Chapter 56 (Campbell)
Conservation Biology & Global Changes

(56) Conservation Ecology

I.

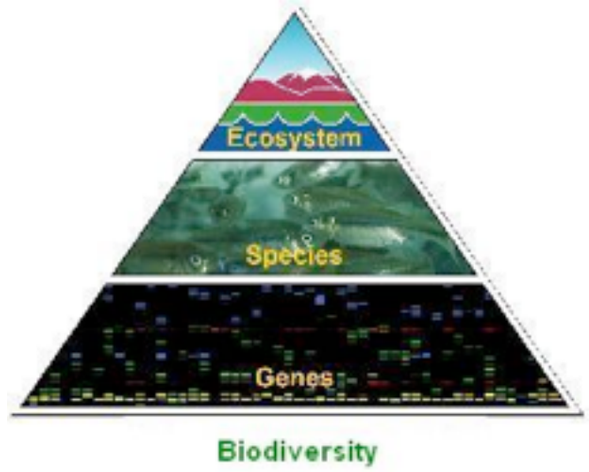
Main Idea: Humans benefit directly and indirectly from biodiversity.

Main Idea: Unfortunately human activities are decreasing biodiversity.

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



Biodiversity

A. Three Levels of Biodiversity

- Genetic Diversity Species Diversity Ecosystem Diversity

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**

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

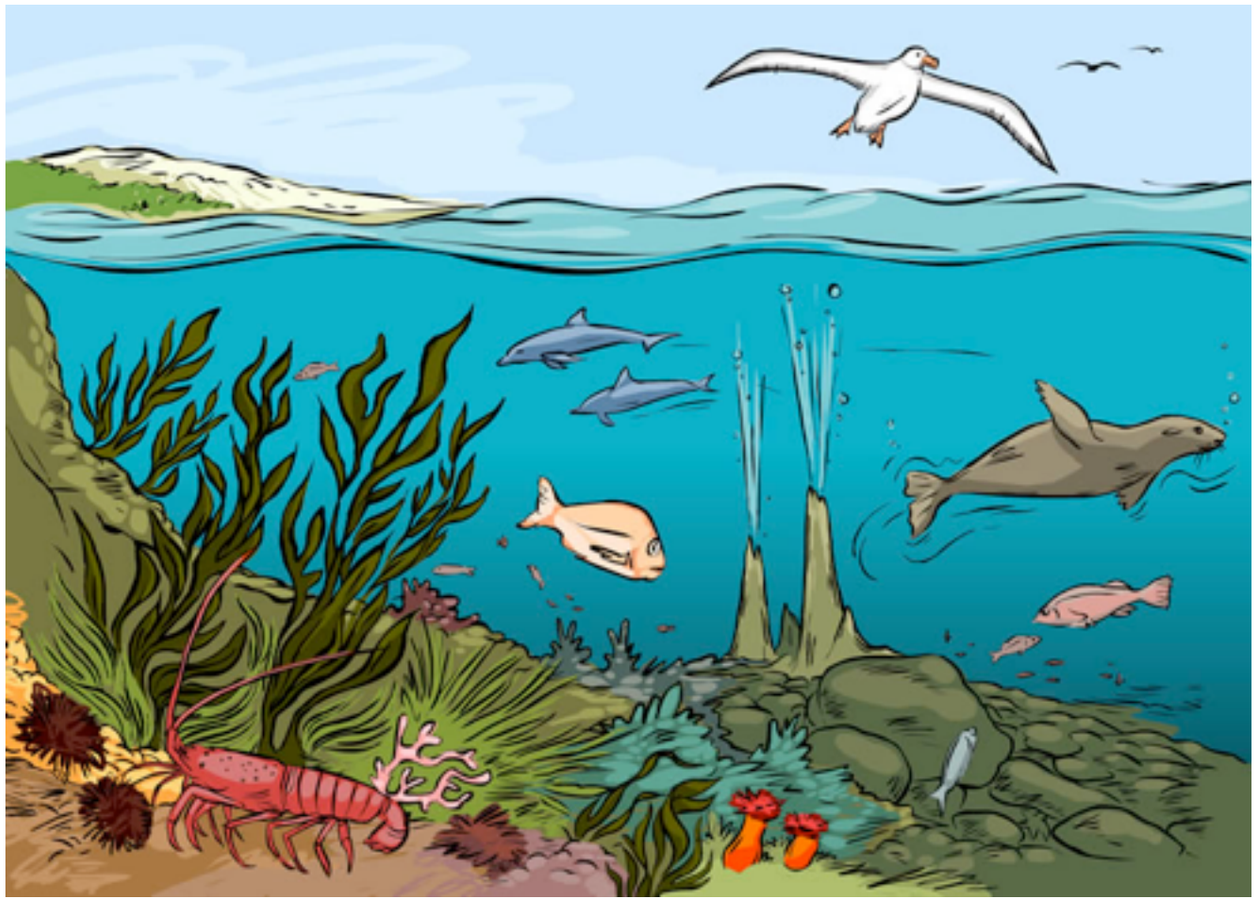
- Their are religious, moral, aesthetic and philosophical arguments to maintain biodiversity.
  - Centered in these beliefs is a theme that other species are entitled to life.
- Additional arguments include a list of practical benefits.

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

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

1.

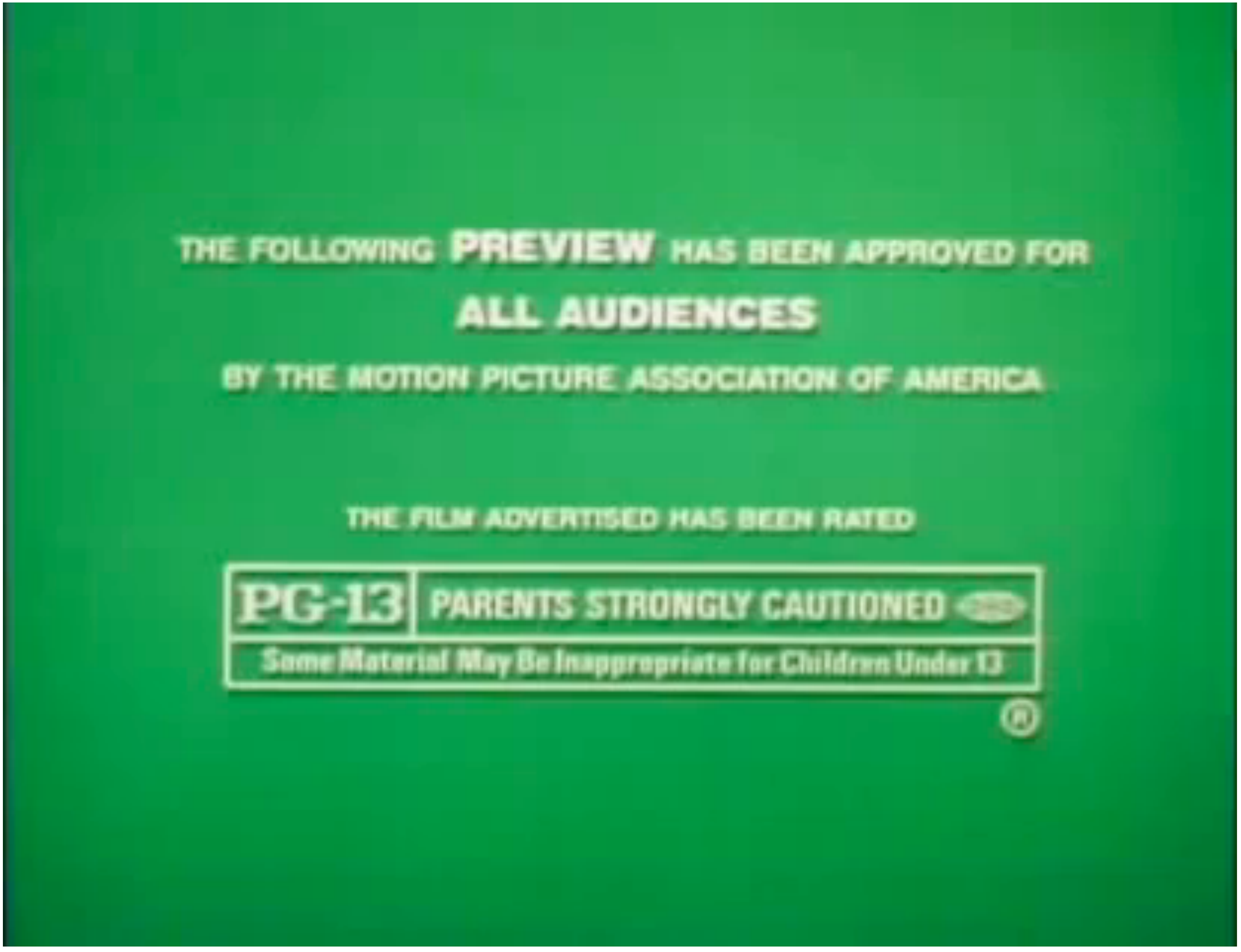


2.

3.

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


THE FOLLOWING PREVIEW HAS BEEN APPROVED FOR
ALL AUDIENCES
BY THE MOTION PICTURE ASSOCIATION OF AMERICA
THE FILM ADVERTISED HAS BEEN RATED
PG-13
PARENTS STRONGLY CAUTIONED
Some Material May Be Inappropriate for Children Under 13

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.

C. Threats to Biodiversity

- Humans are the main causal agent of biodiversity loss.
- There are 4 major threats to biodiversity.
  - Habitat Loss, Invasive Species, Overharvesting & Global Change.

1. Habitat Loss

- Human alteration of habitats is the single greatest threat to habitat loss.
  - Agriculture, Urban Development, Forestry, Mining and Pollution.
- Habitat loss often results in extinction.

1. 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.**

2. Invasive Species

- Non-native species moved intentionally or accidentally in new geographic areas.
  - Free from predators, pathogens and parasites their populations grow rapidly and disrupt community interactions.

2. 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

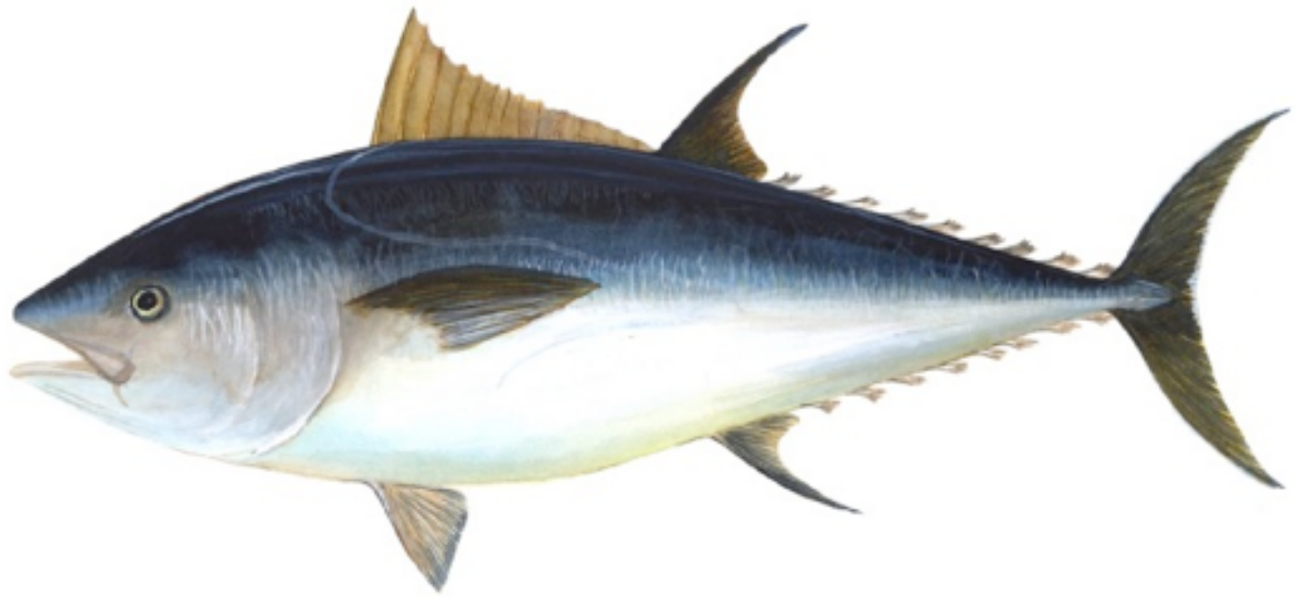
3. Overharvesting

- 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]

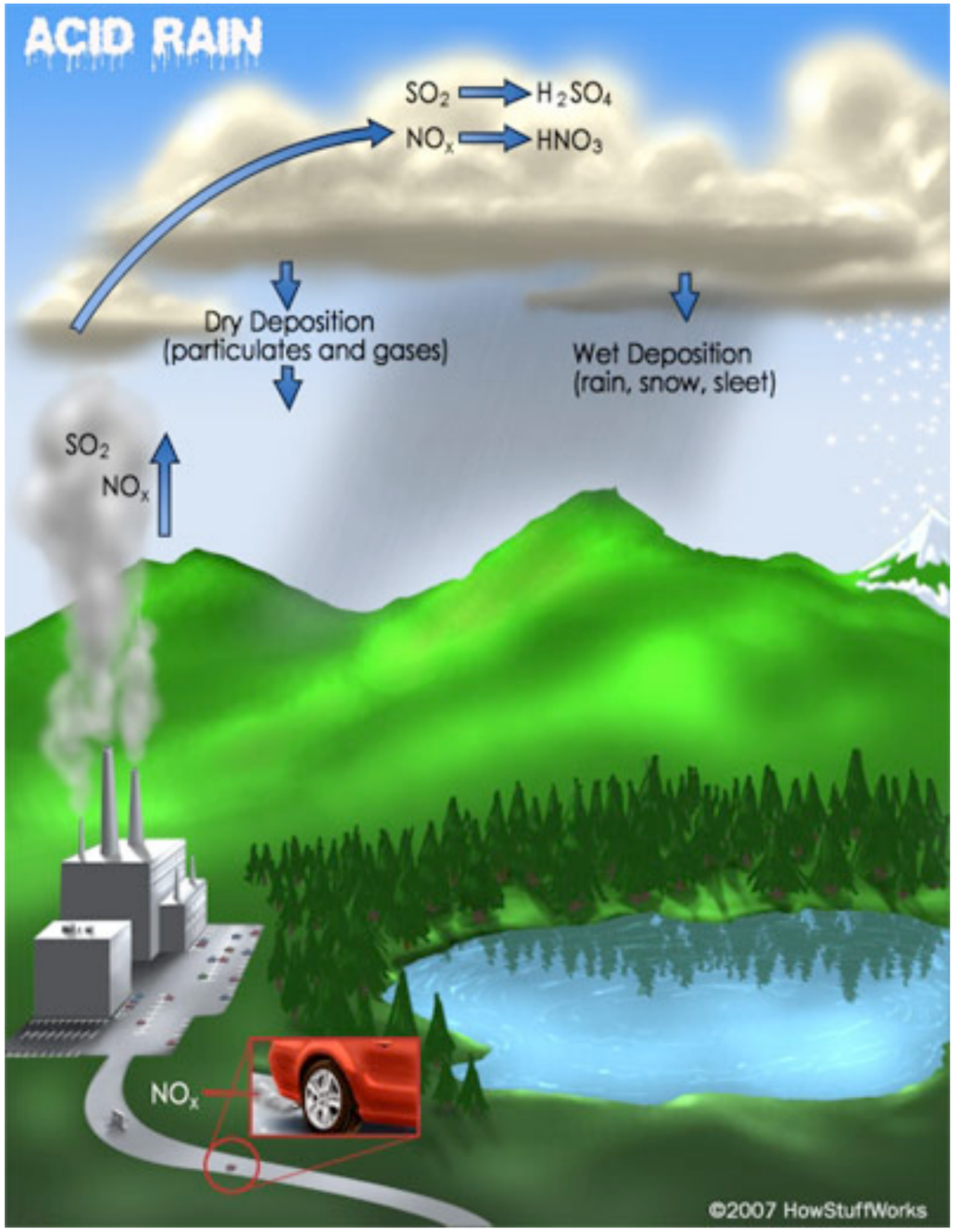
3. Overharvesting (over fishing)

- 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%



4. 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
$SO_2 \rightarrow H_2SO_4$
$NO_x \rightarrow HNO_3$
Dry Deposition
(particulates and gases)
Wet Deposition
(rain, snow, sleet)
SO_2
NO_x
NO_x
©2007 HowStuffWorks

(56) Conservation Ecology

II.

Main Idea: Small populations have low diversity and as a result are more vulnerable.

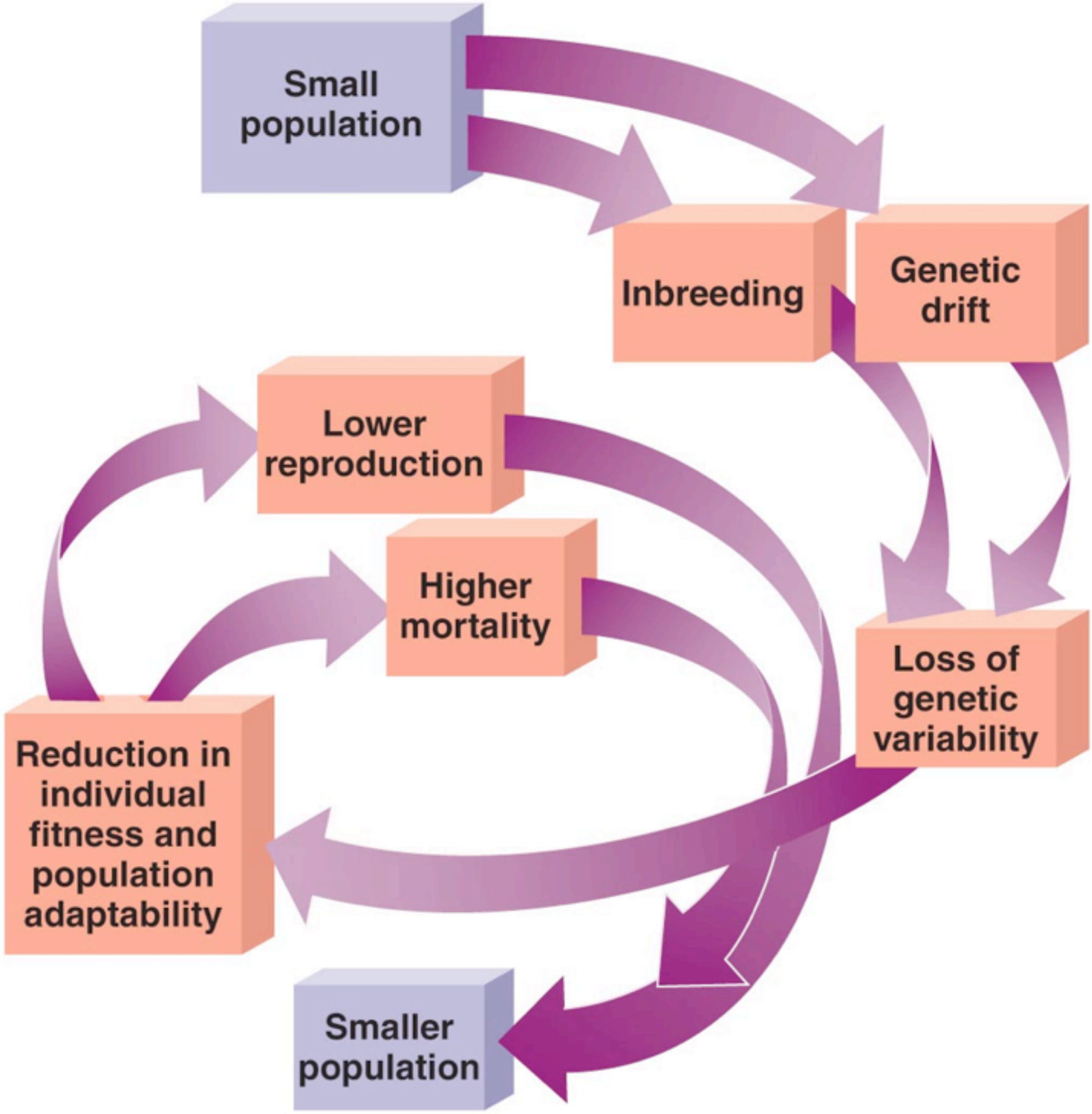
POPULATION CONSERVATION FOCUSES ON POPULATION SIZE, GENETIC DIVERSITY AND CRITICAL HABITAT

A. Small Population Approach

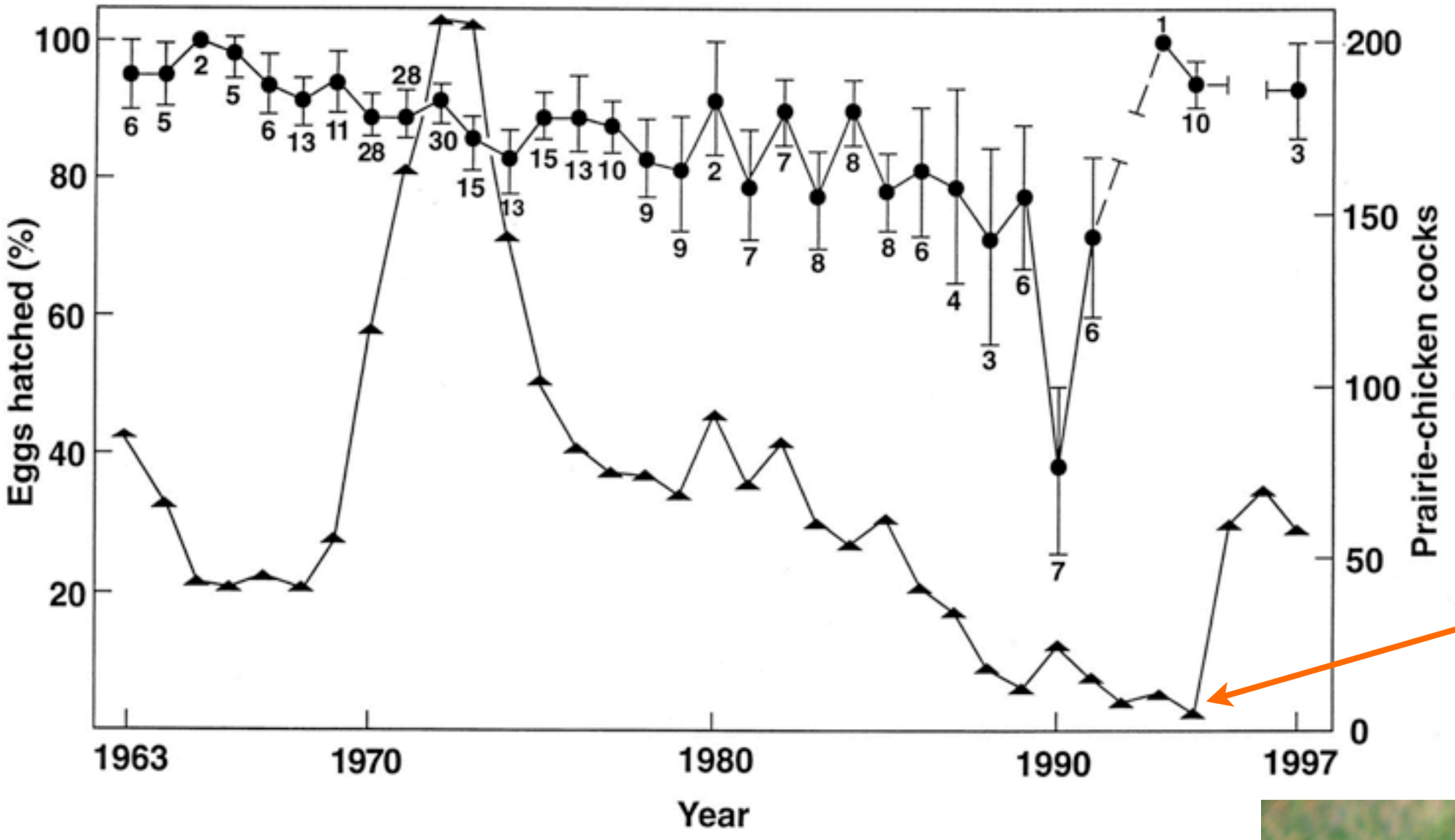
- Particularly vulnerable to over harvesting and habitat loss
- study processes that cause extinctions of small populations

1. The Extinction Vortex: Evolution Implications

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



2. Case Study: Greater Prairie Chicken



Transfusion of genetic variability

Imported 271 birds from a larger population elsewhere

3. 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

4. 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?

How might the age of individuals in a population play a role?

**Read Case Study on Grizzly Bears if you get a chance*

B. Declining Population Approach

- Approach focuses on threatened and endangered populations that are showing a downward trend even though they are above their MVP.
- Small population approach emphasizes small populations themselves as ultimate cause of extinctions
- Declining population approach emphasizes environmental factors that caused the decline in the first place

1. The Extinction Vortex: Evolution Implications

1. Steps for Analysis and Intervention

- 1. Confirm decline 2. Study species 3. Find cause 4. Try solutions 5. Apply a solution

2. Case Study: Red-cockaded woodpecker

**Read Case Study if you get a chance*

C. Weighing Conflicting Demands

- Determining healthy population sizes and habitats is just the beginning.
- We must also weigh the species needs with conflicting demands
  - Consider the Yellowstone Wolf Debate. Where might ranchers, recreationists and conservationists fall on this issue?
- Although a large mammal lies at the heart of this conflict, habitat use is most always the key issue.
- Business profits are sometimes lessened to save species or habitats. Species and habitats are often destroyed for at the expense of products.
- Also need to consider the ecological role of the species and how it relates to the overall health of the community.

(56) Conservation Ecology

III.

Main Idea: The most recent conservation efforts realize the importance of habitats and community diversity.

Main Idea: To conserve individual species a broad conservation effort is also needed.

LANDSCAPE AND REGIONAL CONSERVATION HELP SUSTAIN BIODIVERSITY

A. Landscape Structure & Biodiversity

1. Fragmentation & Edges
2. Corridors that Connect Habitat Fragments

B. Establishing Protected Areas

1. Preserving Biodiversity Hot Spots
2. Philosophy of Nature Reserves
3. Zoned Reserves

**Give this section a quick read if you have the time/interest*

(56) Conservation Ecology

IV.

Main Idea: The earth's habitats and climate are changing.

Main Idea: The rate of change is greater than changes of the past.

Main Idea: Human actions are responsible for some of these changes and the rate at which they are occurring.

EARTH IS CHANGING RAPIDLY AS A RESULT OF HUMAN ACTIONS

A. 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.
  - Grasslands have a "free period" that lasts decades.
  - Tropical Rain Forests' "free period" is only a couple of years.
  - 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.*

Mississippi Water Shed

This animation illustrates how water flows from the middle of the United States down to the Mississippi River. Much of the nutrients, fertilizers and pollution that impact the health of the Mississippi River and Gulf of Mexico originate far up stream This sequence begins with a NASA satellite image of the United States. Then, the sequence highlights the Mississippi River. The sequence shows all the tributaries that feed into the Mississippi River. From there the animation expands to the whole drainage basin, everything between the Rockies and Appalachian Mountains drains through the Mississippi River. The concept of a watershed demonstrates how

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.

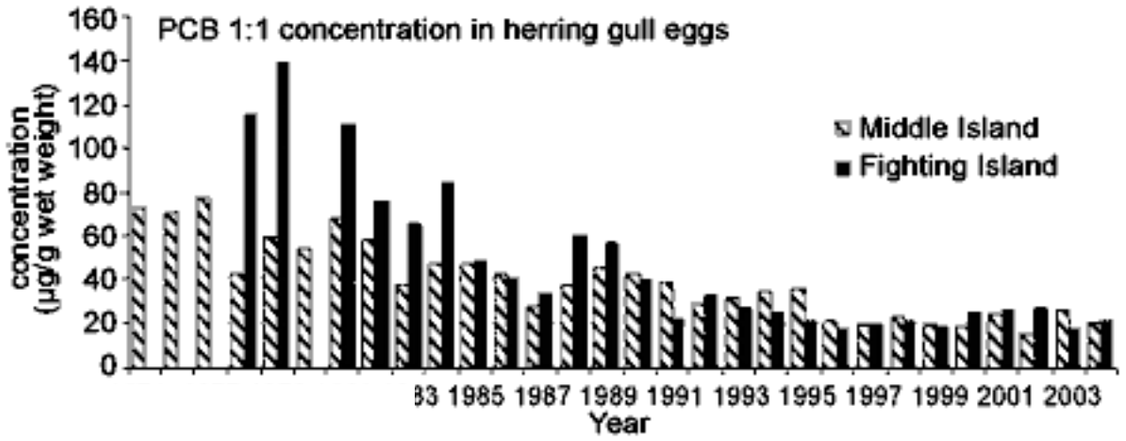
Mississippi Dead Zone

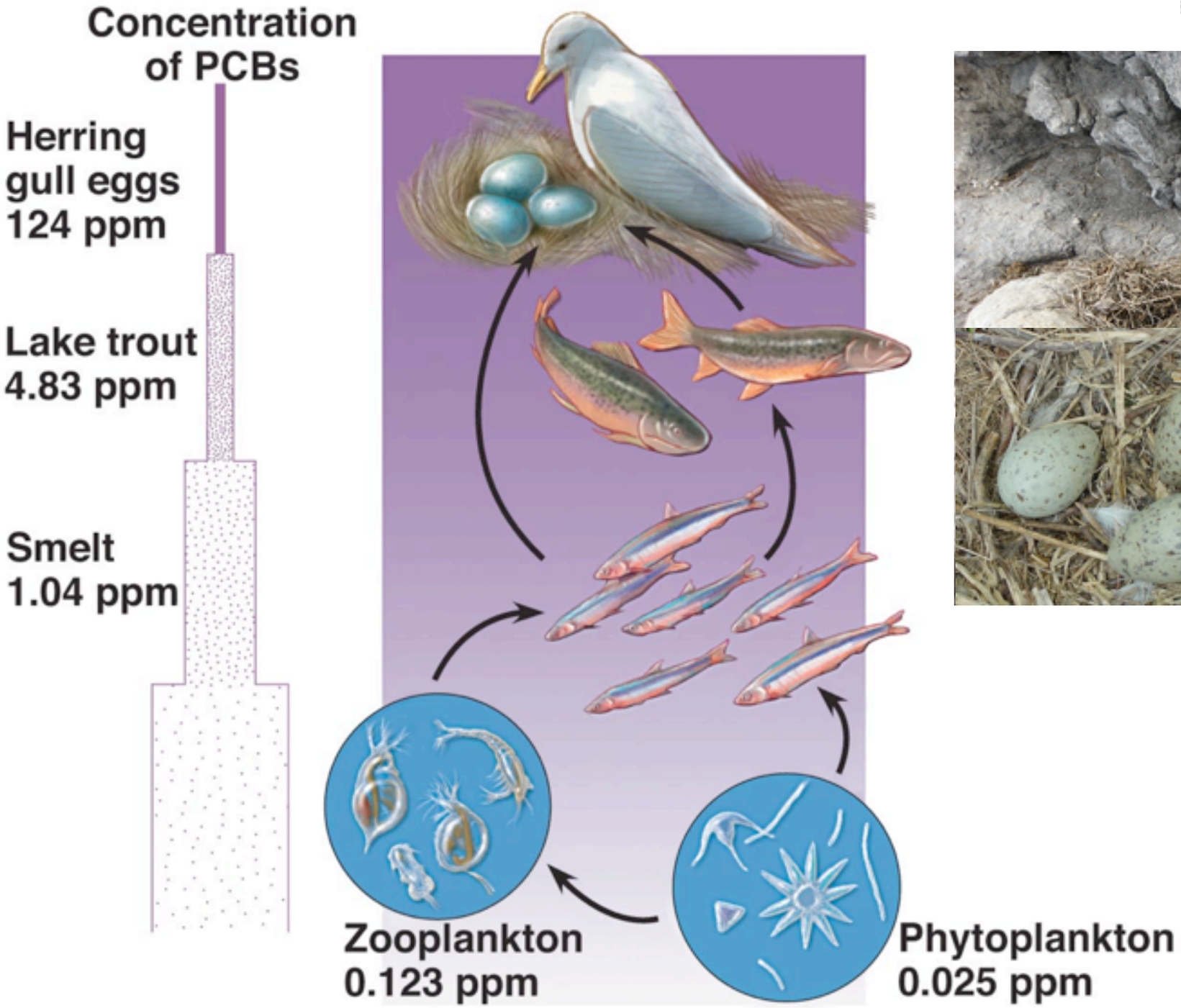
Recent reports indicate that the large region of low oxygen water often referred to as the 'Dead Zone' has spread across nearly 5,800 square miles of the Gulf of Mexico again in what appears to be an annual event. NASA satellites monitor the health of the oceans and spots the conditions that lead to 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

B. 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.
  - In fact some chemicals released are benign only to be later converted into toxic forms
    - Ex. Insoluble mercury dumped in waterways is converted by bacteria on the bottom into methyl mercury; water soluble and highly toxic compound.
- 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.
    - The industrial compound PCB's & the pesticide DDT

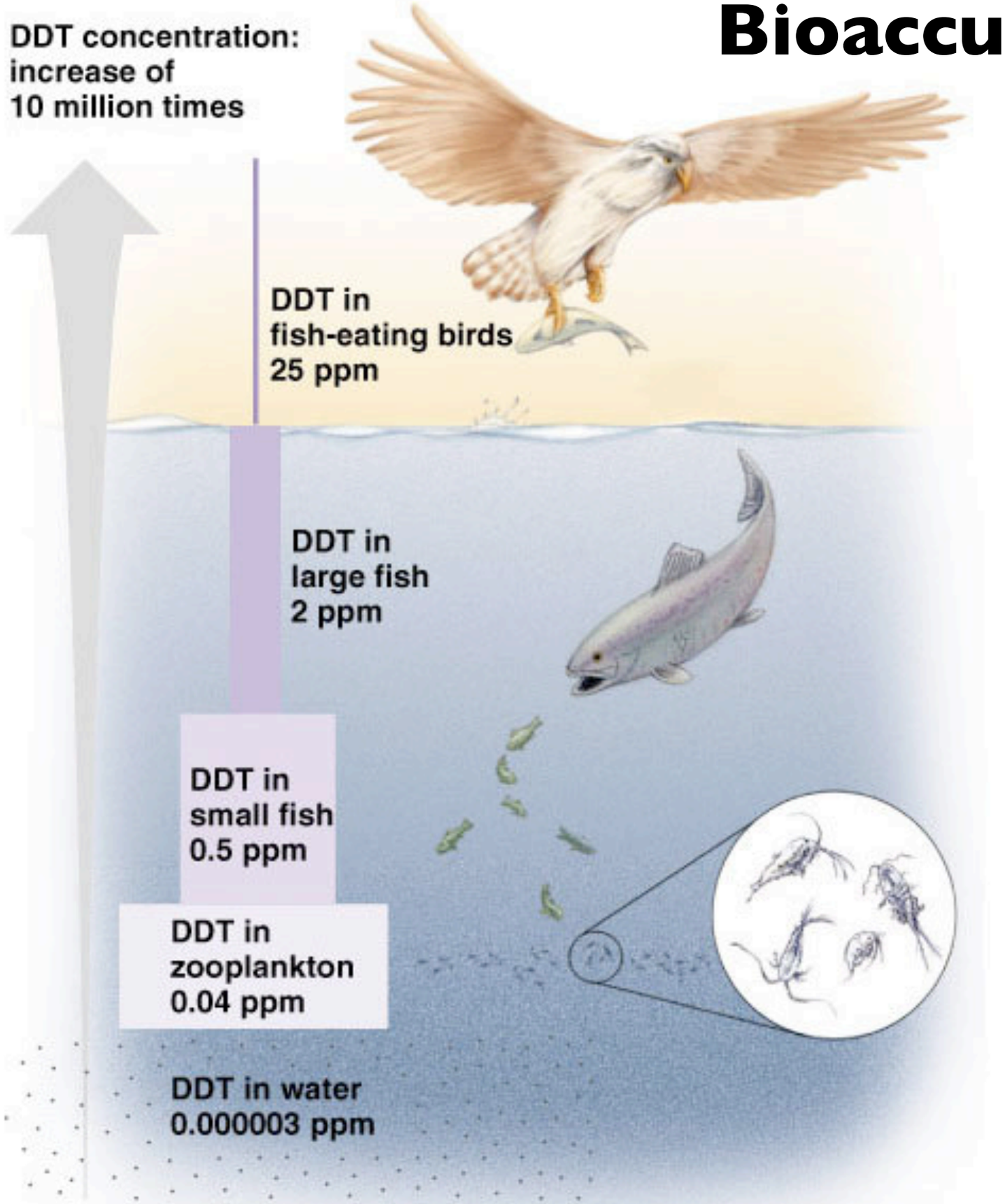
Bioaccumulation: PCB's





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.

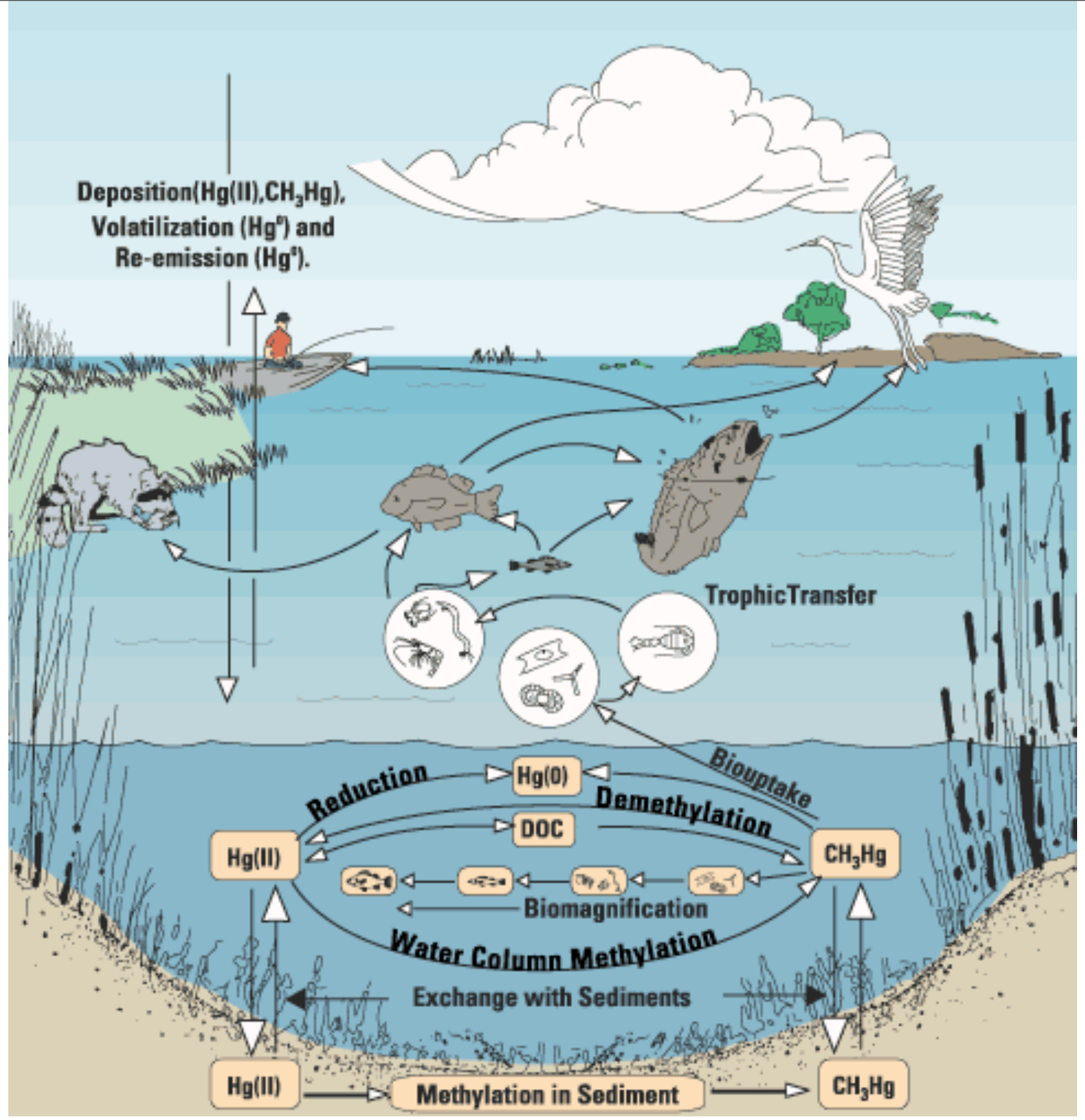
During and after World War II (1939–45), DDT became extremely popular among public health workers, farmers, and foresters. Peak production of the compound reached 386 million pounds (175 million kilograms) globally in 1970. Between 1950 and 1970, 22,204 tons (20,000 metric tons) of DDT was used annually 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.

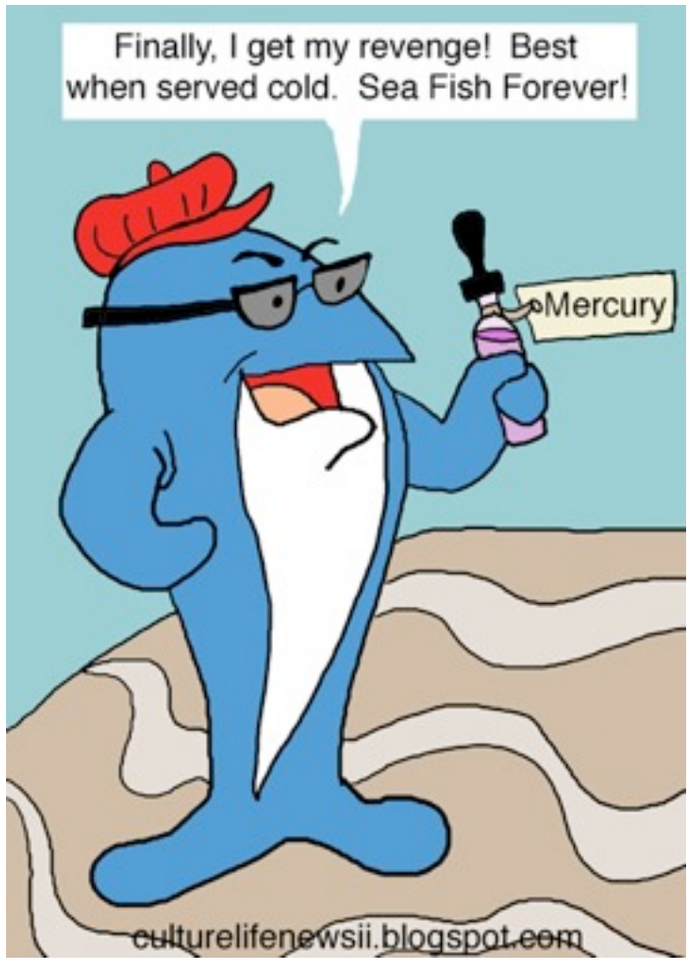
In December 2000, in a convention organized by the United Nations Environment Program, 122 nations agreed to a treaty banning twelve very toxic chemicals. Included among the twelve was DDT. However, the treaty allowed the use of DDT to combat malaria until other alternatives become available. Before 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?

Thursday, September 6, 2012



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:

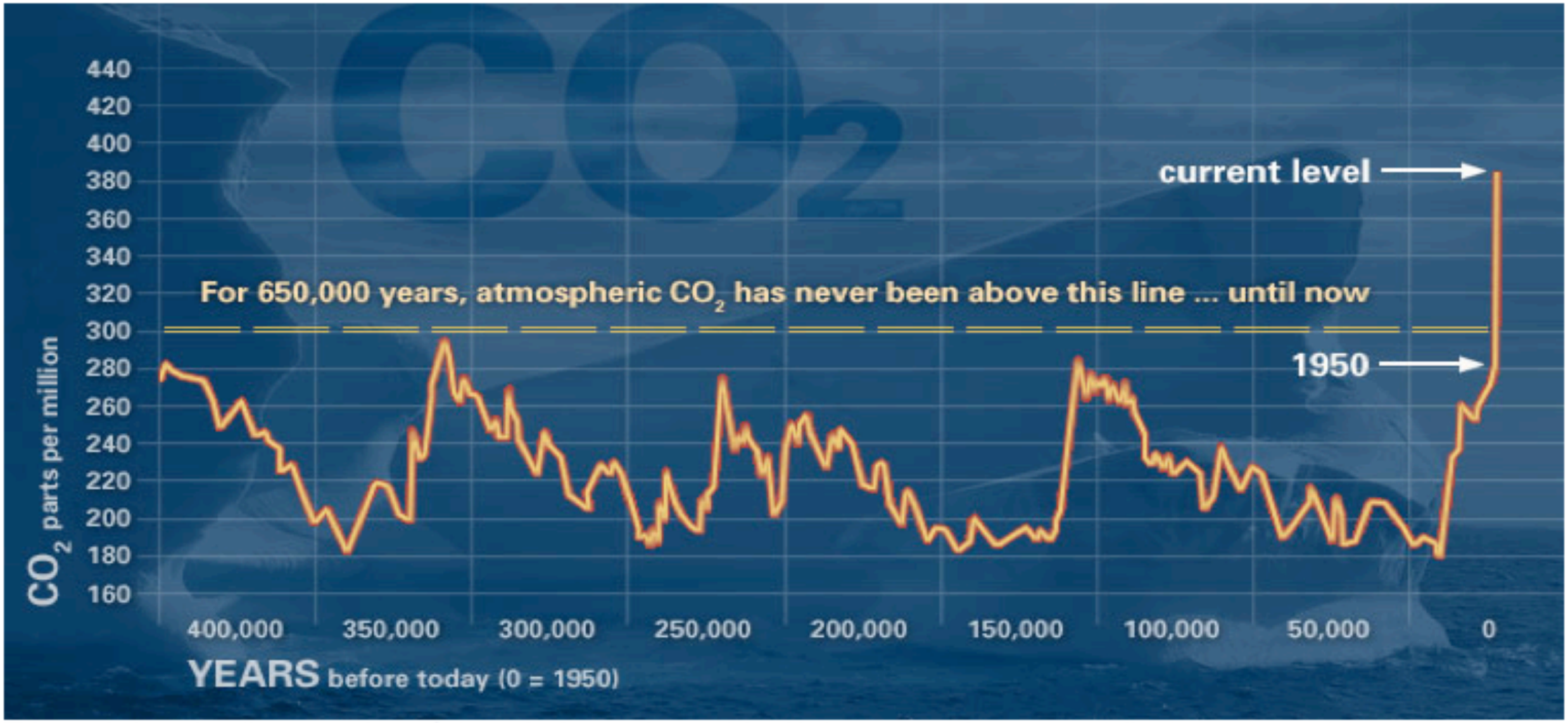


B. Greenhouse Gases & Global Warming

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?

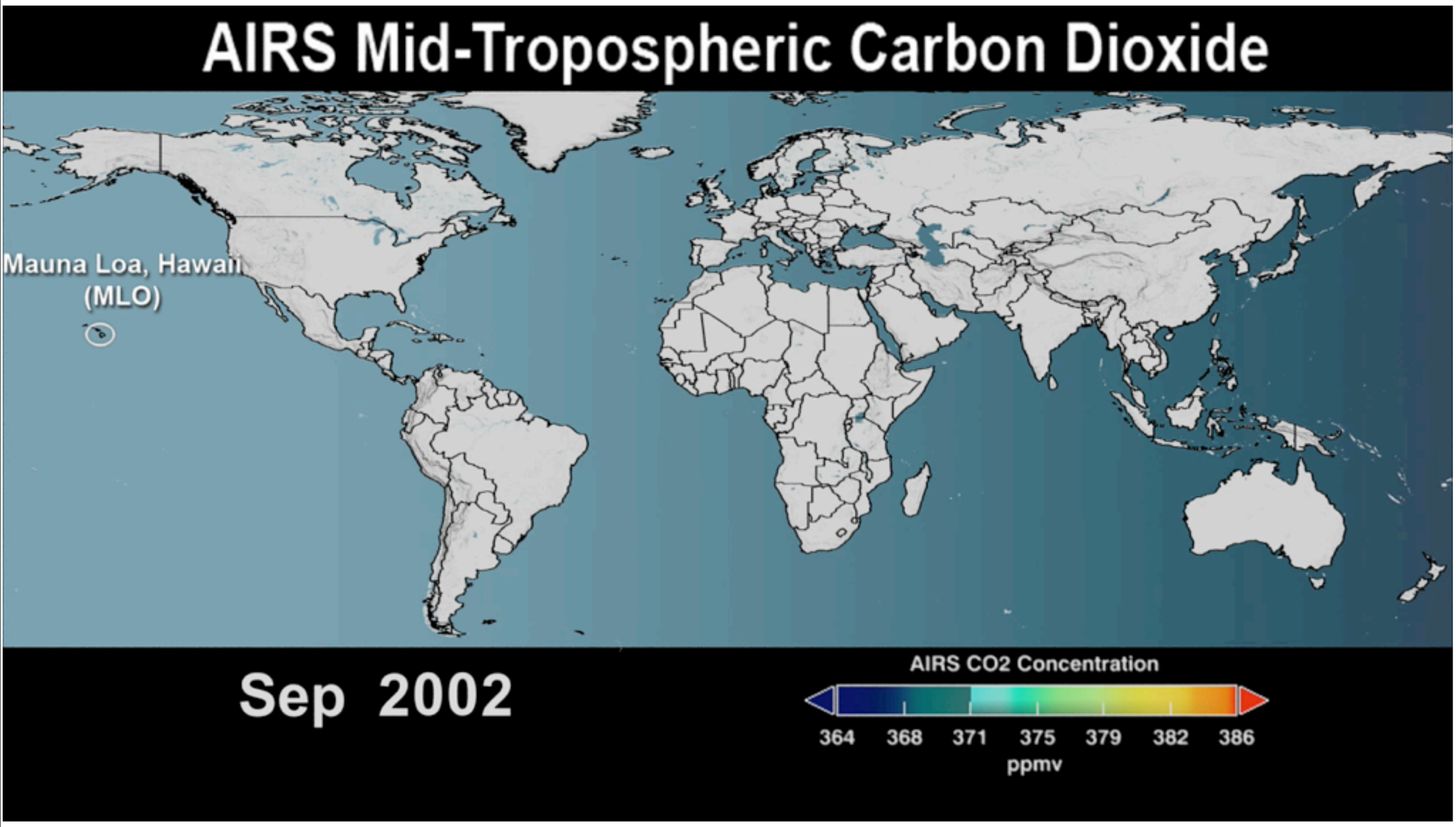


This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

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?

There are many predictable consequences of rising CO_2 levels.

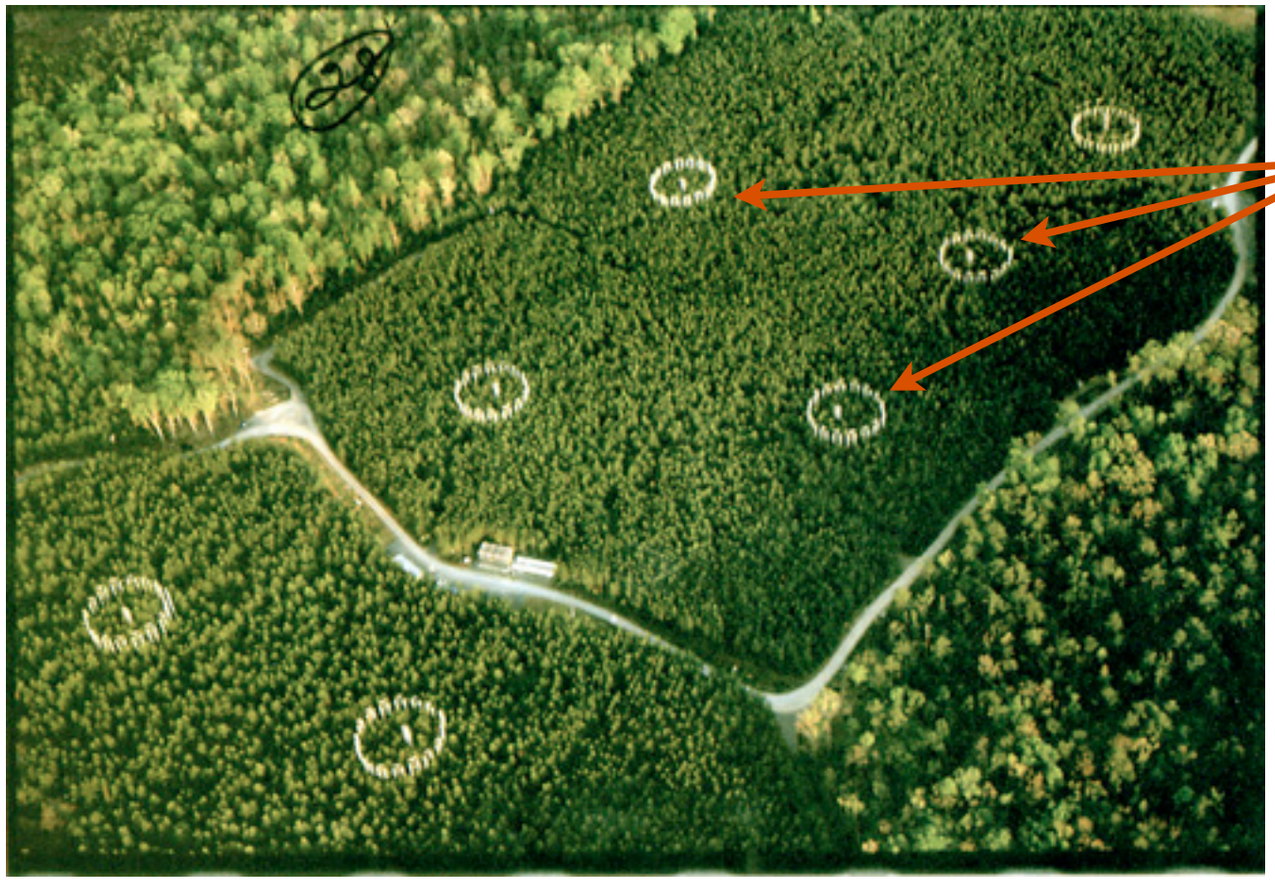
Here are a few...

- Spread of C_3 into regions where C_4 have been more well adapted.
  - Important when C_4 plant is a major food crop.

- Change in plant productivity and species composition.
  - see experiment below

2. The *FACTS-1* Experiment

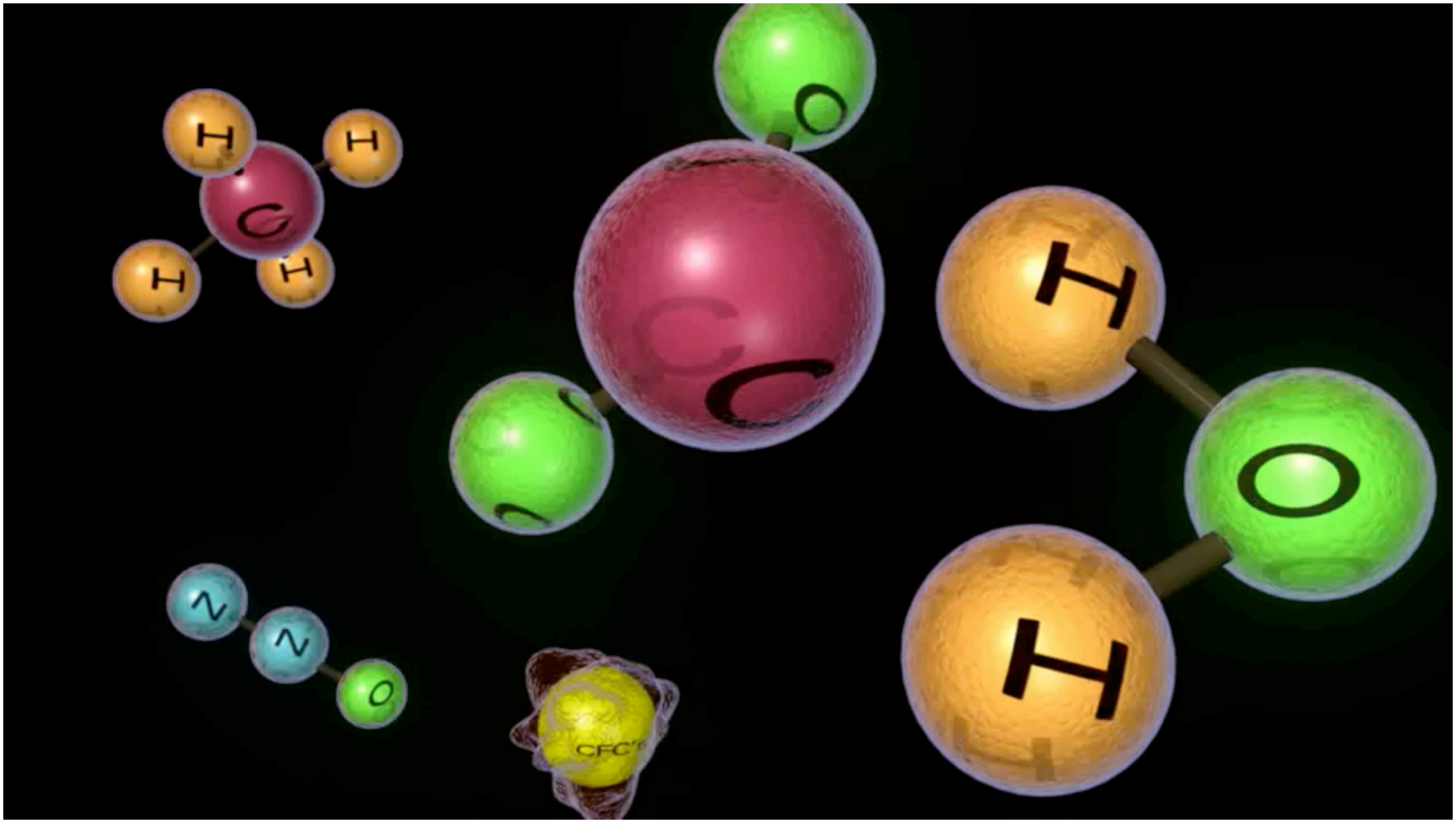
- Purpose: assess how rising CO_2 levels effect temperate forests
- Method:



- Results: after 12 years the experimental plots produced 15% more wood
  - an increase in production but far less than predicted

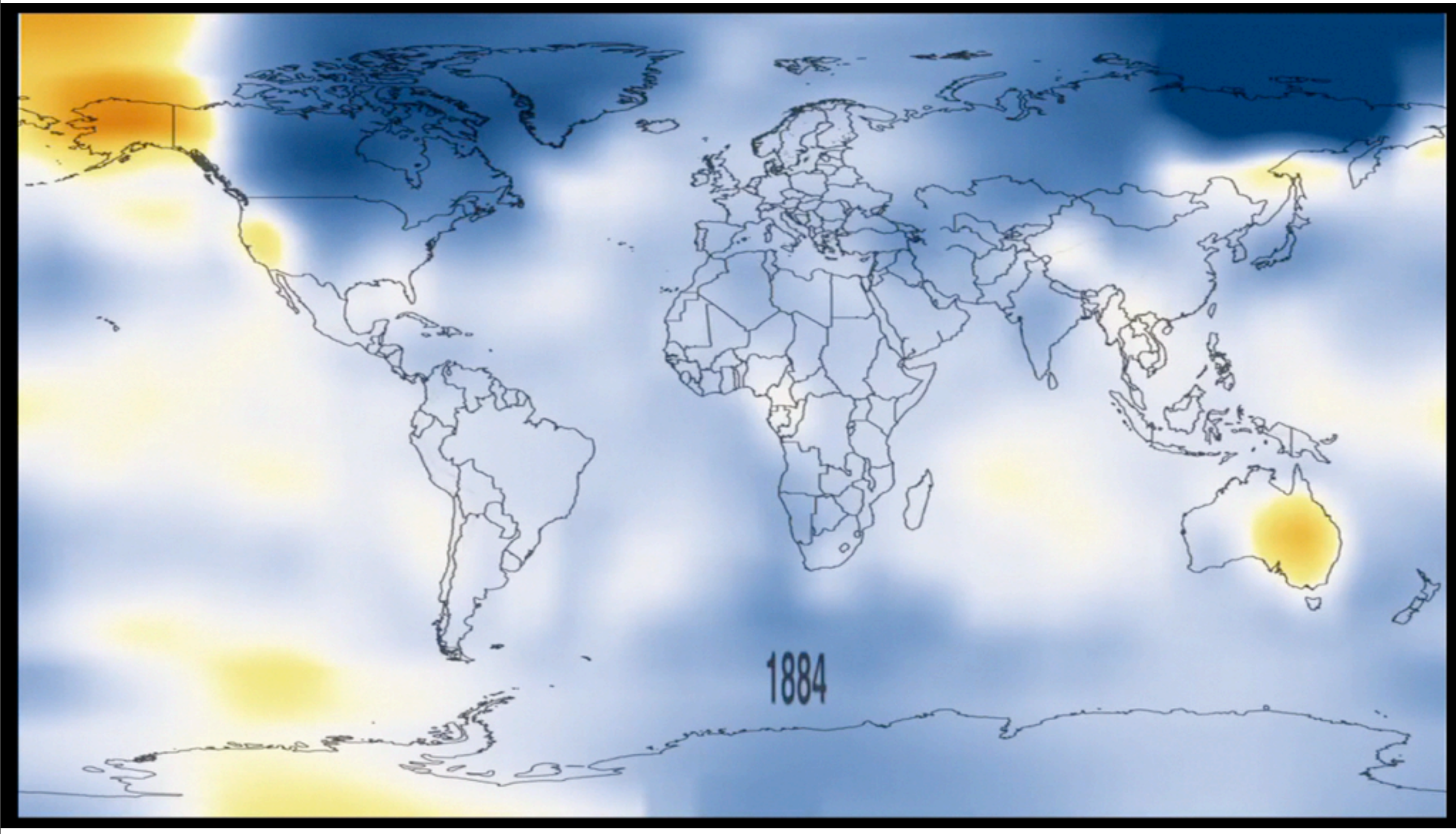
Rising CO_2 levels can have far more reaching effects including but not limited to global warming.

3. Greenhouse Effect & Climate



Methane, Nitrogen Oxides, CFC's, Carbon Dioxide, Water Vapor

Temperature Differences Over Time



A warming earth has many real and potential consequences...

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

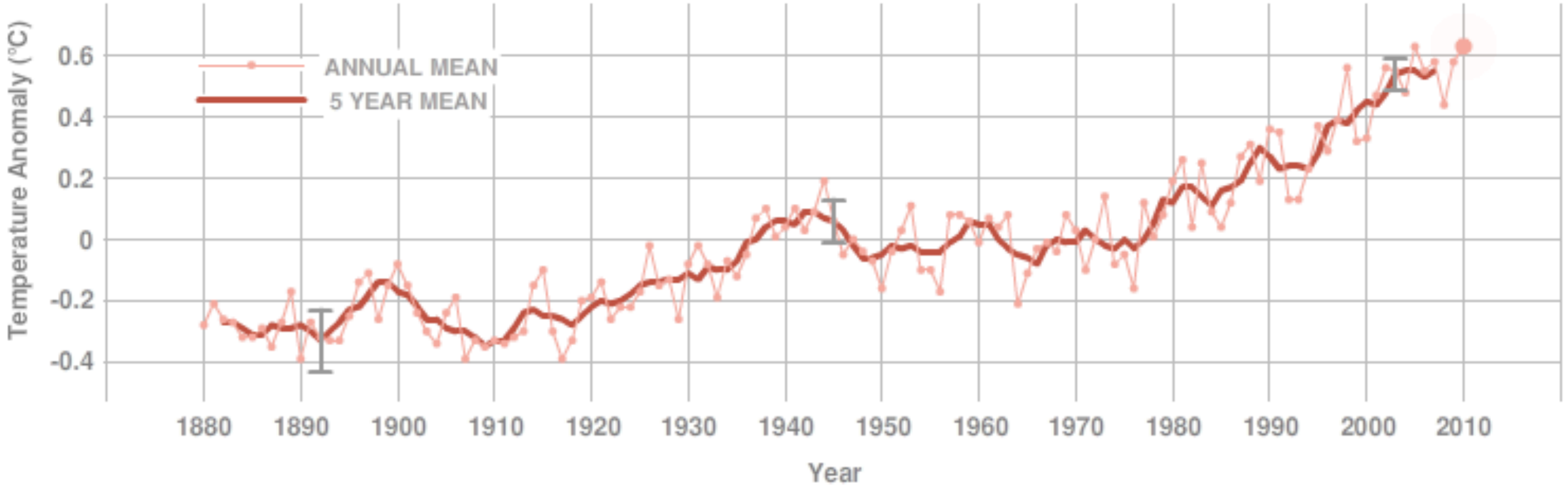
Global Surface Temperature

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

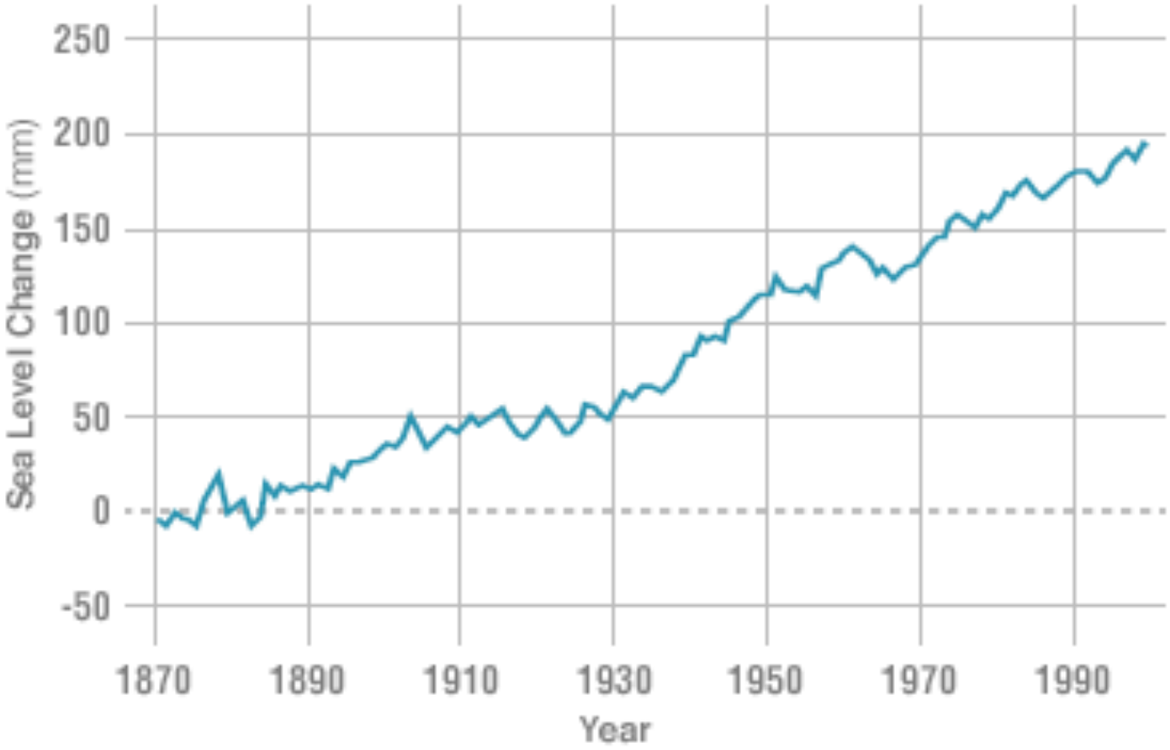
GROUND DATA: 1870-2000

Data source: Coastal tide gauge records.

Credit: CSIRO

RATE OF CHANGE

↑1.70 mm per yr*



*estimate for 20th century

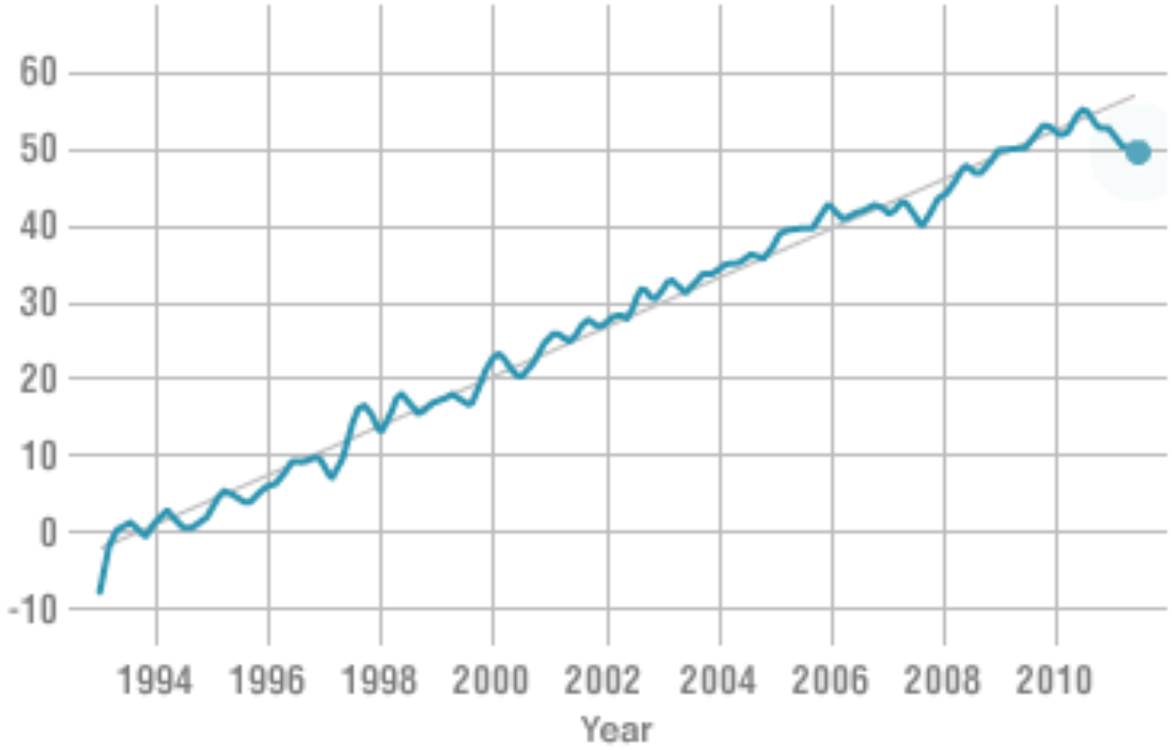
SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.

Credit: CLS/Cnes/Legos

RATE OF CHANGE

↑3.27 mm per yr*



Inverse barometer applied and seasonal signals removed.

*estimate for 1993-2010

Arctic Sea Ice

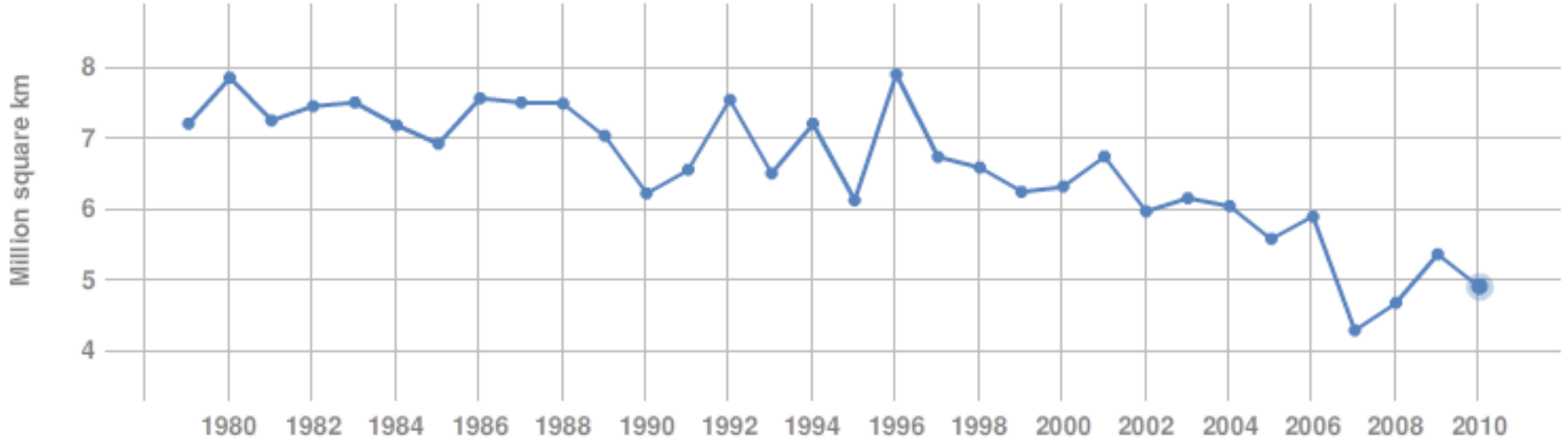
download data

Data updated 2.23.11

AVERAGE SEPTEMBER EXTENT

Data source: Satellite observations

Credit: NSIDC



Land Ice

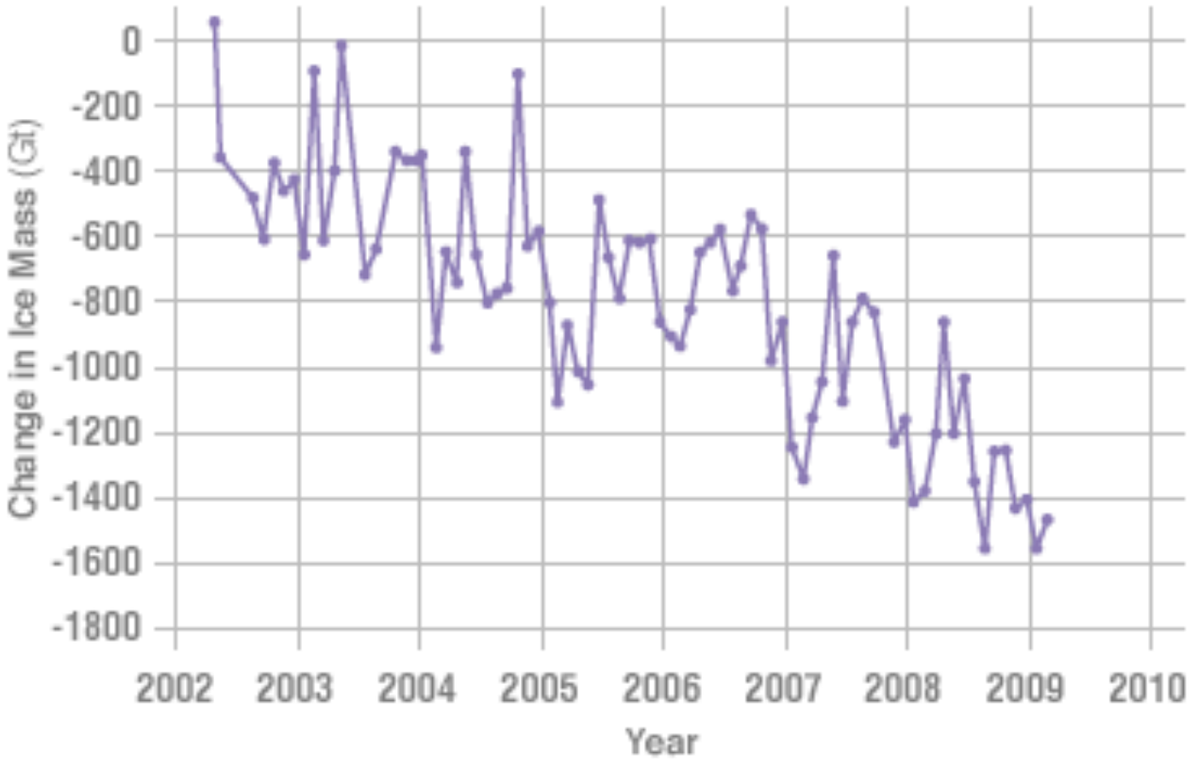
download data

Data updated 2.23.11

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

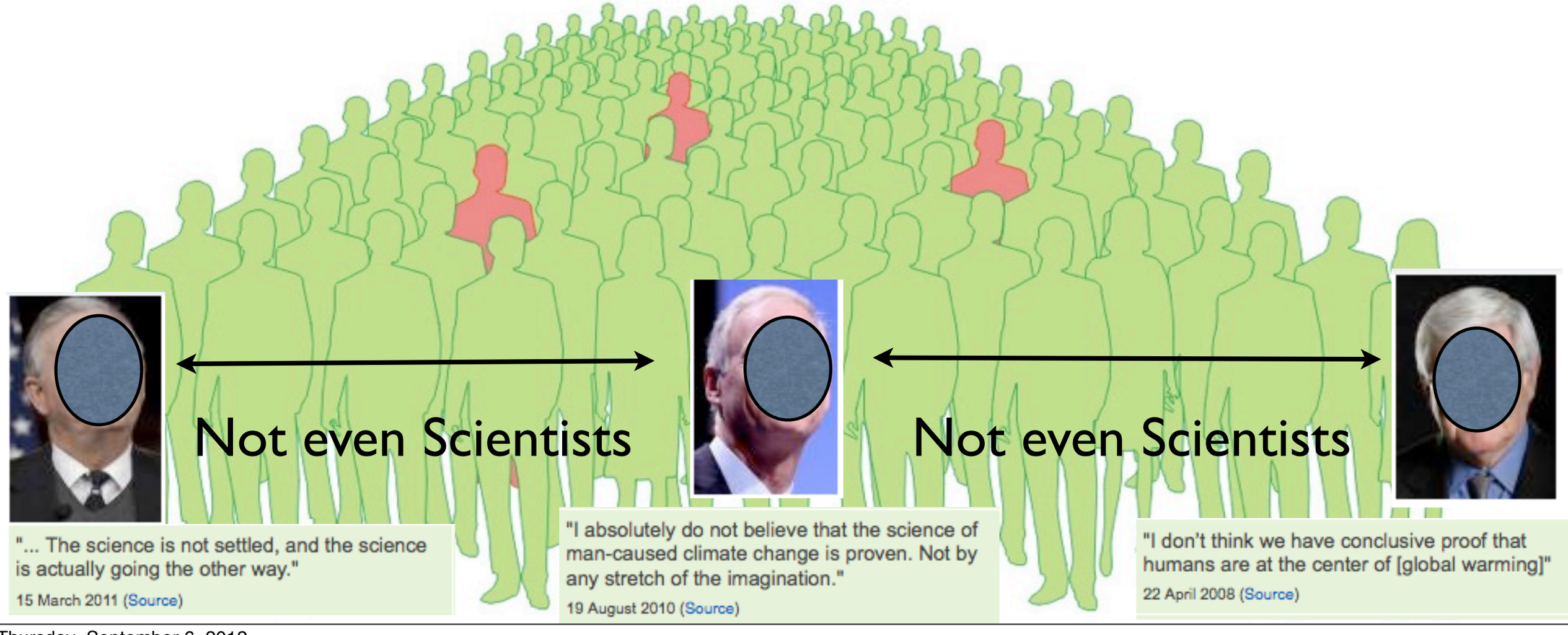
The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.[11]

How do we collect this data?

Many different ways but here is one that has been extremely useful

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

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

THE SHRINKING PUNCAK JAYA

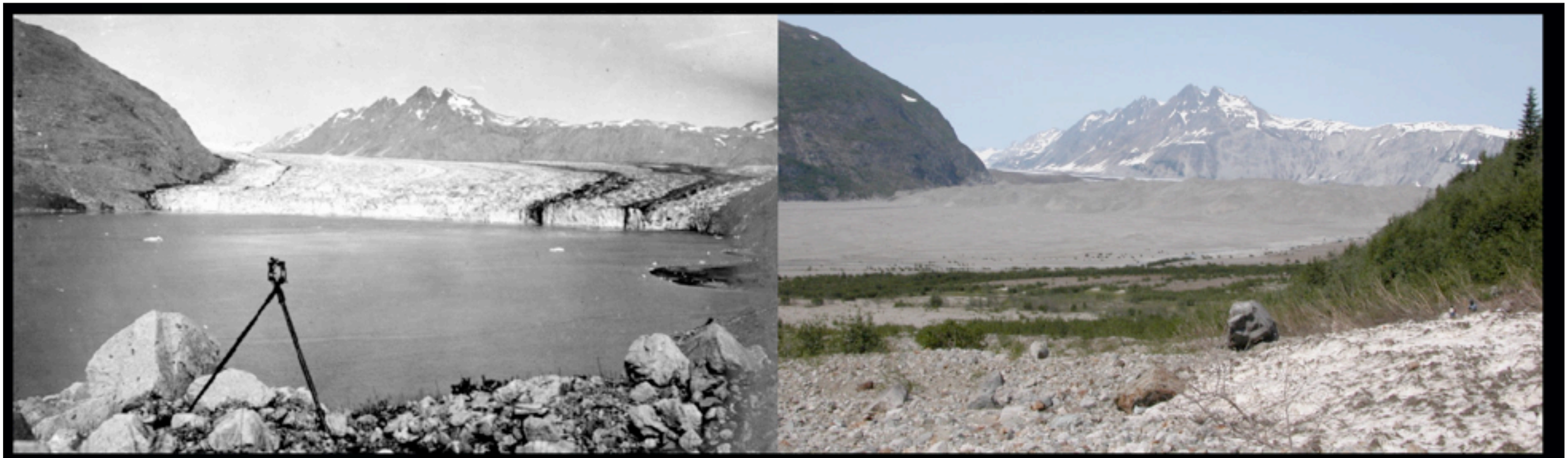
Puncak Jaya Glacier in the Irian Jaya province of Indonesia. Left: 1936. Middle: 1972. Right: 2005. Click here to download image.

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

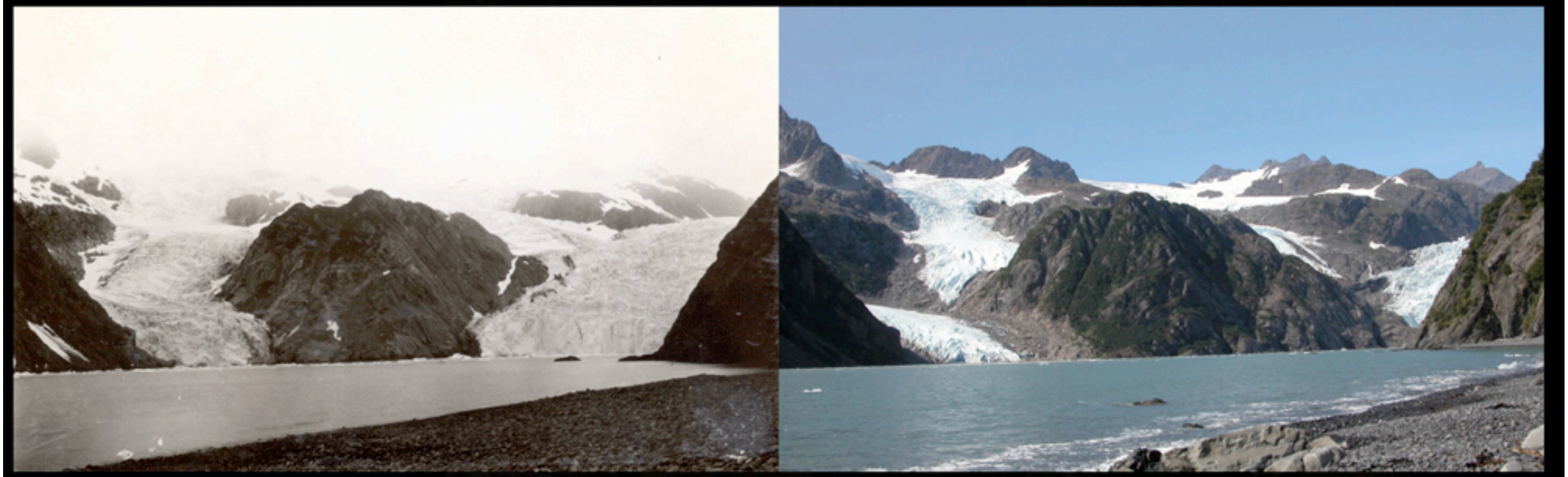
Bear Glacier in Alaska, photographed by Ulysses Sherman Grant on July 20, 1909 (left) and by Bruce F. Molnia on August 5, 2005 (right). Click here to download image.

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...

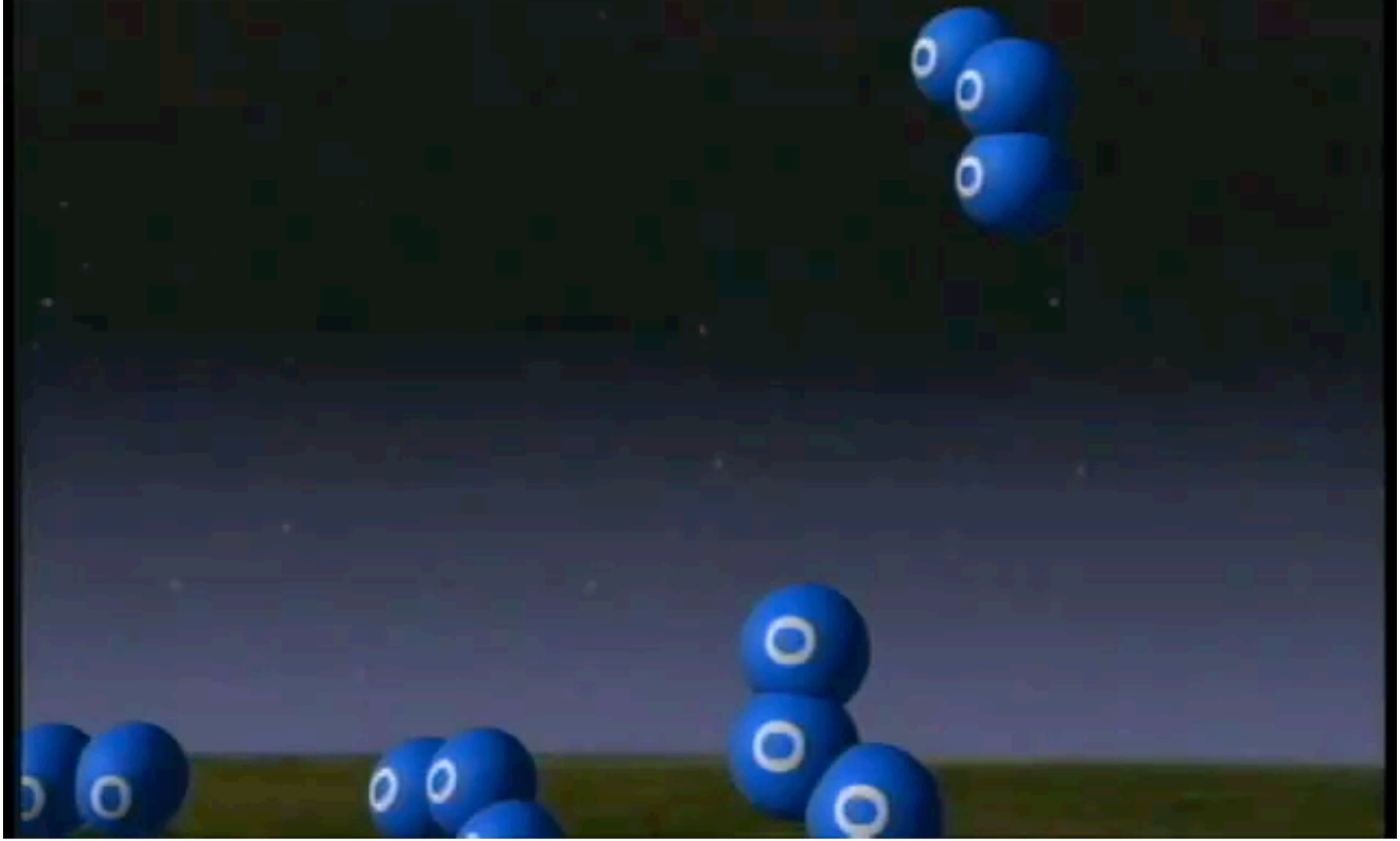
C. Depletion of Atmospheric Ozone

- Like atmospheric levels of CO_2 the levels atmospheric ozone (O_3) have been changing as well
  - Life on earth is protected from the damaging effects of UV radiation by layer of ozone located in the stratosphere.
- Ozone has changed as a result of human activities.
  - The destruction of ozone results primarily from the accumulation of chloroflourocarbons (CFC's), chemicals used in refrigeration and manufacturing.

- 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

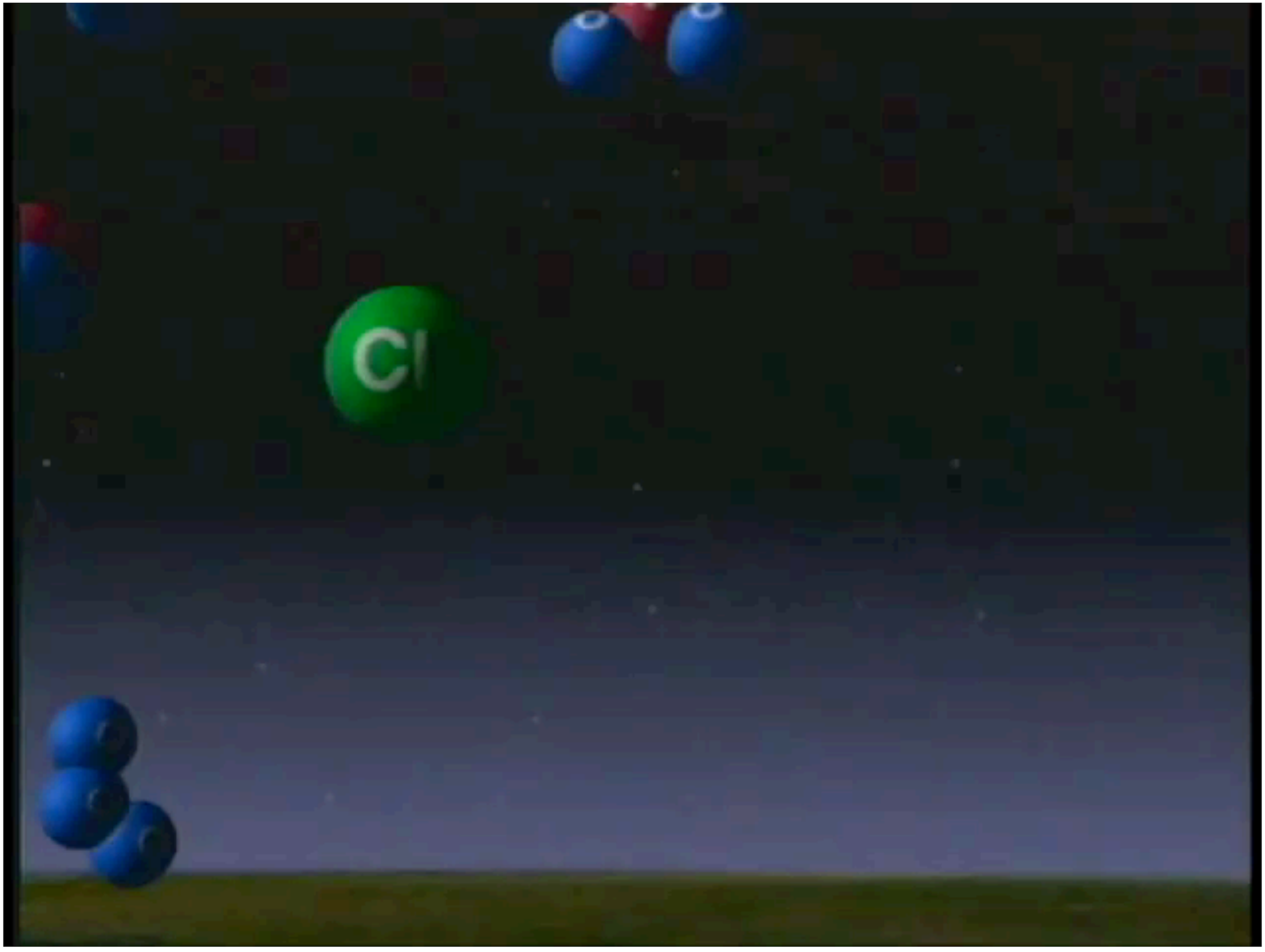
Exploring Ozone

Ozone Formation



Chemical Model Animation of O3 Losing an Oxygen Atom to a Radical

Ozone is very reactive. It easily loses the third oxygen atom in the presence of other highly reactive compounds called radicals, which contain chlorine, hydrogen, nitrogen, or bromine. Minute quantities of these radicals can cause large decreases in ozone because they are not consumed in the reaction. This is called a catalytic cycle.

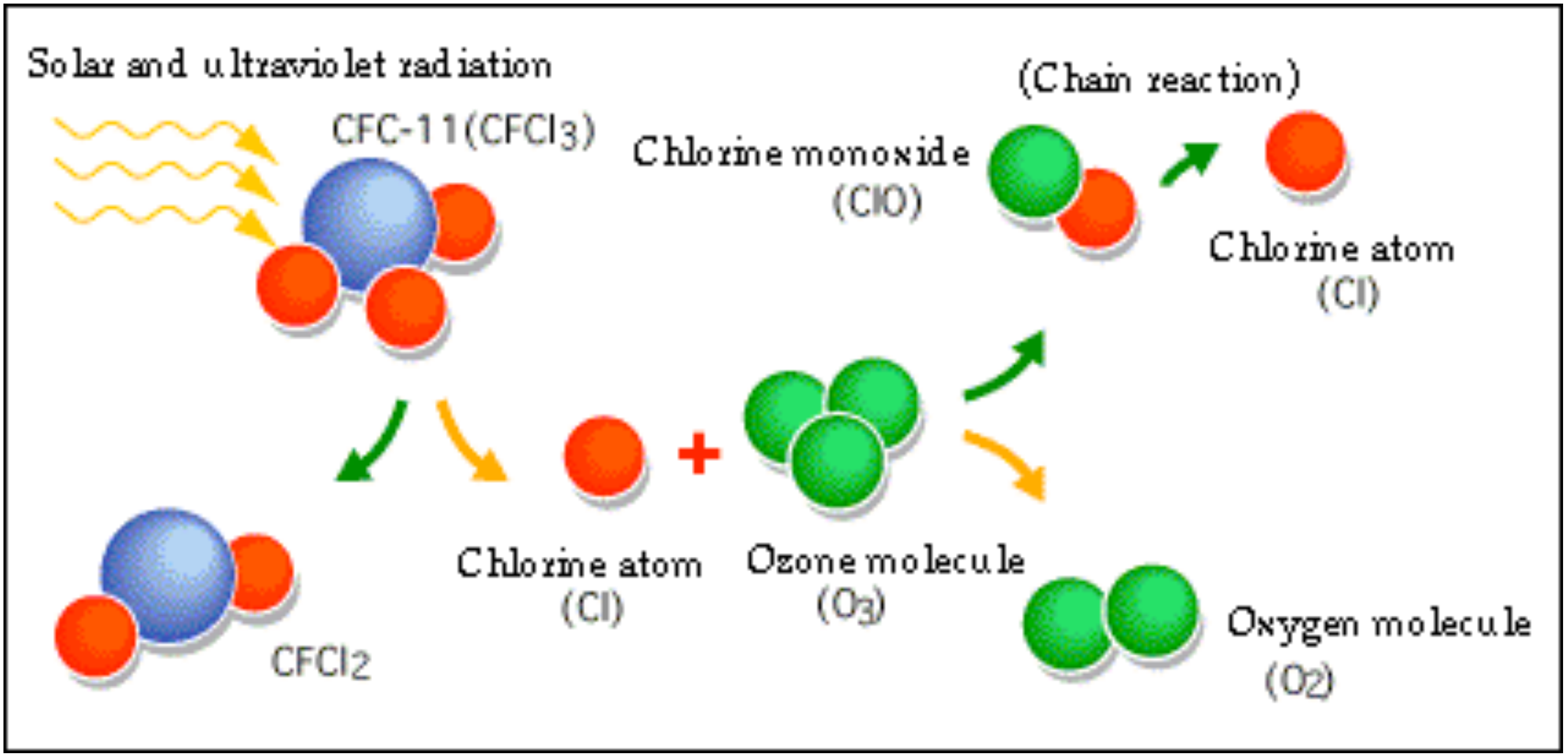


Chemical Model Animation of CFCs Releasing Chlorine to Form Reservoir Gases

Most stratospheric chlorine comes from man-made compounds called chlorofluorocarbons or CFCs. CFCs, widely used in refrigerators and air conditioners, are quite harmless and non-reactive in the lower atmosphere. Carried slowly upward by the earth's winds, they can survive the 5 year journey to the upper stratosphere. Here, above most of the ozone layer, the sun's ultraviolet radiation breaks down the CFCs into the more reactive chlorine compounds that destroy ozone. Chlorine can react with methane to form hydrogen chloride. Chlorine can also react with ozone forming the radical chlorine monoxide. Chlorine monoxide then combines with the radical nitrogen dioxide to form stable chlorine nitrate. Chlorine nitrate and hydrogen chloride are called reservoir gases for the chlorine radical. These reservoir gases usually contain more than ninety percent of the chlorine in the lower stratosphere.

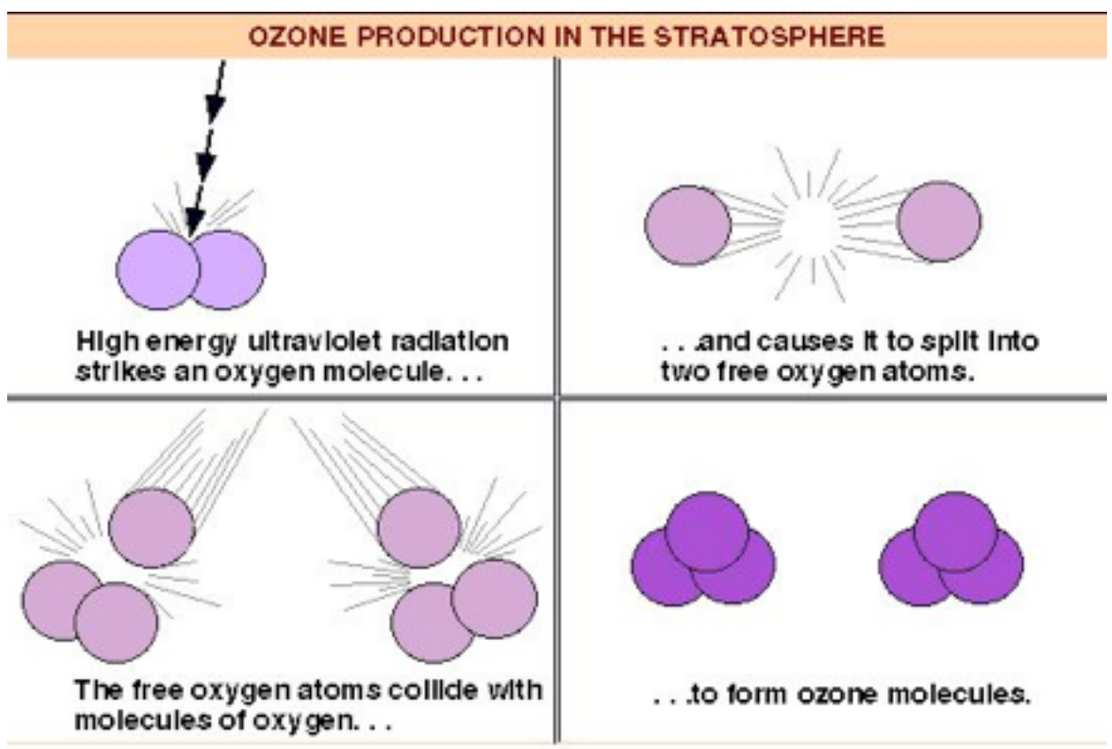
Chemical Model Animation of Chlorine Release from Reservoir Gases over Antarctica

Over the Antarctic continent, ice clouds form in the cold winter darkness. On the surface of the cloud particles, chlorine nitrate and hydrogen chloride react and release chlorine. The chlorine then reacts with ozone forming chlorine monoxide and starting the catalytic ozone destruction cycle. The massive ozone loss results in the development of the Antarctic ozone hole.



CFC Destruction of Ozone

Natural Production of Ozone



CLIMATE CHANGE IN SUMMARY

(56) Conservation Ecology

v.

Main Idea: Some believe that "we" must change how we interact with the earth and its resources.

Main Idea: Some argue that if "we" change our behavior and live more sustainably we can improve human lives and conserve biodiversity.

SUSTAINABLE DEVELOPMENT CAN IMPROVE HUMAN LIVES WHILE CONSERVING BIODIVERSITY

A. Sustainable Biosphere Initiative

1. *Case Study:* Sustainable Development in Costa Rica

B. The Future Of The Biosphere

**Give this section a quick read if you have the time/interest*

Stop and Think

Hypothetically speaking... would YOU be willing as a business owner to make less profit it meant you could maintain the health or biodiversity of an ecosystem.