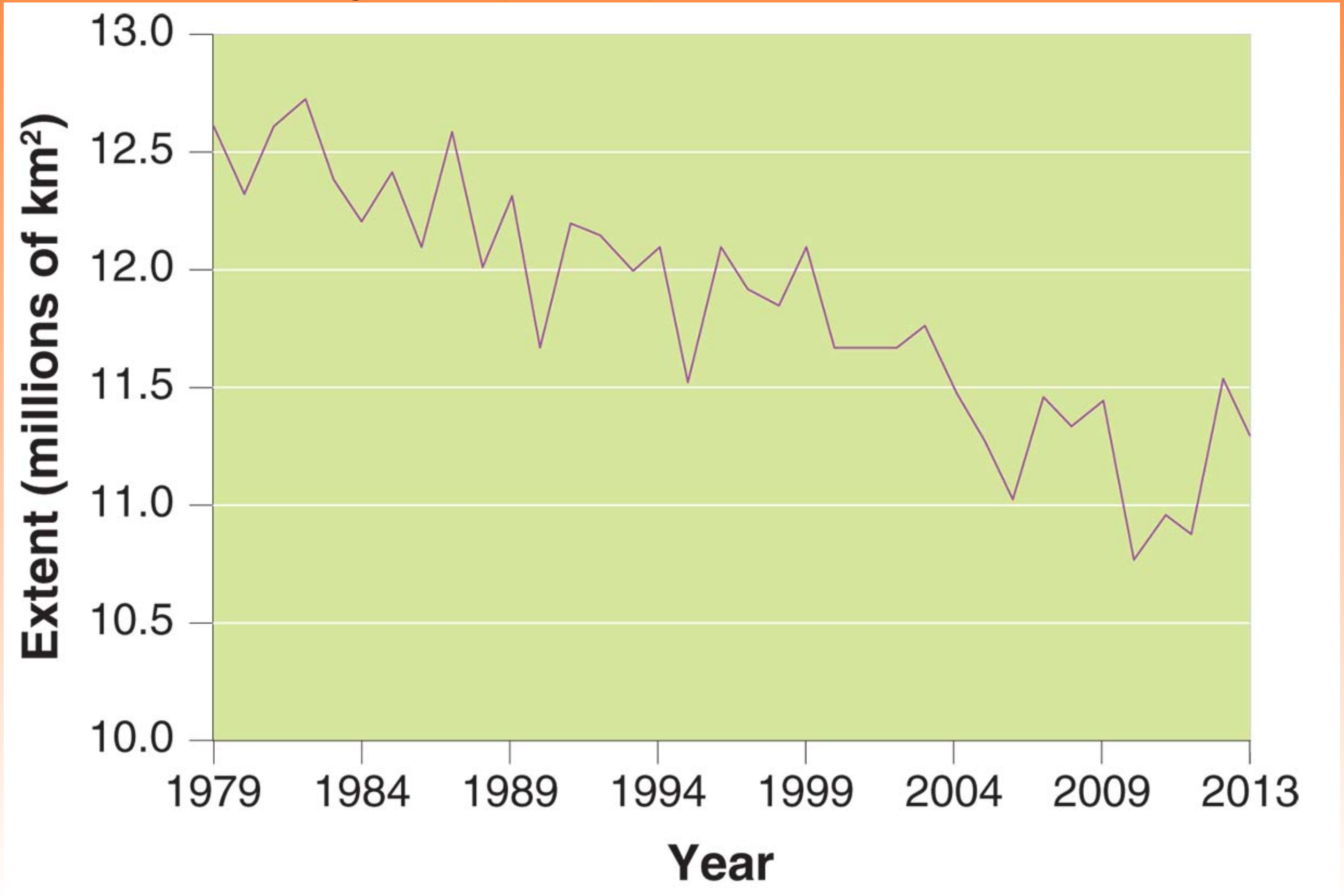


Global climate change is already affecting the environment:

- Melting of polar ice caps, Greenland and Antarctica
- Melting of many glaciers around the world
- Melting of permafrost
- Rising of sea levels due to the melting of glaciers and ice sheets and as water warms it expands
- Heat waves
- Cold spells
- Change in precipitation patterns
- Increase in storm intensity
- Shift in ocean currents

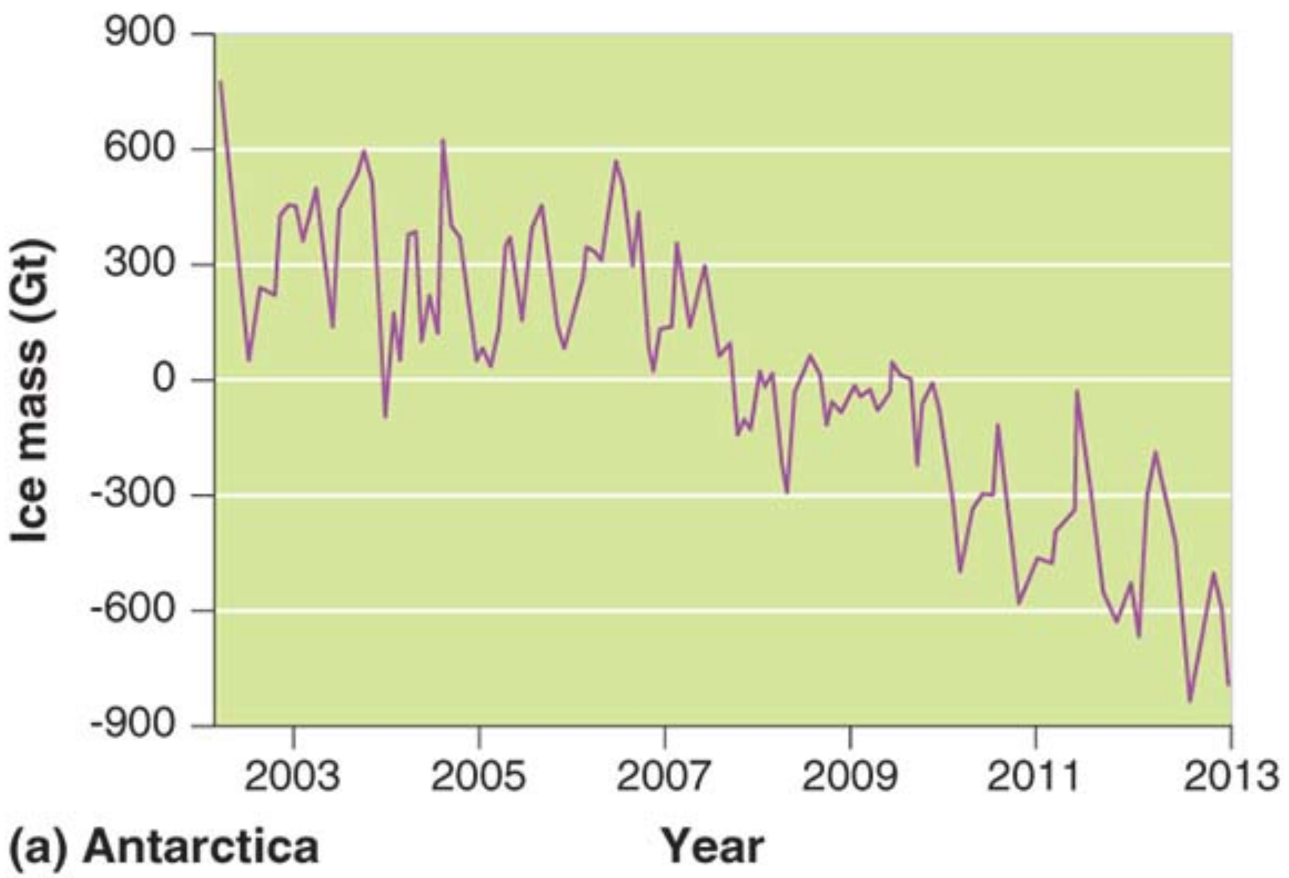
The Effects of Global Climate Change

The melting polar ice cap. Because northern latitudes have experienced the greatest amoun of global warming, the extent of the ice cap near the North Pole has been declining over the past 3 decades. The polar ice cap reaches its minimum late in the summer of each year, so we can look for a trend by examining the extent of ice each September. From 1979 to 2013, the polar ice declined an average of 14 percent per decade.

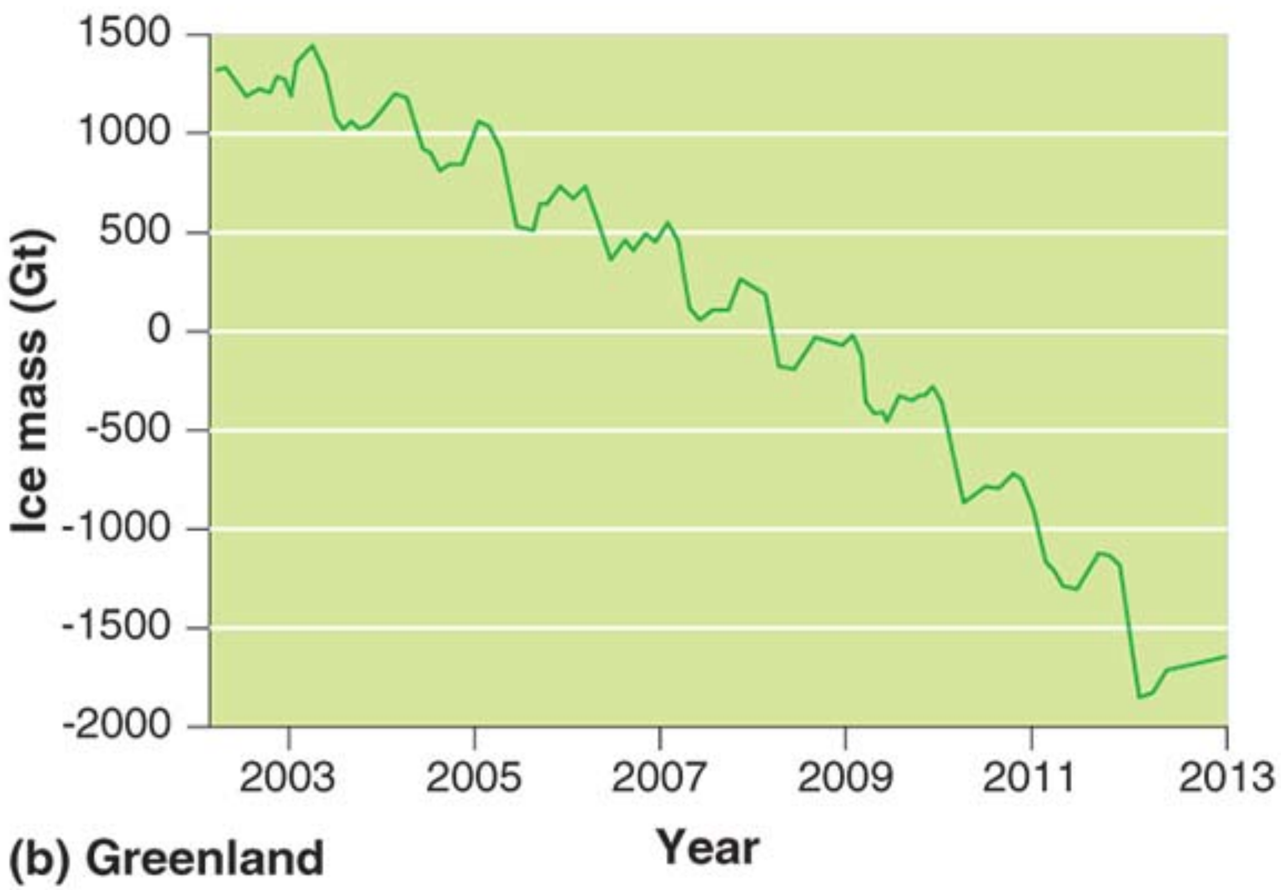


The Effects of Global Climate Change

Declining ice in Antarctica and Greenland. Measurements of ice mass from 2002 to 2013 have detected decline in both (a) Antarctica and (b) Greenland.



(a) Antarctica



(b) Greenland

Global climate change is already affecting organisms

- Wild plants and animals can be affected. The growing season for plants has changed (in part due to changes in precipitation patterns) and animals have the potential to be harmed if they can't move to more appropriate climates.

- Humans may have to relocate, some diseases like those carried by mosquitoes could increase and there could be economic consequences.

- Corals are particularly sensitive to global warming because their rand of temperature tolerance is quite small.

Assessing Uncertainty

TABLE 64.1 The 2007 assessment of global change by the Intergovernmental Panel on Climate Change (IPCC)

The scientists considered the likelihood that specific changes have occurred, the likelihood that humans contributed to the change, and the likelihood that current trends will continue.

Definitions: More likely than not = more than 50% certain; Likely = more than 60% certain; Very likely = more than 90% certain; Virtually certain = more than 99% certain.

Phenomenon and direction of trend	Likelihood that trend occurred in the late 20th century (typically post-1960)	Likelihood of a human contribution to observed trend	Likelihood of future trends based on projections for 21st century from *Special Report on Emissions Scenarios*
Warmer and fewer cold days and nights over most land areas	Very Likely	Likely	Virtually Certain
Warmer and more frequent hot days and nights over most land areas	Very Likely	Likely (nights)	Virtually Certain
Warm spells/heat waves. Frequency increases over most land areas	Likely	More likely than not	Very Likely
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely	More likely than not	Very Likely
Area affected by drought increases	Likely in many regions since 1970	More likely than not	Likely
Intense tropical cyclone activity increases	Likely in many regions since 1970	More likely than not	Likely
Increased incidence of extreme high sea level (excludes tsunamis)	Likely	More likely than not	Likely

The Kyoto Protocol addresses climate change at the international level

- **Kyoto Protocol** An international agreement that sets a goal for global emissions of greenhouse gases from all industrialized countries to be reduced by 5.2 percent below their 1990 levels by 2012.
- Although the United States signed the original Kyoto Protocol, the U.S. Congress never ratified the agreement and the protocol has never been legally binding on the United States.
- In 2005 mayors from 141 U.S. cities and both major political parties gathered in San Francisco to organize their own efforts to reduce the causes and consequences of global warming.

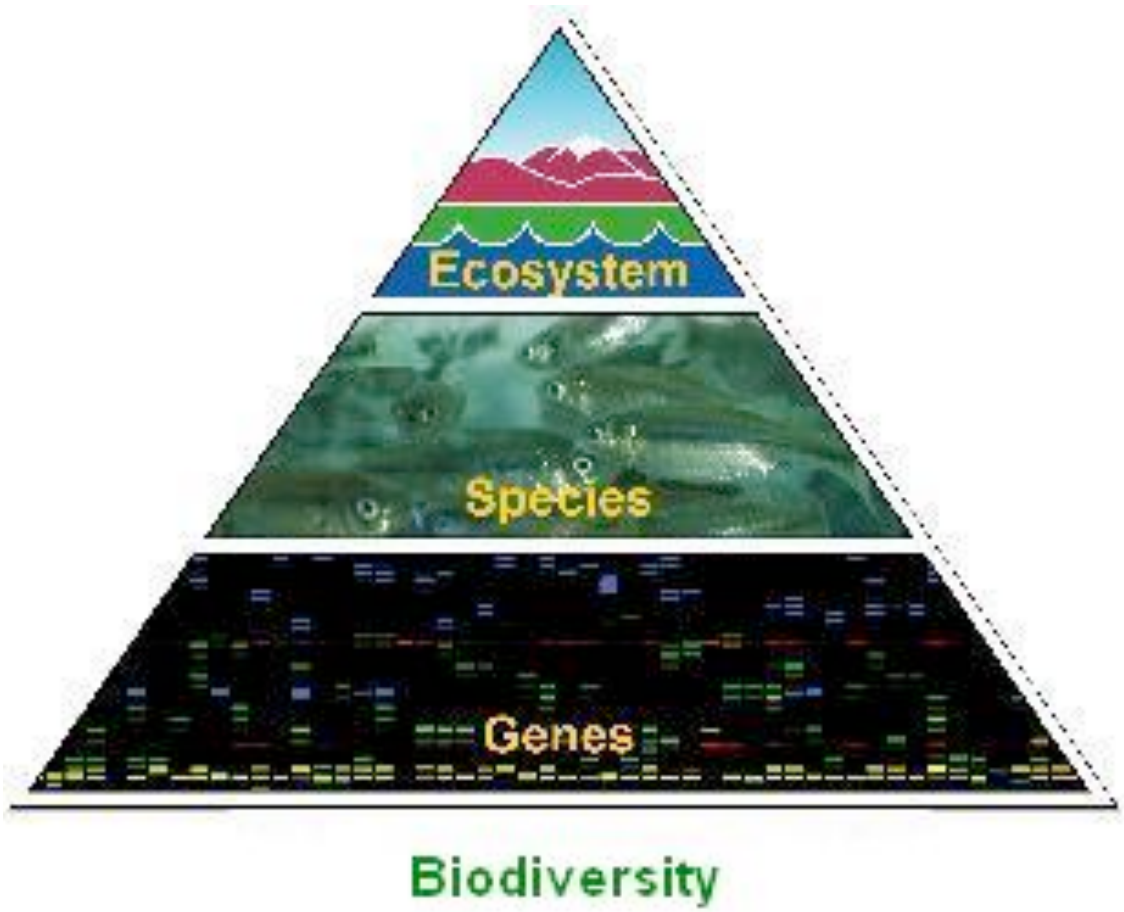
Carbon Sequestration

- **Carbon sequestration** An approach to stabilizing greenhouse gases by removing CO_2 from the atmosphere.
- Some methods include storing carbon in agricultural soils or retiring agricultural land and allowing it to become pasture or forest.
- Researchers are looking at cost-effective ways of capturing CO_2 from the air, from coal-burning power stations, and from other emission sources.
- This captured CO_2 would be compressed and pumped into abandoned oil wells or the deep ocean.

PREFACE

- Currently we have 1.8 million identified and named species. Estimates for additional species range from 10-100 million more.
- Most species are located in tropical forests. Unfortunately humans are destroying these forests at an alarming rate!
- Human activities are altering *trophic structures, energy flow, chemical cycling and natural disturbances*.
  - We have already physically alter half of all land surfaces and used half of all accessible fresh water.
  - Although extinction(s) are natural some estimate that the current rate of extinction today exceeds that of the Cretaceous Period (65 mya).
- **Conservation Biology** attempts to conserve biodiversity and sustain ecosystem services.

HUMAN ACTIVITIES THREATEN EARTH'S BIODIVERSITY

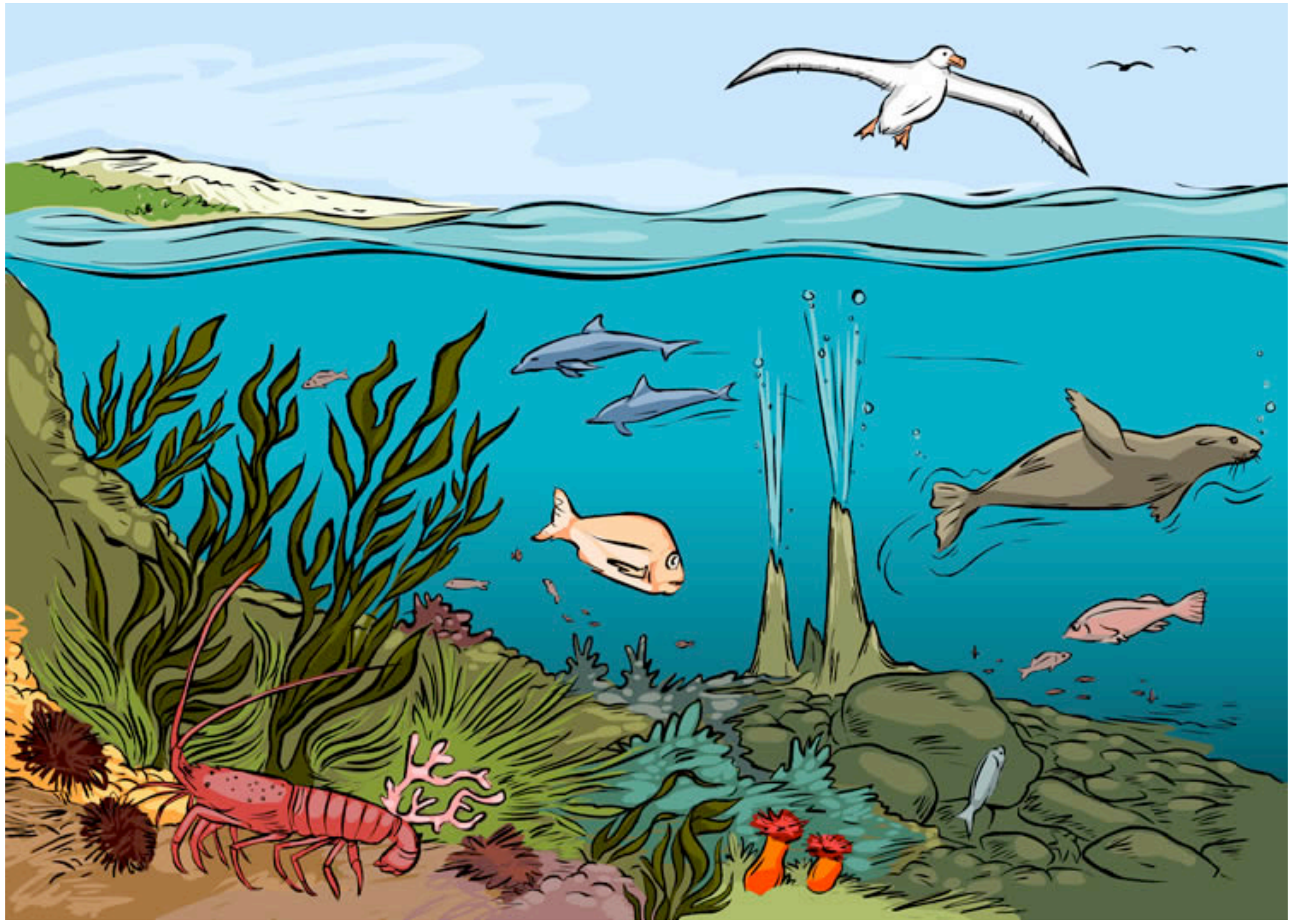


A. Three Levels of Biodiversity

- Genetic Diversity   Species Diversity   Ecosystem Diversity

Can you label each picture with the type of diversity it represents?

1.



2.

3.

1. Genetic Diversity

- Includes **genetic variation** *within* populations and *between* populations.
  - ***The erosion of genetic diversity reduces the adaptive potential of the species!***

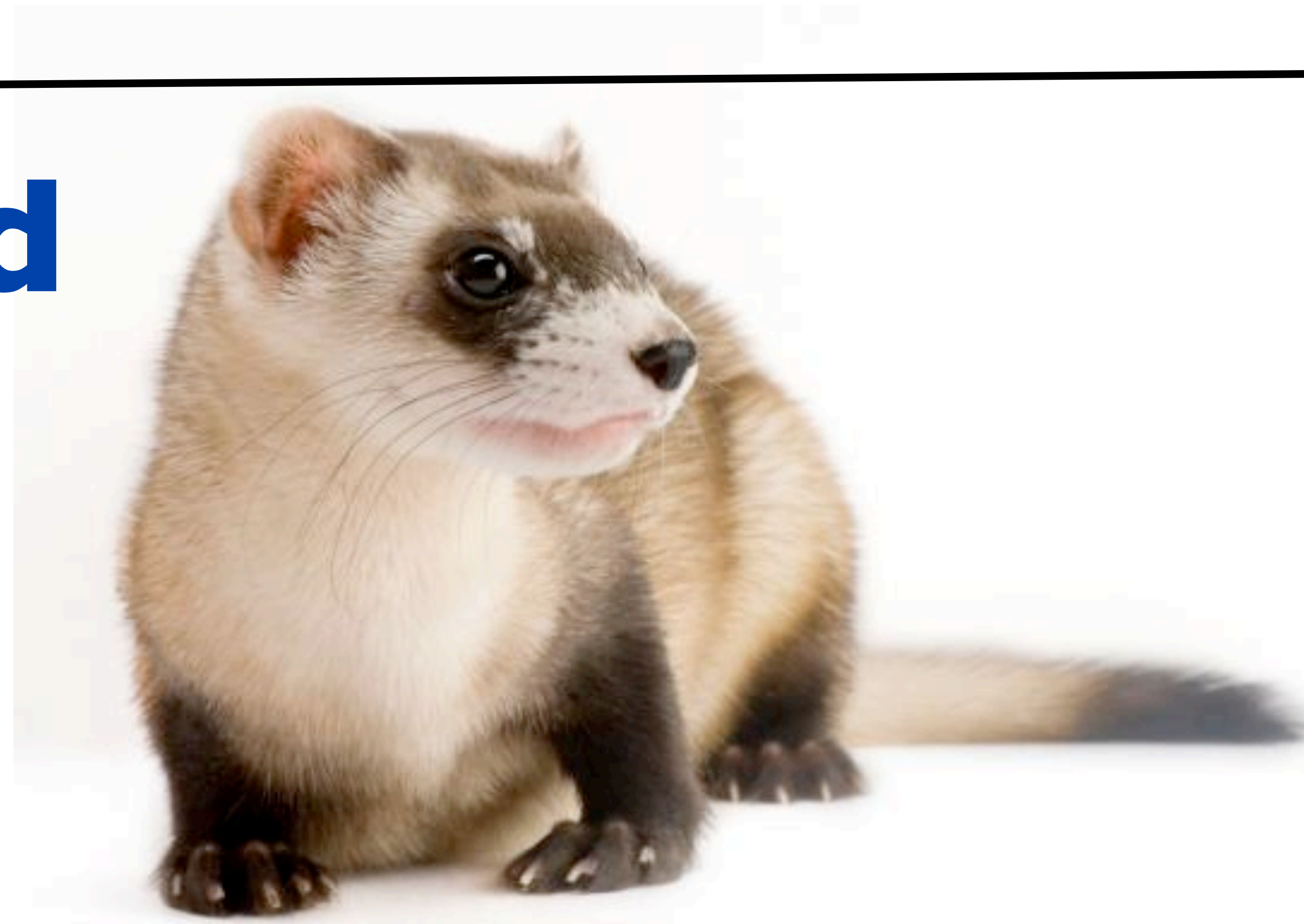
2. Species Diversity

- ***Endangered Species*** are at risk of going extinct.
- ***Threatened Species*** are likely to become endangered in the near future

- **12% of all birds are threatened**
- **21% of all mammals are threatened**
- **30% of all fish have gone extinct or are threatened (historical time)**
  - **123 fish have gone extinct since 1900 in North America alone**
- **32% of all amphibians are endangered and near extinction**

Other Cases of Organisms Endangered by low Genetic Diversity

Black Footed Ferrets



Once thought to be globally extinct, black-footed ferrets are making a comeback. Today, recovery efforts have helped restore the black-footed ferret population to nearly 300 animals across North America. Although great strides have been made to recover the black-footed ferret, habitat loss and disease remain key threats to this highly endangered species.

3. Ecosystem Diversity

- The extinction of one species can have a negative impact on the entire ecosystem.
  - Consider the impact of losing an important pollinator.
  - Consider the impact of lower ecosystem diversity in terms of available niches.

- **Over 50% of all North American wetlands have been lost since European colonization**
- **90% of all stream side ecosystems have been negatively effected**
- **7 million square kilometers of Tropical Rainforests are gone (initially 16 million existed)**
- **Only 3% of Tall Grass Prairies remain in N. America**

B. Biodiversity & Human Welfare

- Their are religious, moral, aesthetic and philosophical arguments to maintain biodiversity.
  - Centered in these beliefs is a theme that other species are entitled to life.
- Additional arguments include a list of practical benefits.

1. Benefits of Diversity

- Biodiversity is a crucial natural resource.
  - Foods, Fibers and Medicines.
- Biodiversity also provides many important ecosystem services.
  - Purify our air and water, detoxify wastes, pollinate crops, produce soil, control pests, reduce impact of extreme weather

1. Benefits of Diversity

- FOOD: diversity improves crop quality and disease resistance.
- FIBERS: some plants have fibers that are used in a variety of human products that include our clothes.
- MEDICINE: Over 25% of all pharmaceuticals are plant derived.
  - A tropical plant *Cephaelis Ipecacuanha* contains a drug called *emetine* which was developed *Ipecac. Ipecac* has long been used to induce vomiting

2. Ecosystem Services

- Ecosystem Services- all processes through which ecosystems help sustain human life.
- It is difficult to put a monetary value on these services. It is likely that they are often undervalued.
- In 1997 an Ecologist, Robert Constanza attempted to estimate the value of these global services. His estimate was 33 Trillion dollars!
  - Recall examples: Purify our air and water, detoxify wastes, pollinate crops, produce soil, control pests, reduce impact of extreme weather.
- Their is growing evidence that an ecosystems ability to perform these functions is linked to its biodiversity.