Big Idea 4: Biological systems interact, and these systems and their interactions possess complex properties.

Enduring understanding 4.A: Interactions within biological systems lead to complex properties. Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

a. Energy flows, but matter is recycled. [See also 2.A.1]

Ecosystems

Main Idea: Physical laws control energy flow and chemical cycling.

Main Idea: Energy flows through ecosystems.

Main Idea: Chemicals (matter) cycles within ecosystems.



PHYSICAL LAWS GOVERN ENERGY FLOW & CHEMICAL CYCLING IN ECOSYSTEMS Conservation of Energy

- First Law of Thermodynamics: energy can not be created nor destroyed...only transferred and transformed.
 - The sun is the ultimate source of energy for most ecosystems and life itself on our planet.
 - Energy enters ecosystems as solar radiation.
 - Autotrophs transform solar radiation into chemical energy.
 - Heterotrophs consume autotrophs and transfer this chemical energy through food chains.

- Second Law of Thermodynamics: energy exchanges (transfers and transformations) increase the entropy of the universe. In other words energy exchanges are inefficient some energy is always lost as heat
 - Remember energy is passing through food chains.
 - As chemical energy is passing through food chains it is ultimately transformed to heat and transferred back to space

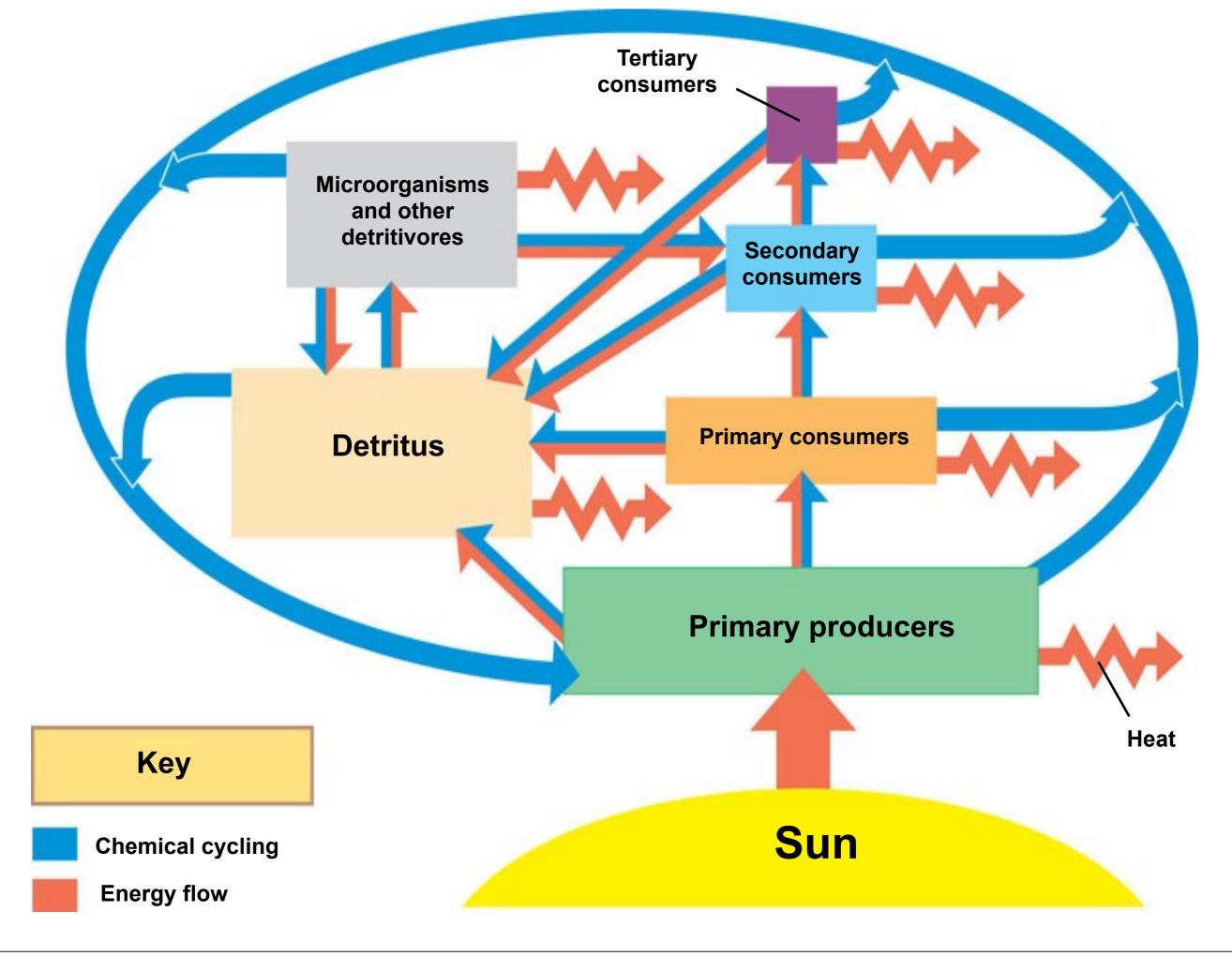
Conservation of Mass

- Law of Conservation of Mass: like energy, matter can not be created or destroyed.
 - Very little matter enters earth from space.
 - Thus the matter on earth is constant. Matter has been, is and will continue to be recycled over time.
 - Be Careful! Matter can be gained and lost from ecosystems themselves.

Energy, Mass & Trophic Levels

- Primary Producers consists of autotrophs and their trophic level supports all others. Think of it this way...autotrophs link heterotrophs to the ultimate source of energy for most life...the sun!
 - Producers (autotrophs) are photosynthetic organisms that use solar energy to synthesize organic compounds (sugars) which they use to fuel cellular respiration and as building blocks for growth.
 - As producers begin to synthesize compounds chemical bonds must be formed. It is the energy in these bonds that provide the energy for life processes and growth.
 - An exception to this scenario is found in chemosynthetic bacteria that serve as producers in a few less common ecosystems.

Does the 2nd Law of Thermodynamics contradict the theory of evolution? Explain



- Decomposers/Detrivores
 consume Detritus, nonliving
 organic material (dead organisms
 and feces)
- Two most significant and important decomposers are <u>Fungi</u> and <u>Bacteria</u>
- They play a critical role in recycling matter...decomposers convert organic material into inorganic material that producers can then uptake and reuse. (recycled back into the ecosystem)
 - Consider This! If decomposition stopped detritus would build up and life would not exist





Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

b. Changes in regional and global climates and in atmospheric composition influence patterns of primary productivity.

Ecosystems

Main Idea: Energy and other limiting factors control primary production.

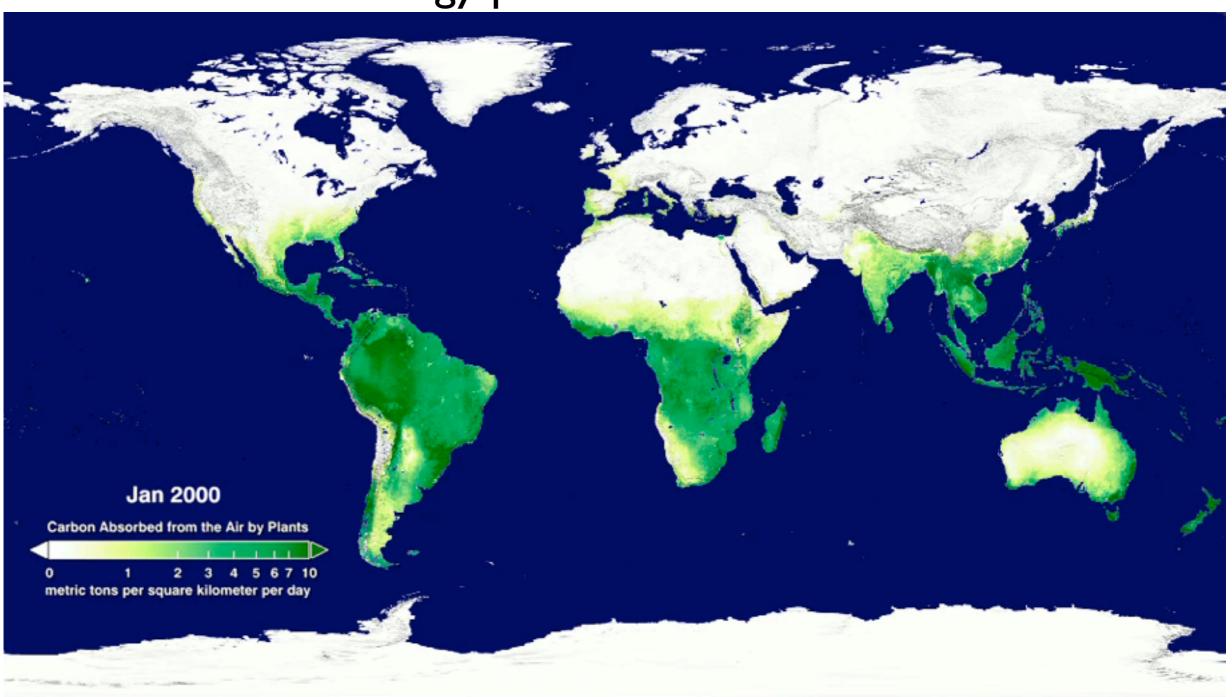
Main Idea: Primary production dictates the energy budget for the entire ecosystem.



ENERGY AND OTHER LIMITING FACTORS CONTROL PRIMARY PRODUCTION IN ECOSYSTEMS

- Primary production is the amount of light energy converted to chemical energy in a given period of time
- The amount of light energy converted to chemical energy by autotrophs effects the amount of heterotrophs it can support in higher trophic levels.
- Energy transfer is a major theme in biology, energy transfer underlies all biological interactions.

• Gross Primary Production (GPP) is the total amount of solar energy converted to chemical energy per unit time.

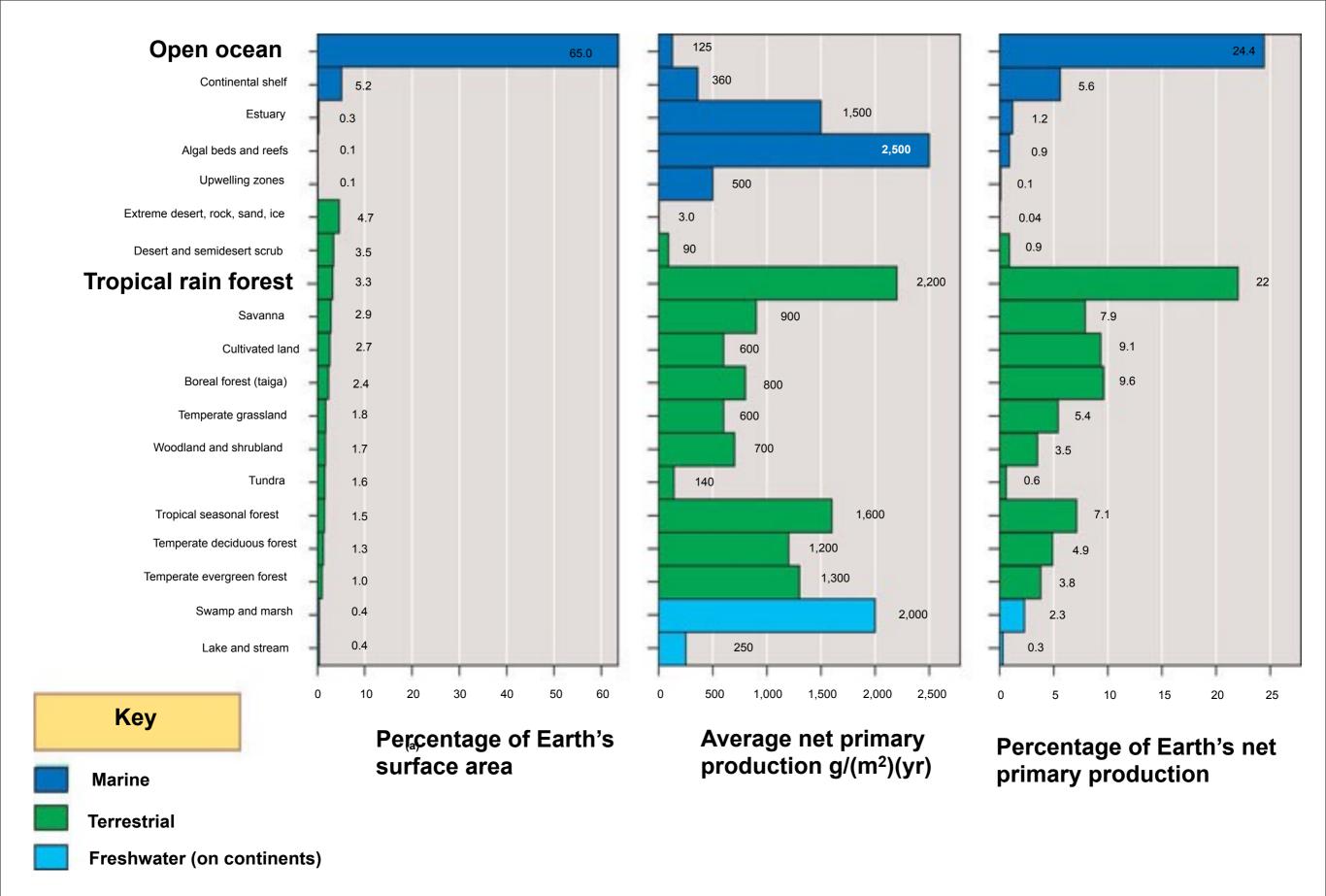


The gross primary productivity of the world's land areas for the period 2000-2009 as calculated from Terra's MODIS instrument. The original 8-day average GPP data has been smoothed to a 24-day average to make the animation less noisy.

Gross and Net Production

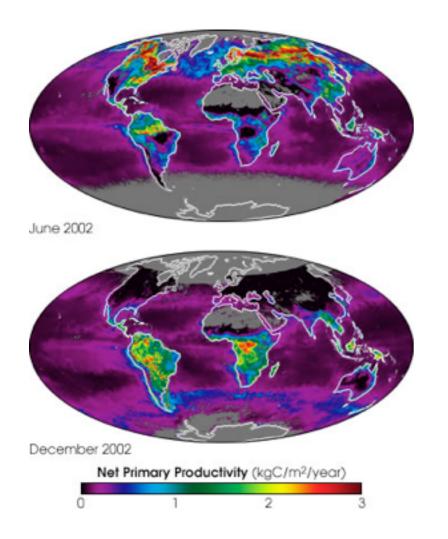
- Gross Primary Production (GPP) is the total amount of solar energy converted to chemical energy per unit time.
- **Net Primary Production (NPP)** is the difference between GPP and autotrophic respiration R_a.
 - NPP = GPP R_a (on average NPP is about half of GPP)
 - NPP can be expressed in two ways:
 - $\{J/(m^2)(year)\}$ or $\{g/(m^2)(year)\}$

Be careful! Do not confuse standing crop (total biomass) with primary production (new biomass per unit time)



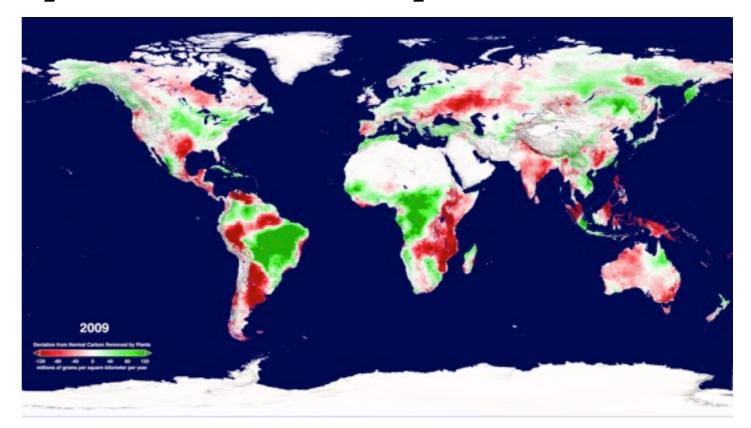
Net Primary Productivity

Summer

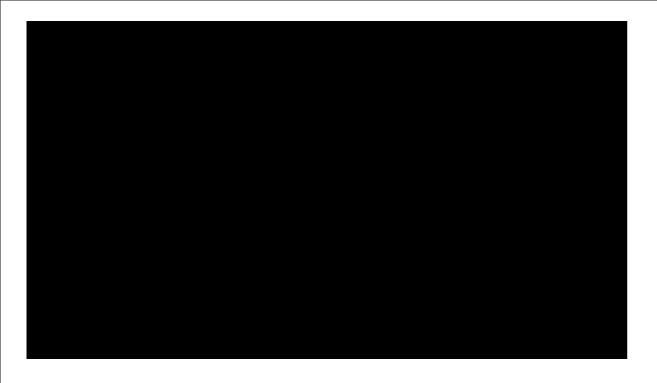


Winter

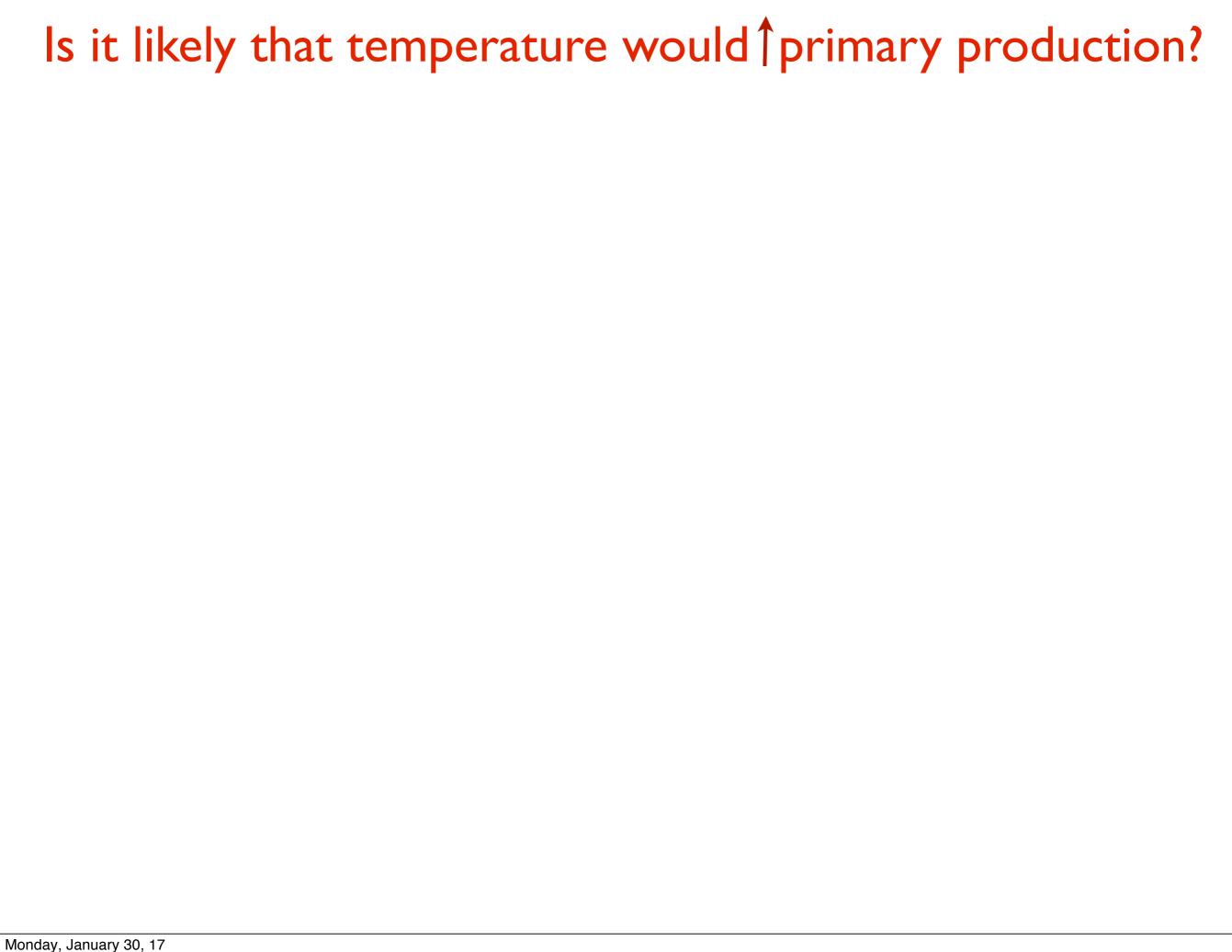
How are satellites able to measure productivity?



The change from normal of the annual net primary productivity of the world's land areas for the period 2000-2009 as calculated from Terra's MODIS instrument. This version adds a date and colorbar to the animation.



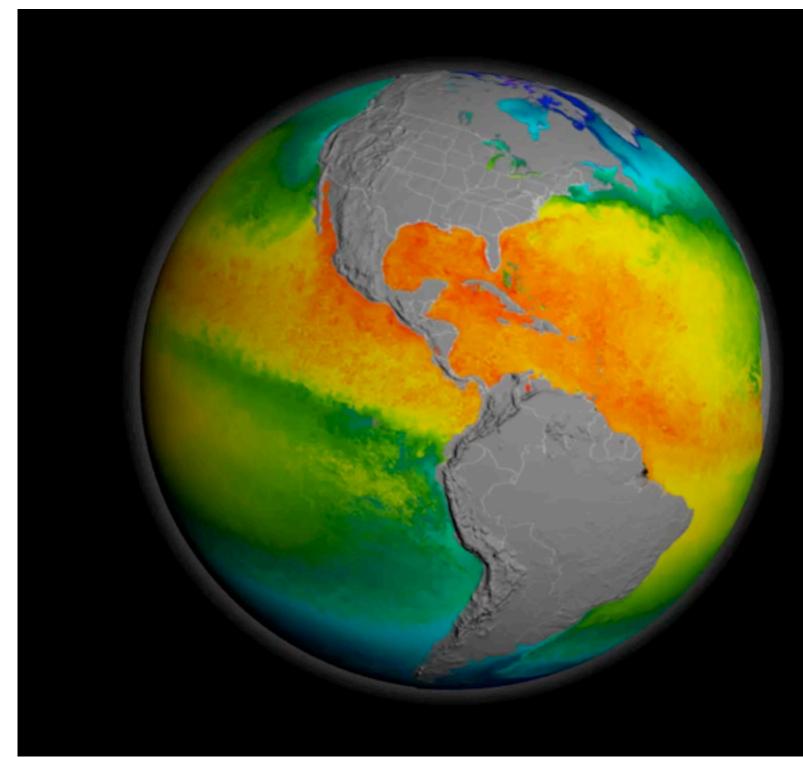
The past decade is the warmest on record since instrumental measurements began in the 1880s. Previous research suggested that in the '80s and '90s, warmer global temperatures and higher levels of precipitation -- factors associated with climate change -- were generally good for plant productivity. An updated analysis published this week in Science indicates that as temperatures have continued to rise, the benefits to plants are now overwhelmed by longer and more frequent droughts. High-resolution data from the Moderate Resolution Imaging Spectroradiometer, or MODIS, indicate a net decrease in NPP from 2000-2009, as compared to the previous two decades.



Is it likely that temperature would primary production?

Not generally however consider this...

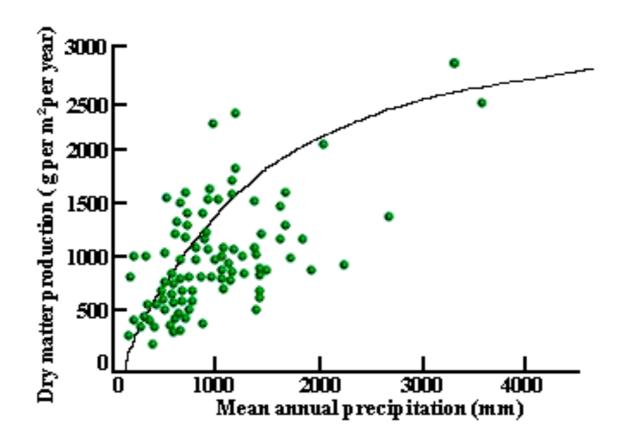
Is it likely that temperature would primary production? Not generally however consider this...



A recent study indicates there is a correlation between ocean nutrients and changes in sea surface temperature (SST). The results show that when ocean water warms, marine plant life in the form of microscopic phytoplankton tend to decline. When water cools, plant life flourishes. Changes in phytoplankton growth influence fishery yields and the amount of carbon dioxide the oceans remove from the atmosphere. This could have major implications on the future of our ocean's food web and how it relates to climate change.

Primary Production in Terrestrial Ecosystems

- Water and Temperature are the key limiting factors.
- In fact precipitation is a useful tool for predicting productivity because there is such a strong correlation between the two.
 - Actual evapotranspiration is a second useful tool used to predict terrestrial productivity



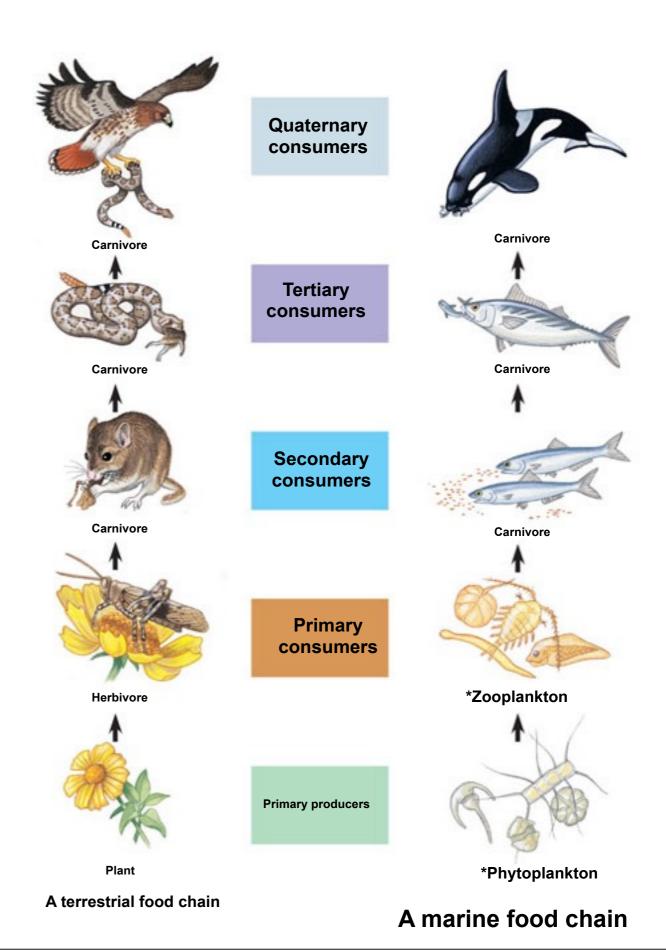
Where did we see this graph before?

Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

c. Organisms within food webs and food chains interact. [See also 2.D.1]

Trophic Structure

- Trophic Structure...feeding relationships within the community.
- The movement of food energy from autotrophs through and up to the largest consumers...food chains.



Food Webs

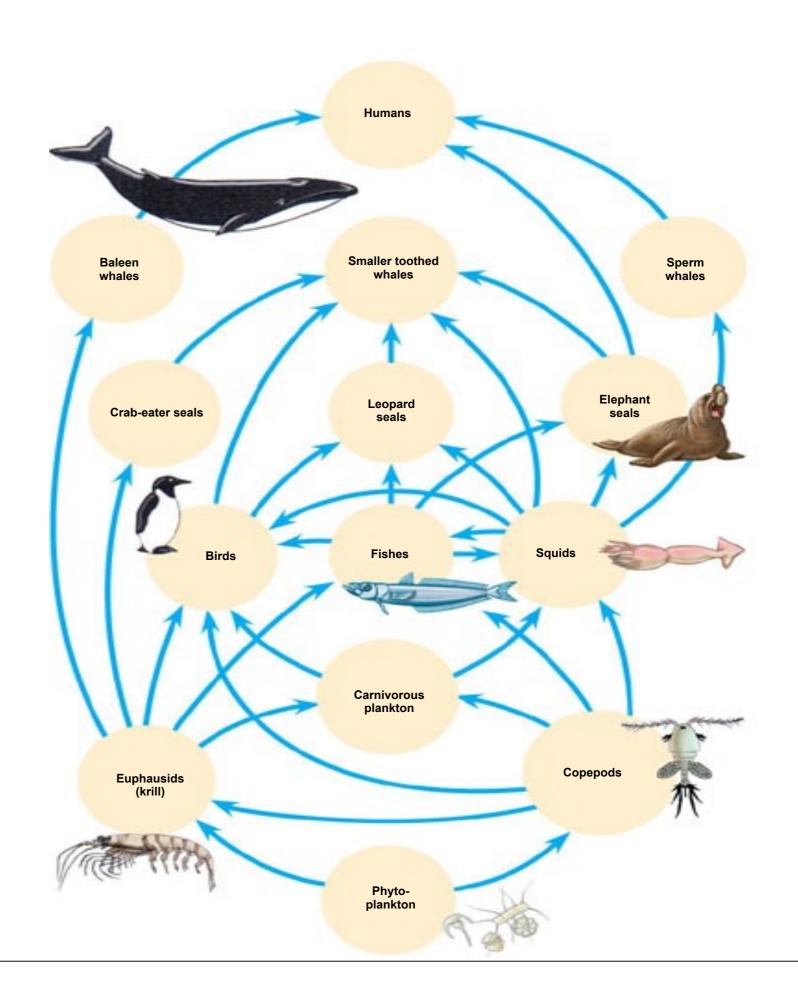
- Interconnected and linked food chains make up **food webs**.
- The arrow points in the direction of foods movement. In other words A→ B indicates that B is eating A. Many students reverse this so be careful

Could you interpret these feeding relationships IF...

I.the pics were removed?

2. the pics and names were removed?

3. What if I removed all pics, names and turned in upside down?



Food Chain Lengths

- Food chains are limited in their lengths.
- The two common hypotheses..
 - The Energetic Hypothesis states that the energy transfer one one trophic level to another is inefficient (about 10-20%) and after 3 5 transfers there is not enough energy to support another level.
 - The Stability Hypothesis states long chains are unstable, that fluctuations in lower trophic levels are magnified in the higher levels.
 - The most current data supports the energetic hypothesis.

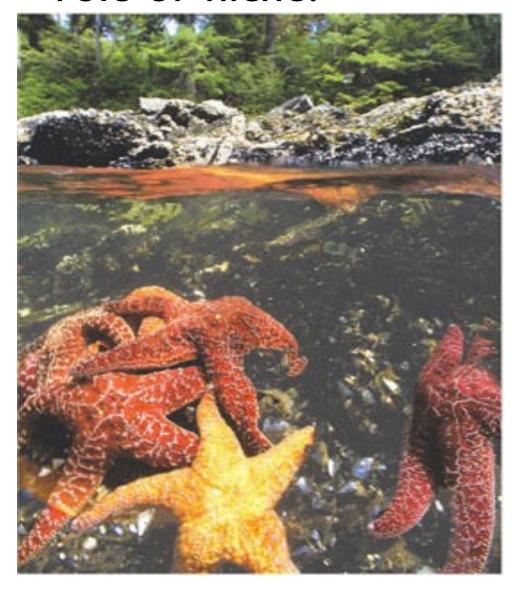
Dominant & Keystone Species

- Certain species have a proportionally larger impact in the community due to their abundance or a key role that they play in community interactions
 - 1. **Dominant Species**; are the most abundant or have the highest biomass.
 - These species often effect the occurrence and distribution of other species.
 - These species are likely dominant for one of two reasons
 - either they are superior competitors, that is they capture limited resources better than others
 - they avoid predation and disease better than others

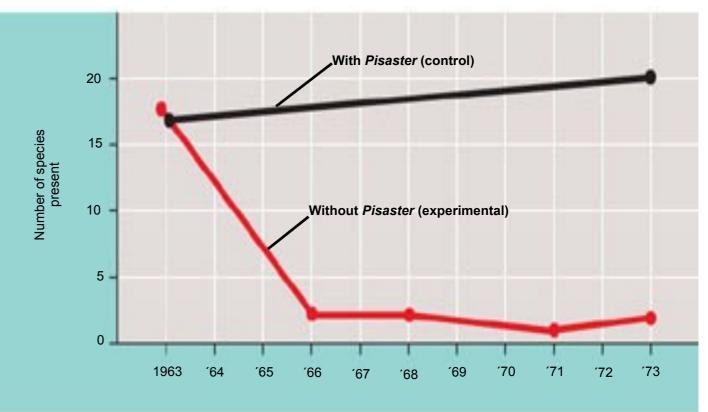
How could you test the effects of dominant species?

Dominant & Keystone Species

 2. Keystone Species; are not the most abundant but they exert strong control on community dynamics due their unique role or niche.



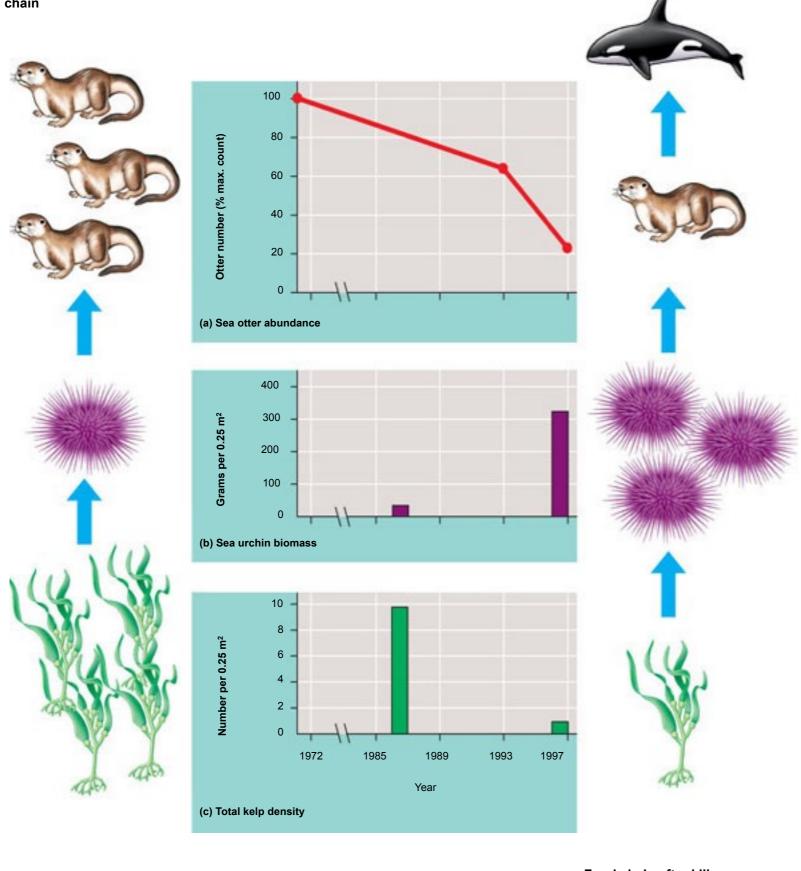
(a) The sea star *Pisaster ochraceous* feeds preferentially on mussels but will consume other invertebrates.



(b) When *Pisaster* was removed from an intertidal zone, mussels eventually took over the rock face and eliminated most other invertebrates and algae. In a control area from which *Pisaster* was not removed, there was little change in species diversity.

What is a "keystone"?

Food chain before killer whale involvement in chain



Food chain after killer whales started preying on otters

Note:

• Engineer
Species; exert
strong control
on community
by changing the
physical
environment.



Community Organization & Control

- 3 Possible Scenarios:
 - I. Bottom-Up Model (V→H); available nutrients control vegetation which then controls herbivores abundance which in turn controls predators abundance
 - Top-Down Model (V← H); predators control
 herbivores abundance which in turn controls vegetations
 abundance which in turn controls nutrient uptake
 - 3. Bi-Directional Model (V ←→ H); each trophic level is sensitive to the one above and below itself

How would nutrient levels be effected if you removed the top predator in 4 level trophic community? What if had only 3 trophic levels? Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

d. Food webs and food chains are dependent on primary productivity.

Ecosystems

Main Idea: Energy transfer is not efficient, most energy is lost.



ENERGY TRANSFER BETWEEN TROPHIC LEVELS IS TYPICALLY AROUND 10% (WITH 90% LOST)

 Secondary production: the amount of chemical energy in consumers food that is actually converted to their own new biomass during some time period.

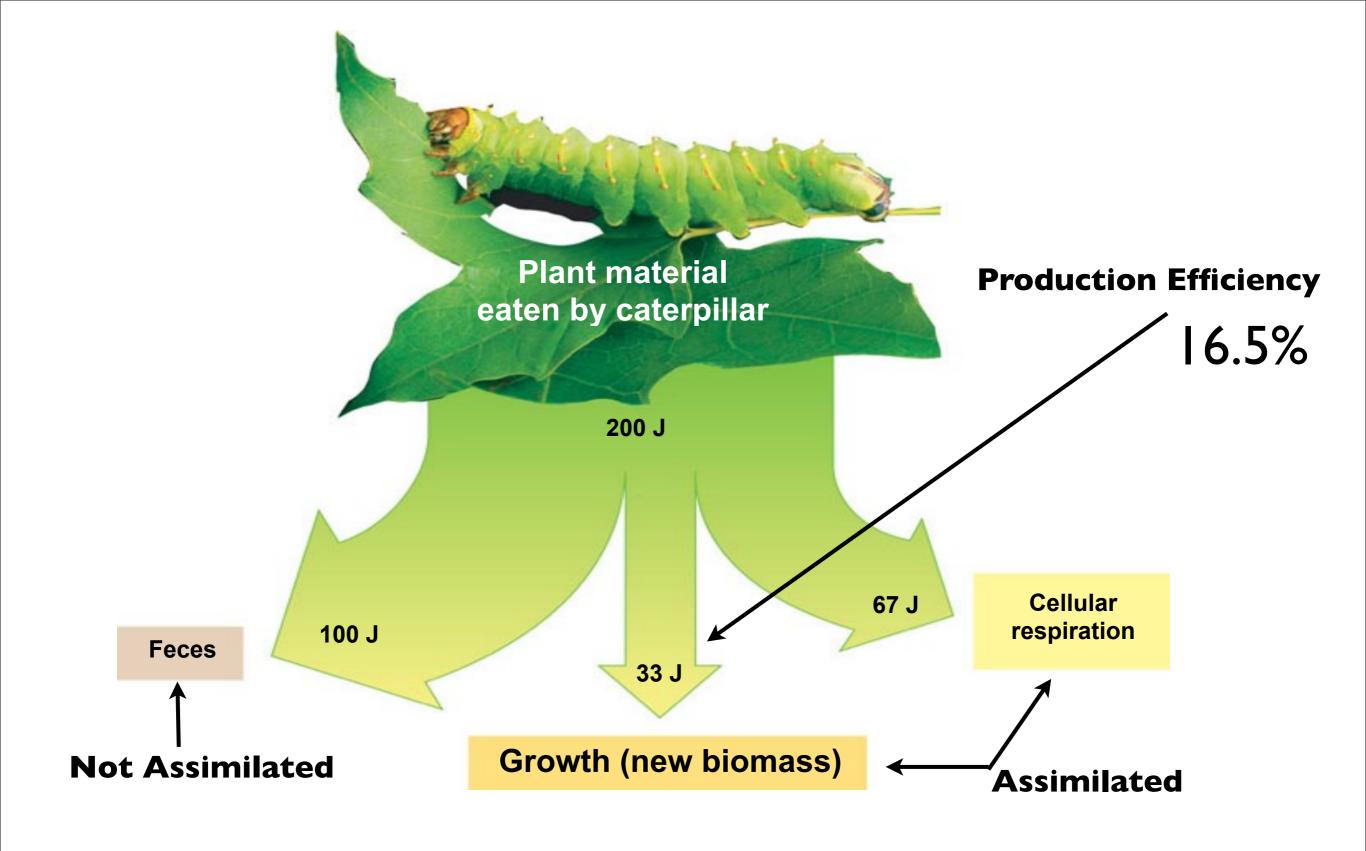
Production Efficiency

- Think about it... only the chemical energy stored by herbivores is biomass (either in their own growth or reproduction of offspring) This is only energy available to secondary consumers
- We can measure production efficiency.

Production Efficiency =

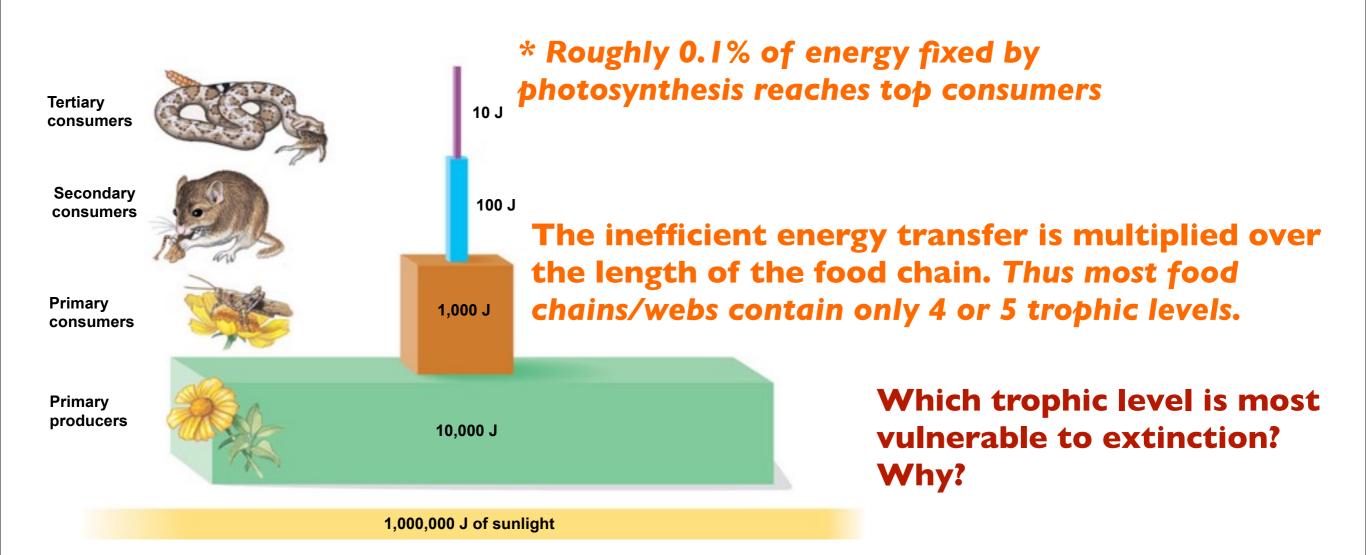
Net Secondary Production X 100%

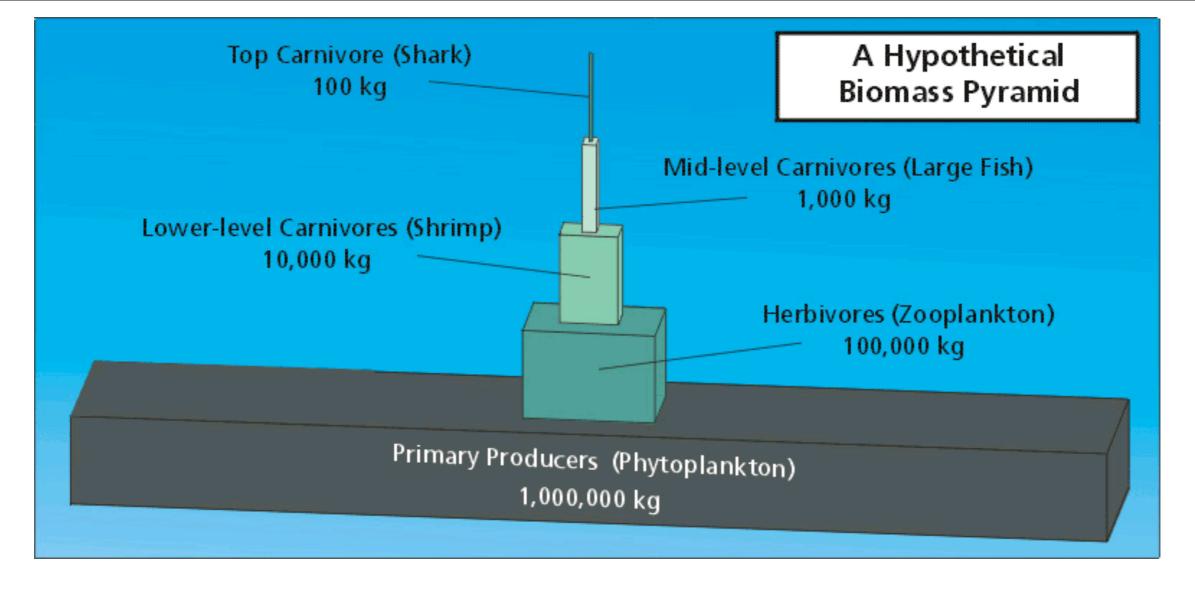
Assimilation of Primary Production



Trophic Efficiency & Ecological Pyramids

- Trophic Efficiency, the percent of production transferred one trophic level to the next. (Ranges between 5-20%)
 - Trophic efficiency must be less than production efficiency.

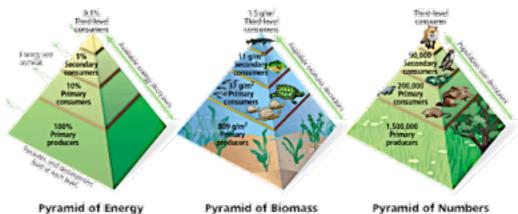


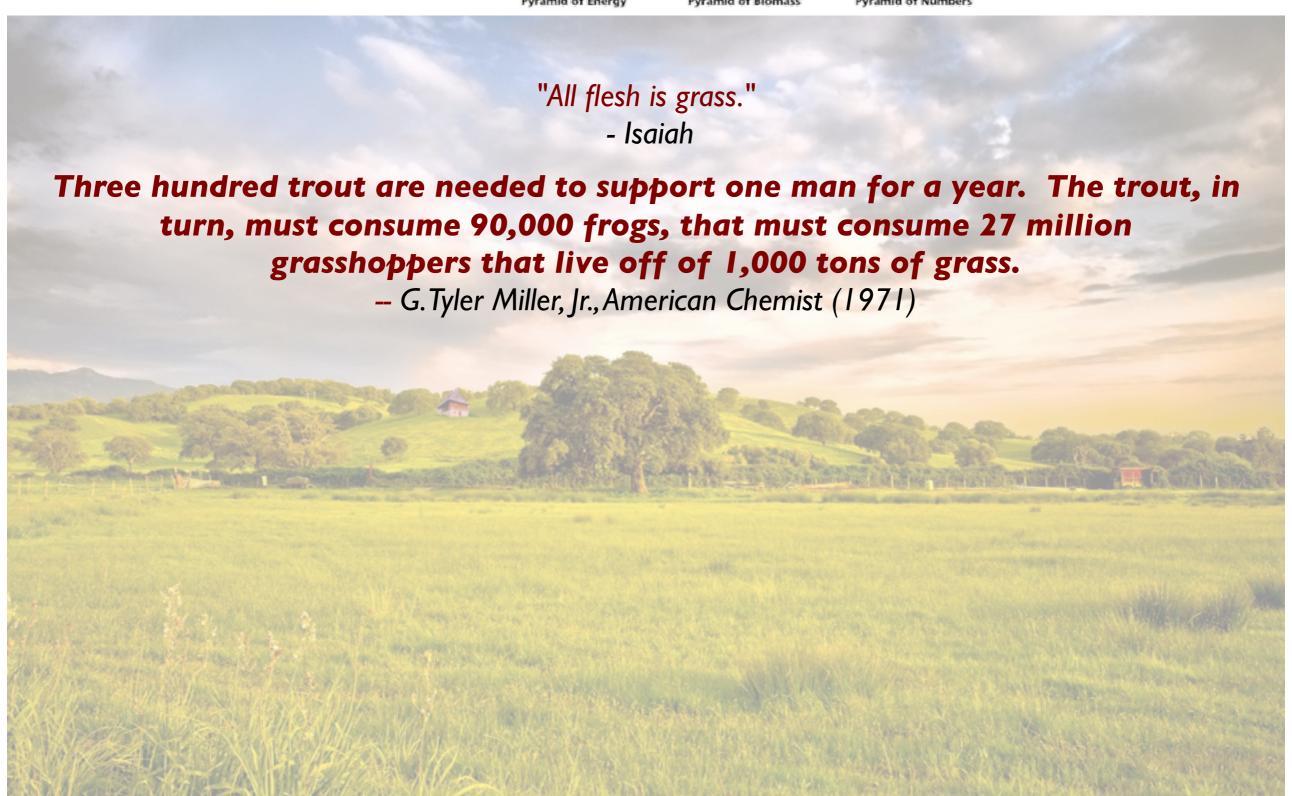


Each tier represents the standing crop (the total dry mass of all organisms) in a trophic level.

Can you make an argument that humans might be better off if they were vegetarians?

Most common or Standard Pyramids





Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

e. Models allow the prediction of the impact of change in biotic and abiotic factors.

Evidence of student learning is a demonstrated understanding of each of the following:

- 1. Competition for resources and other factors limits growth and can be described by the logistic model.
- 2. Competition for resources, territoriality, health, predation, accumulation of wastes and other factors contribute to density- dependent population regulation.

Population Ecology

Main Idea: Conditions are rarely ideal and as such the environment can support a limited number of individuals

Main Idea: The maximum number of individuals that the environment can sustain is its carrying capacity.

Main Idea: Population growth rate decreases as a population approaches its carrying capacity.

Can you think of any limiting factors?

"REAL" POPULATION GROWTH

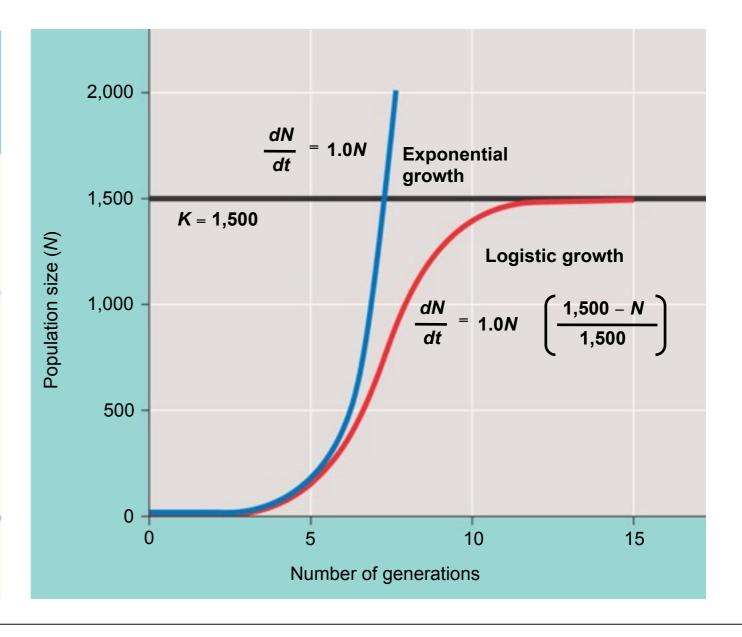
- Start with exponential growth and add an expression that reduces the per capita rate of increase as N increases.
 - K = carrying capacity
 - so (K-N)/K is the fraction of K that is still available for population growth
 - when N is small relative to K, the (K-N)/K approaches 1.0 (maximum growth rate)
 - when N is large relative to K, the (K-N)/K approaches 0 (slow growth rate)
 - when N = K, population growth stops!
 - population growth decreases dramatically as N approaches K

Logistic Growth Model

- "graphed" logistic growth takes on a "S" shaped curve
- the equation for logistic growth is seen below

$$\frac{dN}{dt} = r_{max} N \frac{(K - N)}{K}$$

Individual per Year				
Population Size:	Intrinsic Rate of Increase: r _{max}		Per Capita Growth Rate:	Population Growth Rate:
		$\left(\frac{K-N}{K}\right)$	$r_{max}\left(\frac{K-N}{K}\right)$	$r_{max}N\left(\frac{K-N}{K}\right)$
20	0.05	0.98	0.049	+1
100	0.05	0.90	0.045	+5
250	0.05	0.75	0.038	+9
500	0.05	0.50	0.025	+13
750	0.05	0.25	0.013	+9
1,000	0.05	0.00	0.000	0



Logistic Growth in Real Populations

- Logistic Model Assumptions
 - I. that populations adjust instantly and smoothly as it approaches the carrying capacity (K)
 - However there is often a delay involved causing the population to overshoot the carrying capacity
 - 2. that each individual added has the same negative effect on growth rate
 - However some have a more difficult time surviving/reproducing if the population is too small...Allee Effect
 - Furthermore many populations fluctuate greatly, making it difficult to establish an accurate carrying capacity
 - This model is a starting point for more complex ones!

REGULATION OF POPULATION GROWTH

- As it turns many factors that regulate population size are in fact density dependent.
- Understanding these factors can have practical applications
 - preventing extinctions, managing endangered species, managing pests

Population Change Over Time

- Once again will simplify matters by ignoring immigration and emigration or assume they cancel each other out!
- A factor that does not effect birth rates and death rates as the population becomes more dense is said to be density independent.
- Should birth rates and death rates change as population size change then those factors are said to be density dependent.

Density Dependent Population Regulation

*Negative Feedback regulates population growth. Without this mechanism populations would continually grow, exceed their carrying capacity and crash. (*negative feedback is a common and important theme in biology, you must understand it completely)

Density Dependent Factors.

Competition

Territoriality

Predation

Toxic Waste

Disease

Intrinsic Factors

Propose how each of these might regulate population growth as density increases. Can you provide examples?

Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

f. Human activities impact ecosystems on local, regional and global scales. [See also 2.D.3]

Evidence of student learning is a demonstrated understanding of each of the following:

- 1. As human populations have increased in numbers, their impact on habitats for other species have been magnified.
- 2. In turn, this has often reduced the population size of the affected species and resulted in habitat destruction and, in some cases, the extinction of species.

THE HUMAN POPULATION

Human population has exploded over the last few centuries

A. Human Population

- Year Population I 200 million 1000 275 million I 650 500 million 1750 700 million I 804 I billion 1900 1.6 billion I 927 2 billion 1950 2.55 billion I 960 3 billion 1970 3.7 billion I 975 4 billion 1990 5.3 billion I 999 6 billion 2005 6.45 billion 2006 6.5 billion 2010 6.8 billion projections: 2020 7.6 billion 2030 8.2 billion 2040 8.8 billion 2050 9.2 billion
- Nearly 80 million people are added to the earth each year at the current rate
- 200,000 are added each day this equivalent to the city of Richmond, Virginia
- Growth rate has decreased over the last few decades, it has departed from true exponential growth
- Likely this change is a result of voluntary population control (China) and diseases (AIDS)
- http://www.poodwaddle.com/clocks/worldclock/

Conservation Ecology

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

Biodiversit

Three Levels of Biodiversity

Genetic Diversity Species Diversity Ecosystem Diversity

I. 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

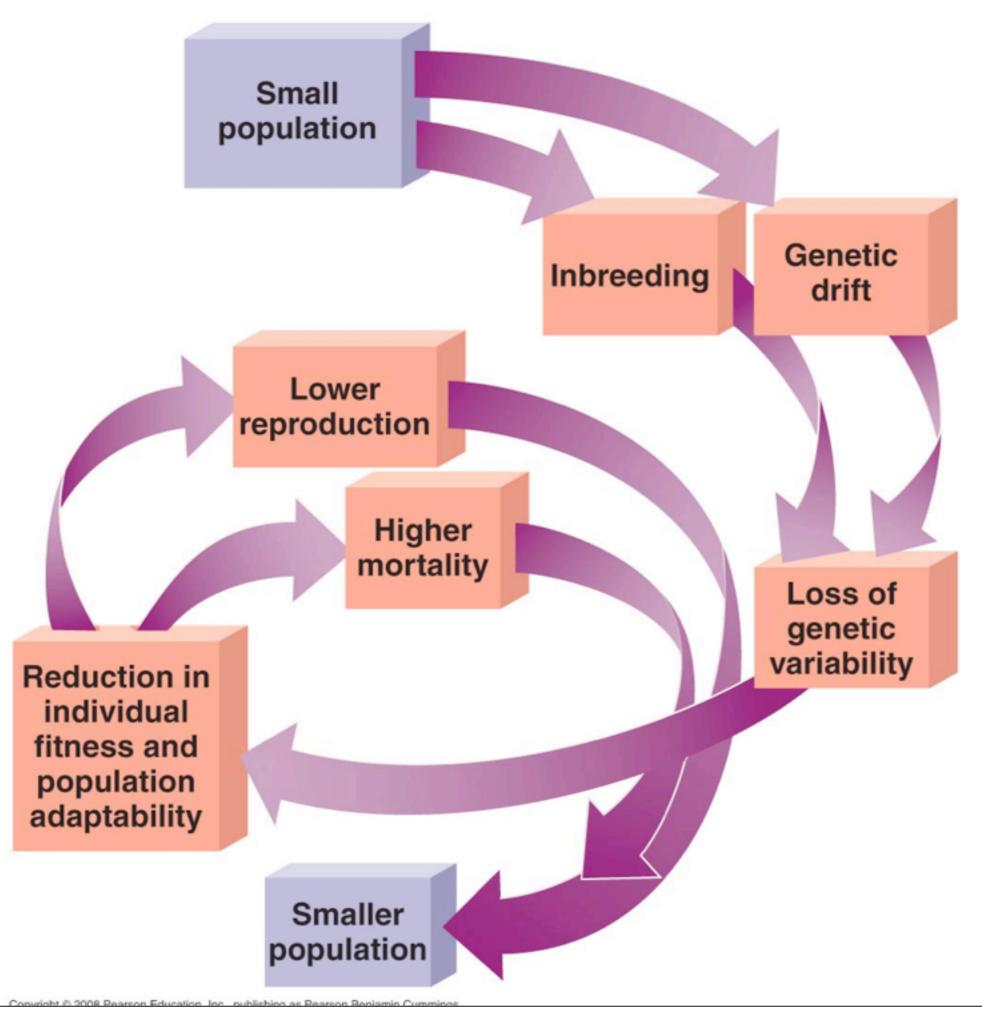
POPULATION CONSERVATION FOCUSES ON POPULATION SIZE, GENETIC DIVERSITY AND CRITICAL HABITAT

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.



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

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.

I. 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.

&

I. 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.

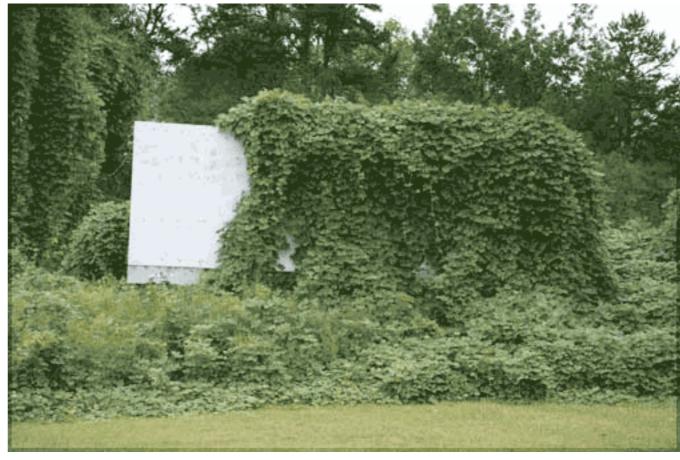
2. Invasive Species

- 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.

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





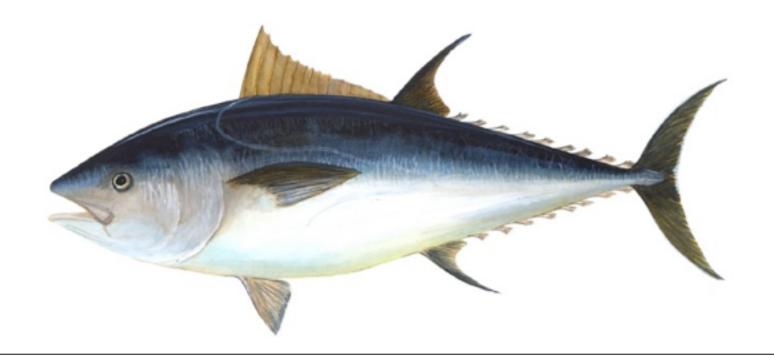
3. Overharvesting

- 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



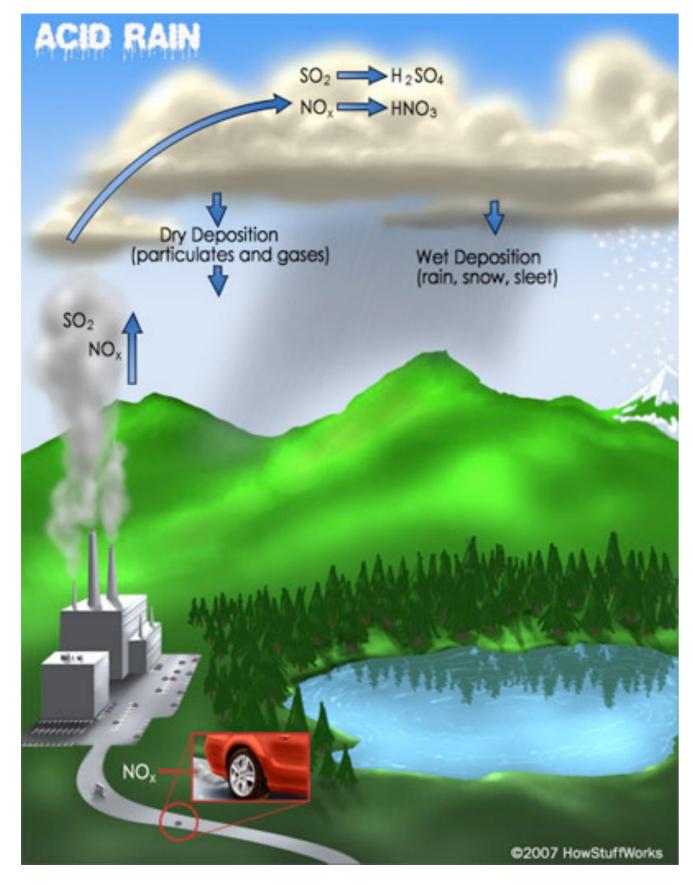
Overharvesting (over fishing)

- 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







Conservation Ecology

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

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 lowa 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.
- ••
- I. 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.

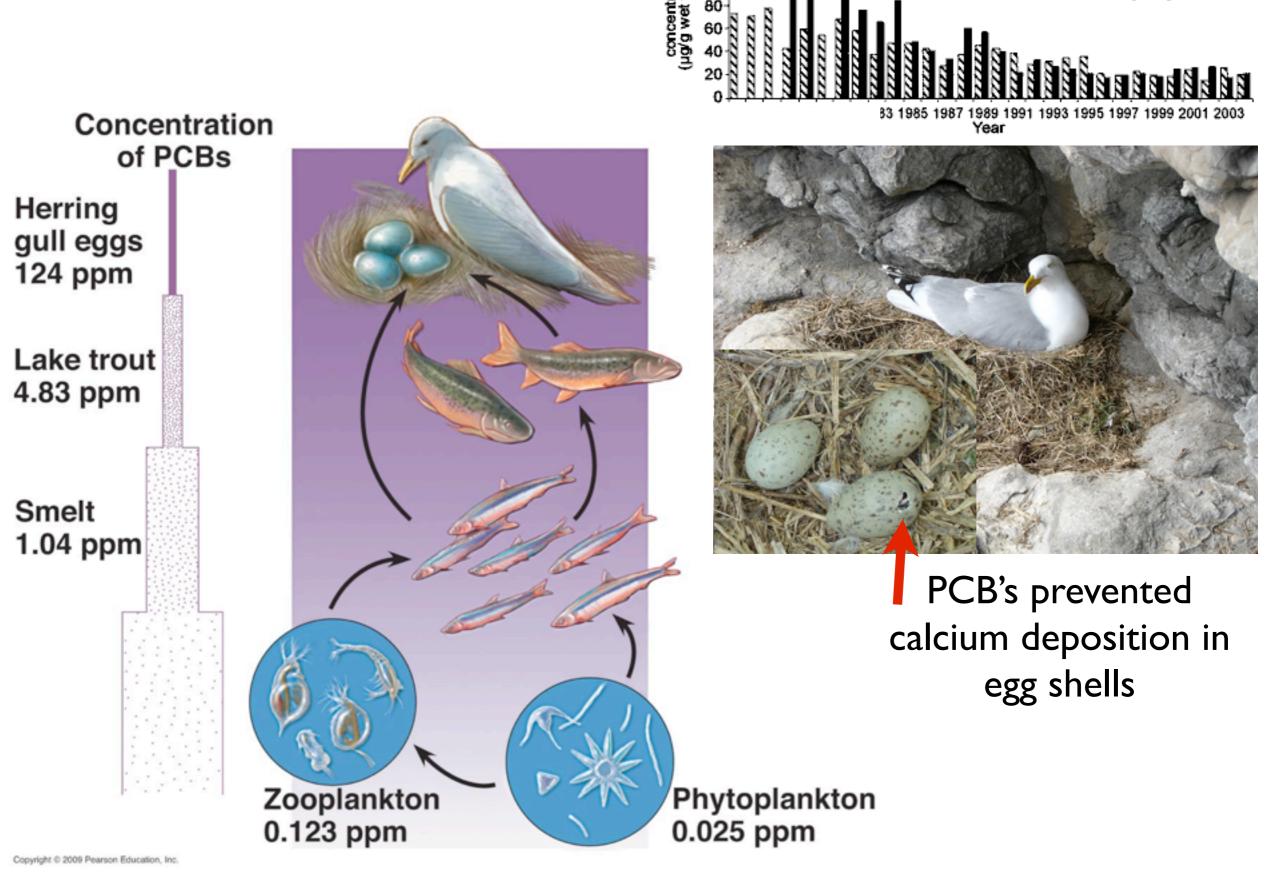


Recent reports indicate that the large region of low oxygen water often referred to as the 'Dead Zone' has spread across nearly 5,800 square miles of the Gulf of Mexico again in what appears to be an annual event. NASA satellites monitor the health of the oceans and spots the conditions that lead to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

Toxins in the Environment

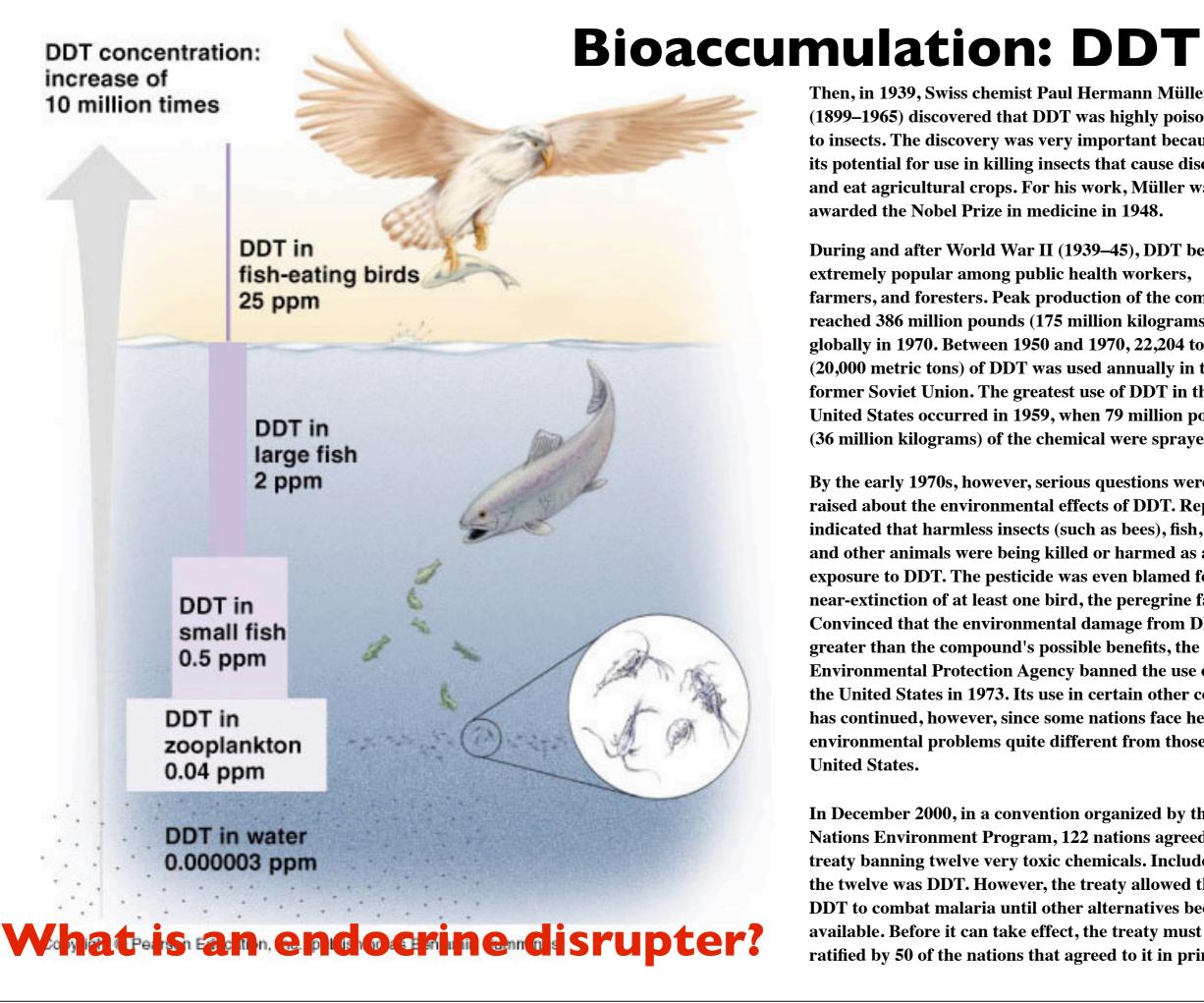
- Humans release a variety of toxins, often times synthetic (novel to organisms) into the environment.
- Many toxins can't be degraded by microorganisms and persist in the environment for years.
 - In fact some chemicals released are benign only to be later converted into toxic forms
 - Ex. Insoluble 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 1:1 concentration in herring gull eggs

■ Middle Island
■ Fighting Island



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.

















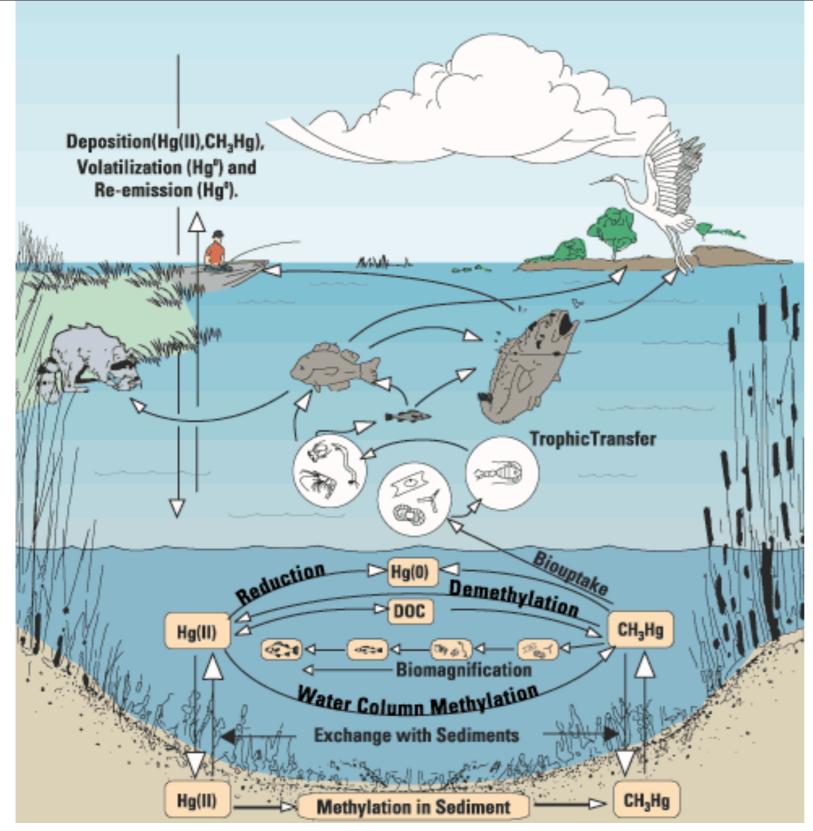




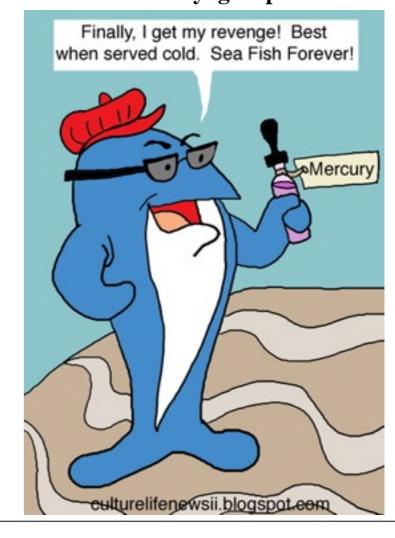








In the environment, sulfate-reducing bacteria take up mercury in its inorganic form and through metabolic processes convert it to methylmercury. Sulfate-reducing bacteria are found in anaerobic conditions, typical of the wellburied muddy sediments of rivers, lakes, and oceans where methylmercury concentrations 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:

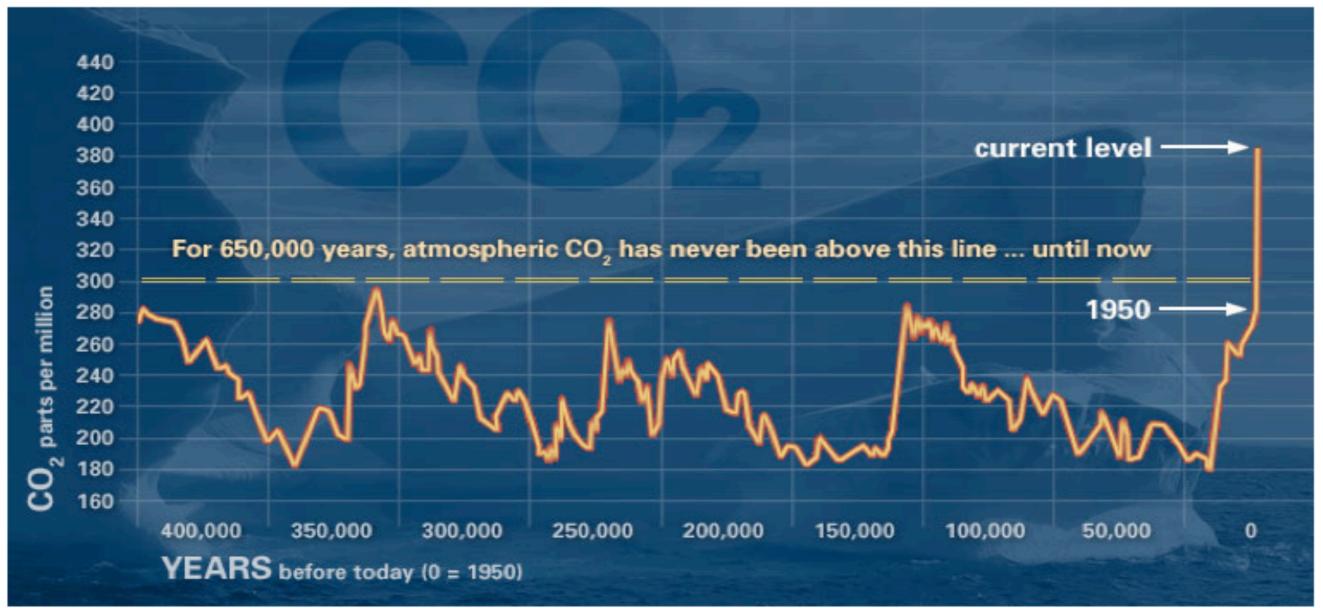


Greenhouse Gases & Global Warming

Rising atmospheric CO₂ levels

- Since the industrial revolution the levels of CO₂ in atmosphere have been increasing. (estimates of 274 ppm in 1850)
- Since 1958 we have been able to accurately measure CO₂ levels in the atmosphere. (1958 = 316ppm), (today it exceeds 385 ppm)
- Computer models estimate that in 60 years the amount of CO₂ 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?

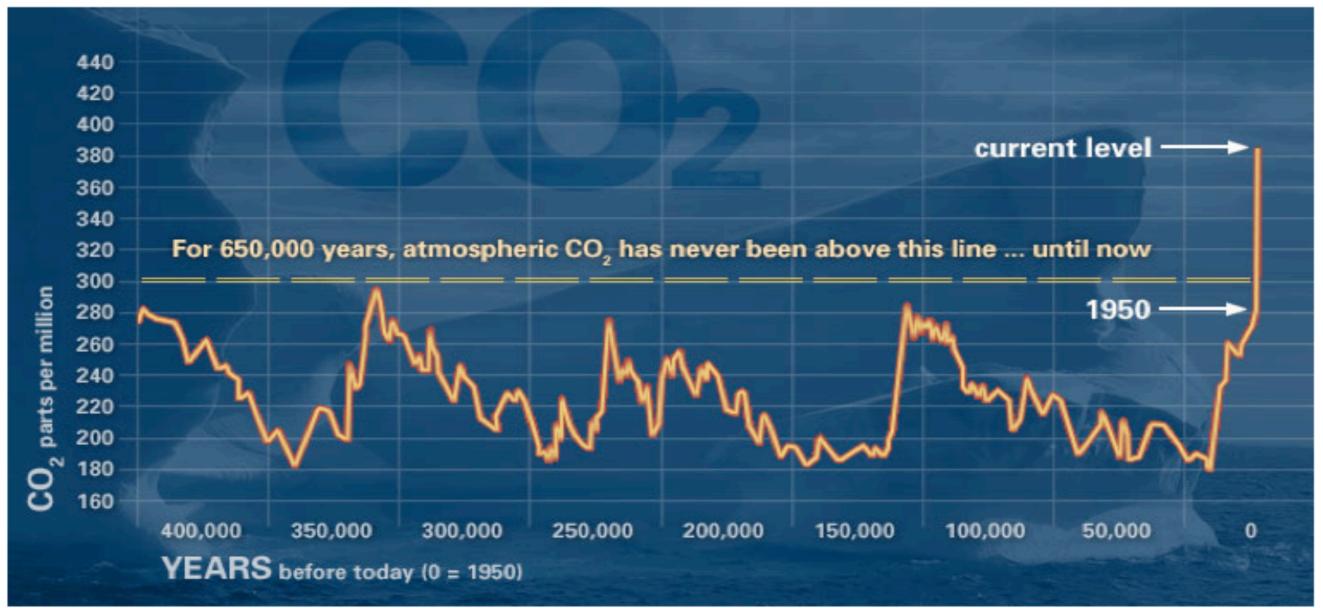


This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO₂ has increased since the Industrial Revolution. (Source: NOAA)

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



Climate change: How do we know?

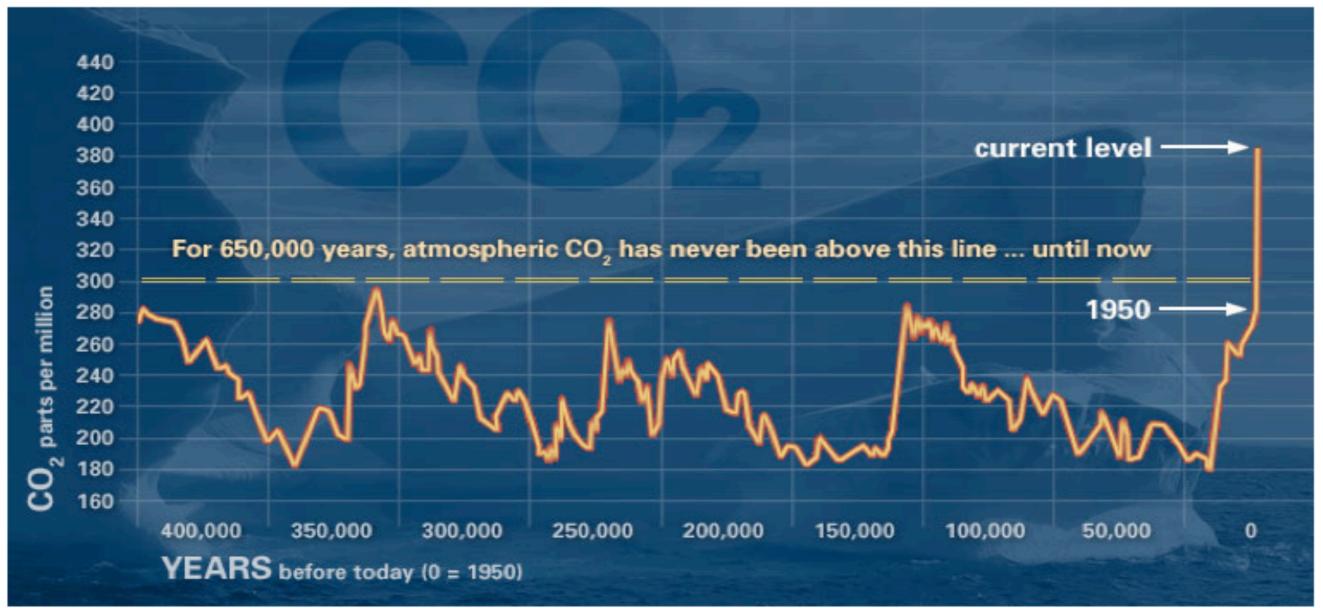


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Climate change: How do we know?



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO₂ has increased since the Industrial Revolution. (Source: NOAA)

What do the skeptics say about the rising CO₂ levels in the atmosphere?

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

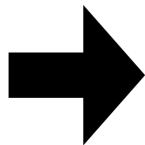
17 August 2011 (Source)



There are many predictable consequences of rising CO₂ levels. Here are a few...

- Spread of C₃ into regions where C₄ have been more well adapted.
 - Important when C₄ plant is a major food crop.



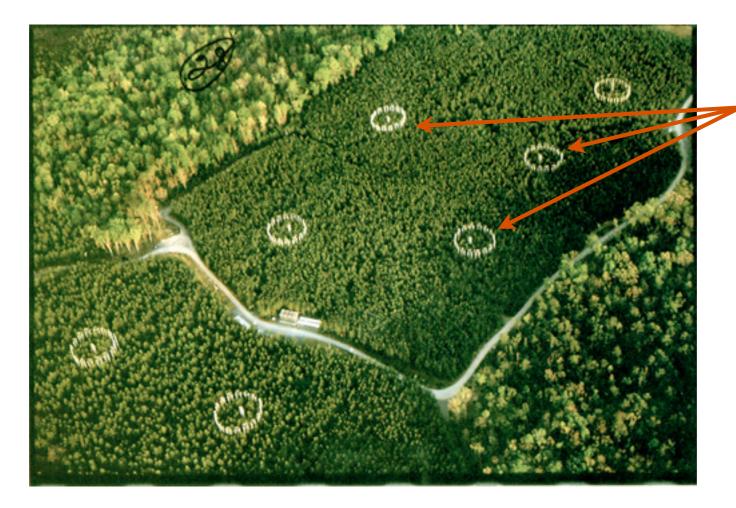




- Change in plant productivity and species composition.
 - see experiment below

The FACTS-1 Experiment

- Purpose: assess how rising CO₂ levels effect temperate forests
- Method:

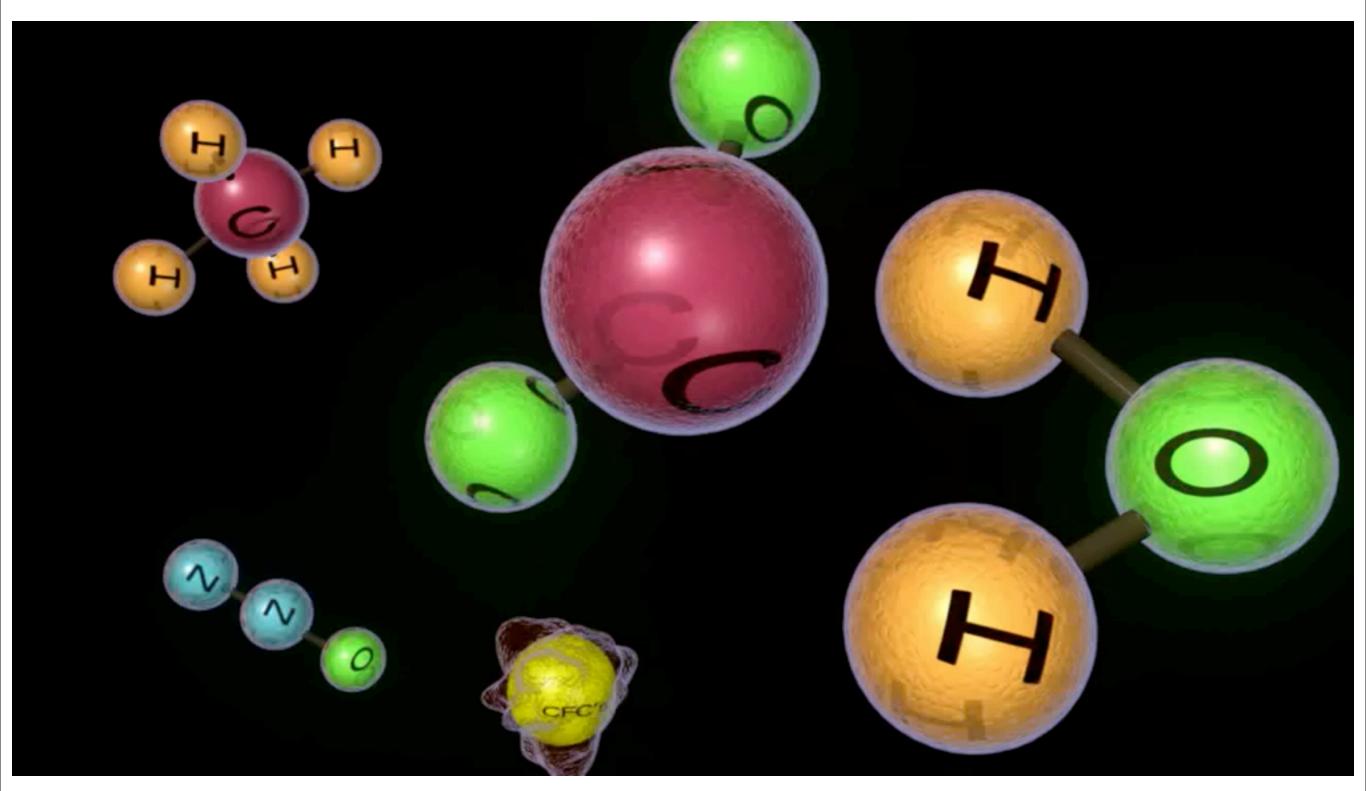


Experimental plots

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

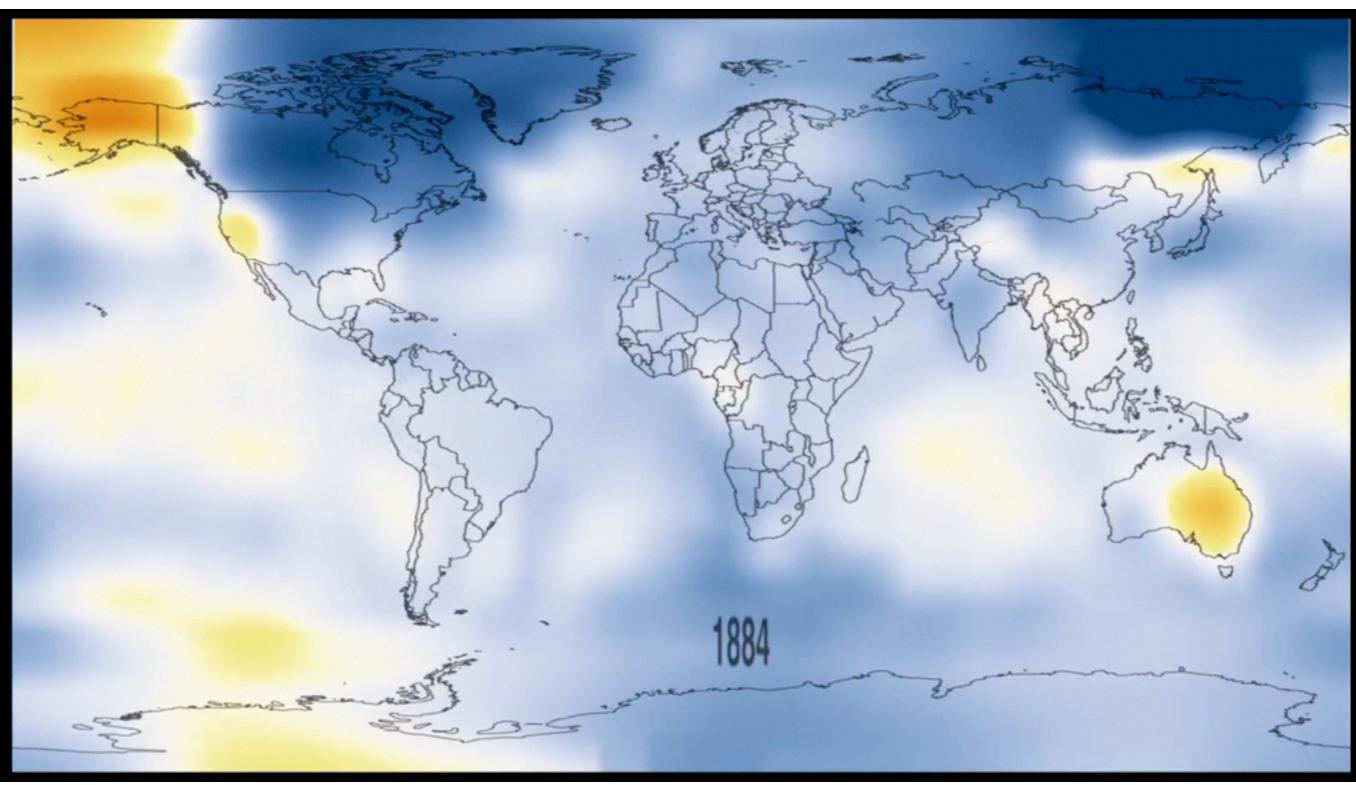
Rising CO₂ levels can have far more reaching effects including but not limited to global warming.

Greenhouse Effect & Climate

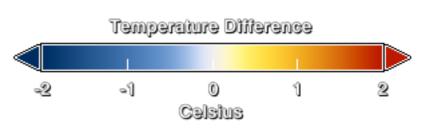


Methane, Nitrogen Oxides, CFC's, Carbon Dioxide, Water Vapor

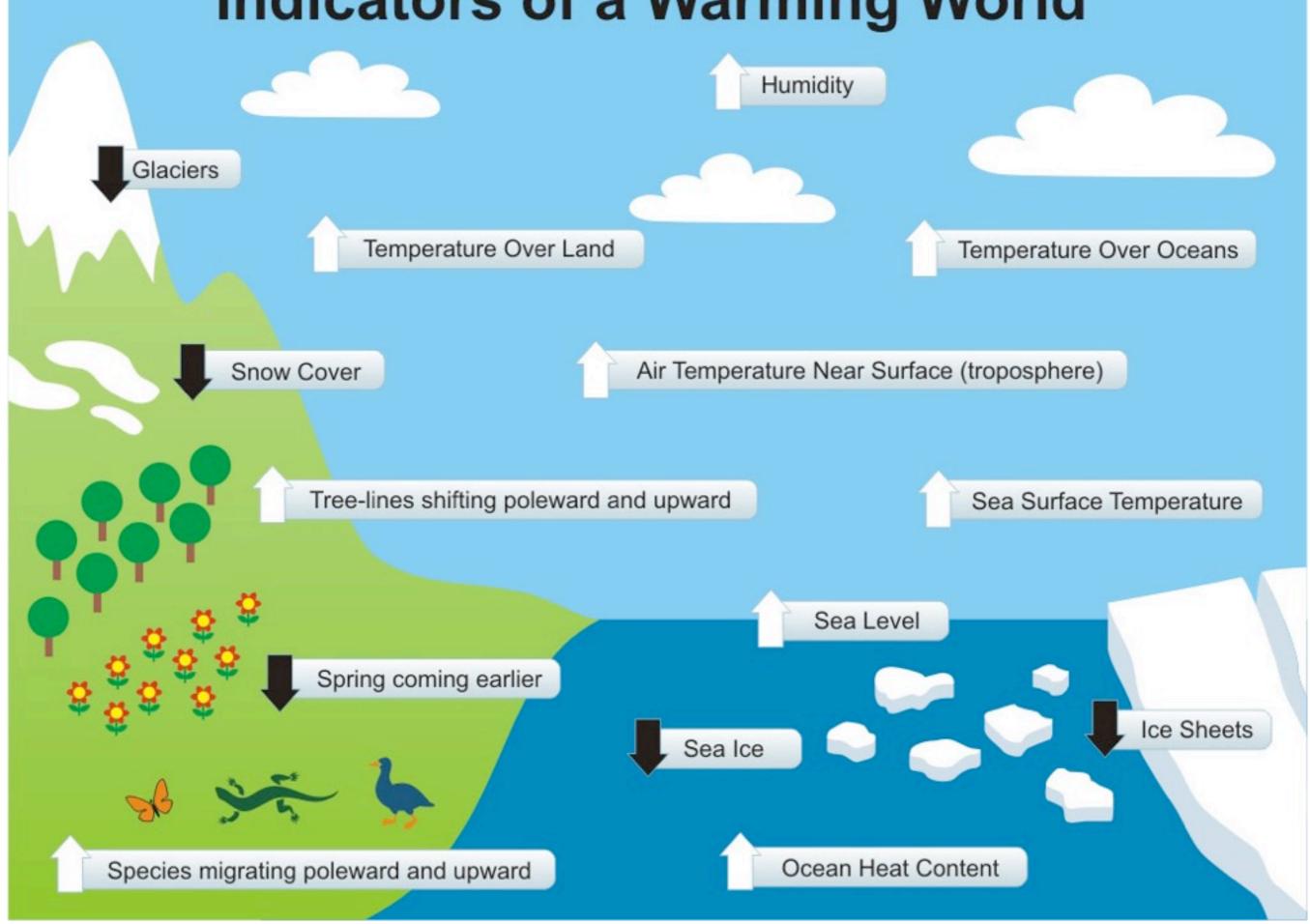
Temperature Differences Over Time



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



Indicators of a Warming World



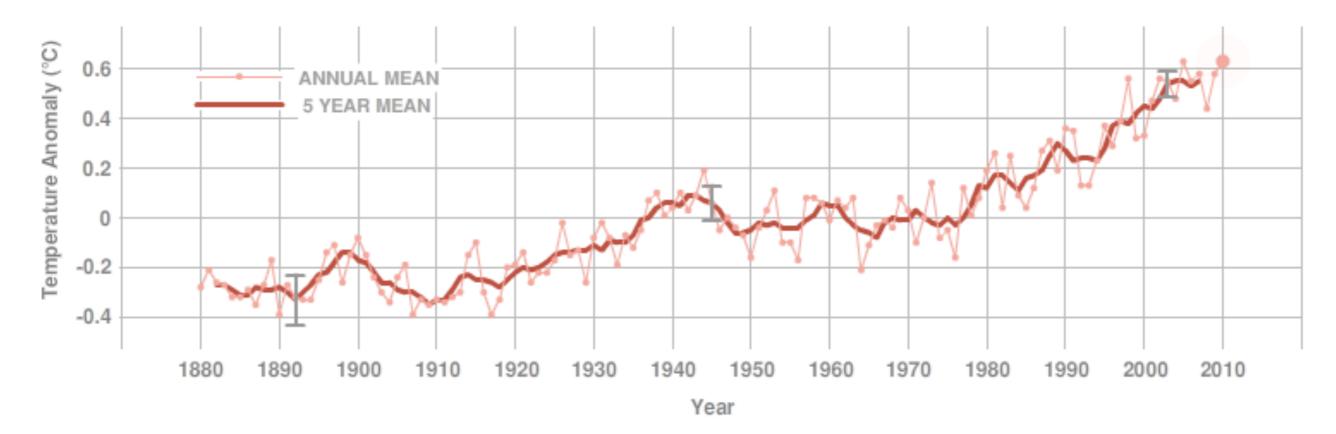
Global Surface Temperature

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

"the last 4 or 5 years, have they been cooler or

"would it be fair to say then that there has been

the last 13 years compared to 1998?"

Objective Data

Global temperature is still rising and 2010 was the hottest recorded.

a cooling of global temperatures at least over The last decade 2000-2009 was the hottest on record.

Politician

"we've actually had global cooling in the last ten years"

7 December 2009 (Source)

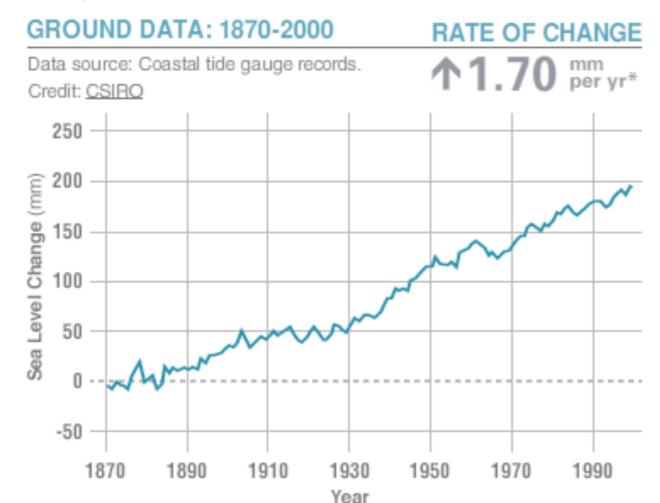
"What the science says is that temperatures peaked out globally in 1998. So we've gone for 10 plus years where the temperatures have gone down."

14 April 2009 (Source)



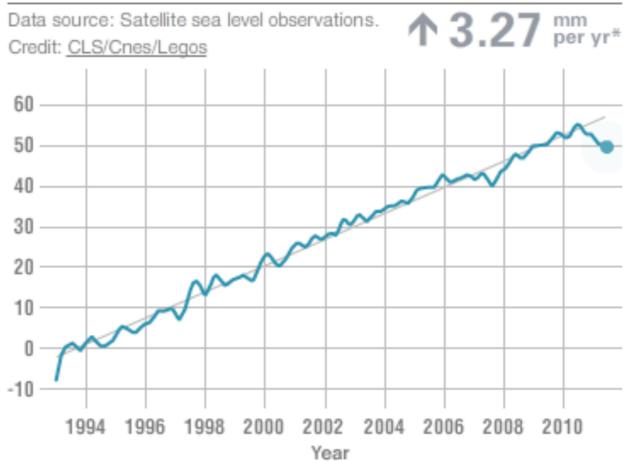
Sea Level

Data updated 8.5.11



^{*}estimate for 20th century

SATELLITE DATA: 1993-PRESENT RATE OF CHANGE



Inverse barometer applied and seasonal signals removed.

^{*}estimate for 1993-2010

Arctic Sea Ice

Data updated 2.23.11

AVERAGE SEPTEMBER EXTENT

Data source: Satellite observations

Credit: NSIDC





Land Ice

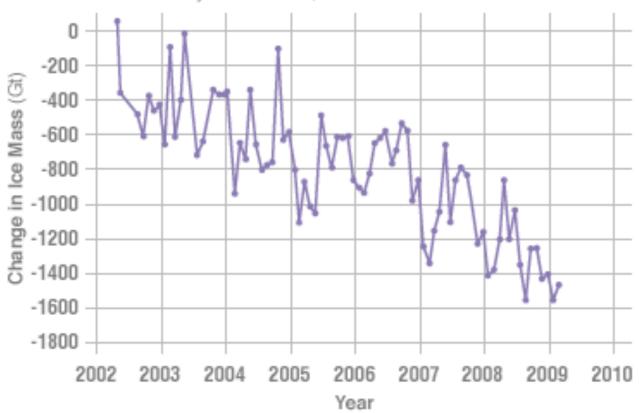
Data updated 2.23.11

♣ download data

ANTARCTICA MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.

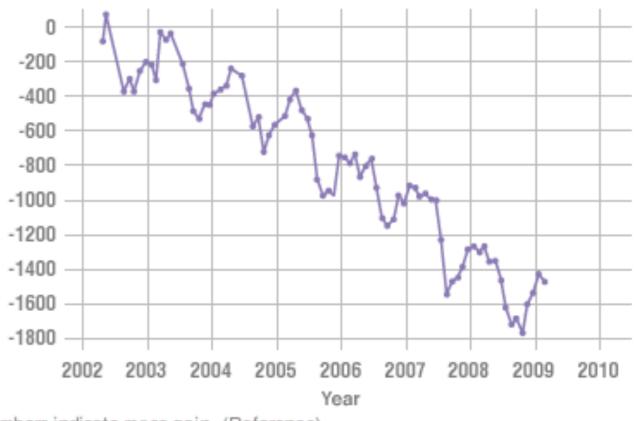
Credit: NASA/University of California, Irvine



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. 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



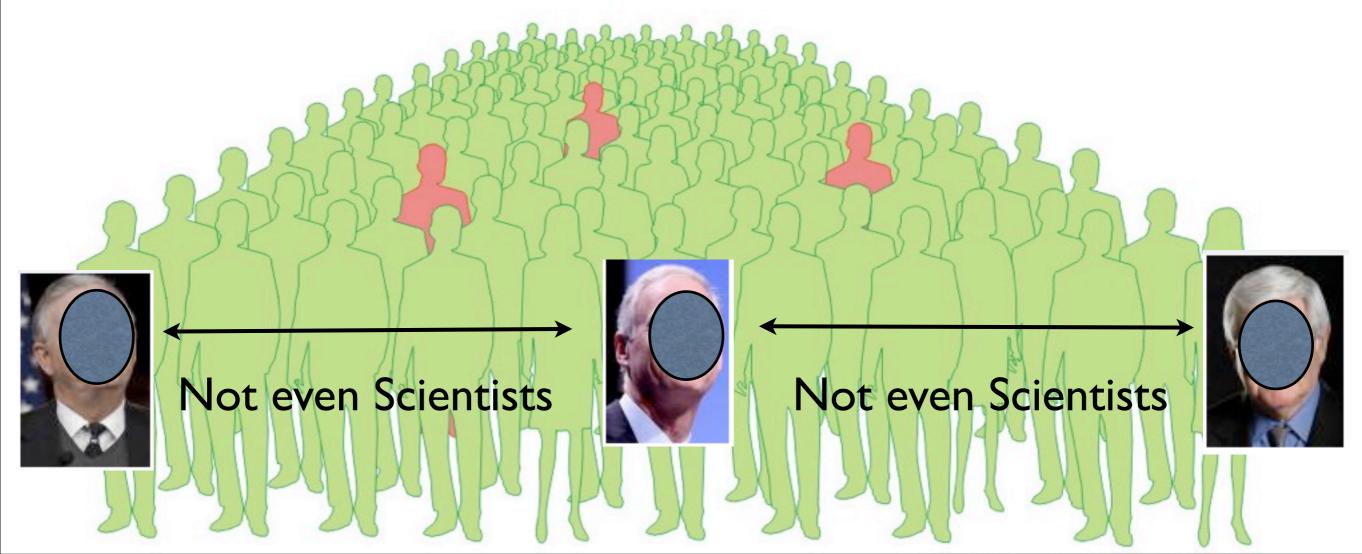
Warming oceans

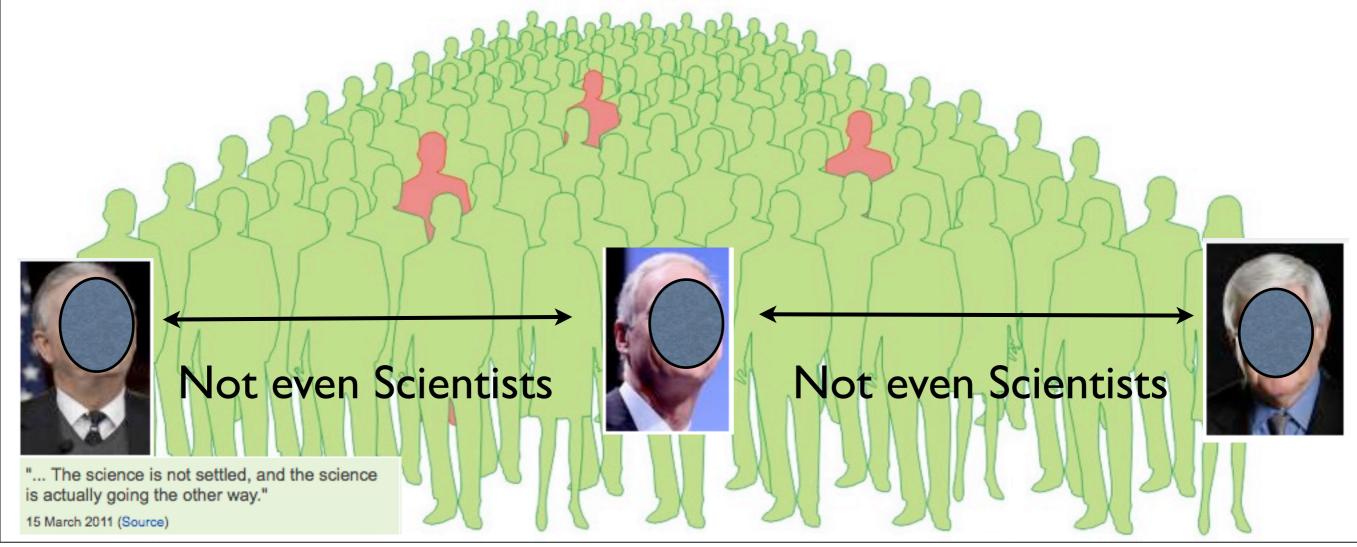
The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969.

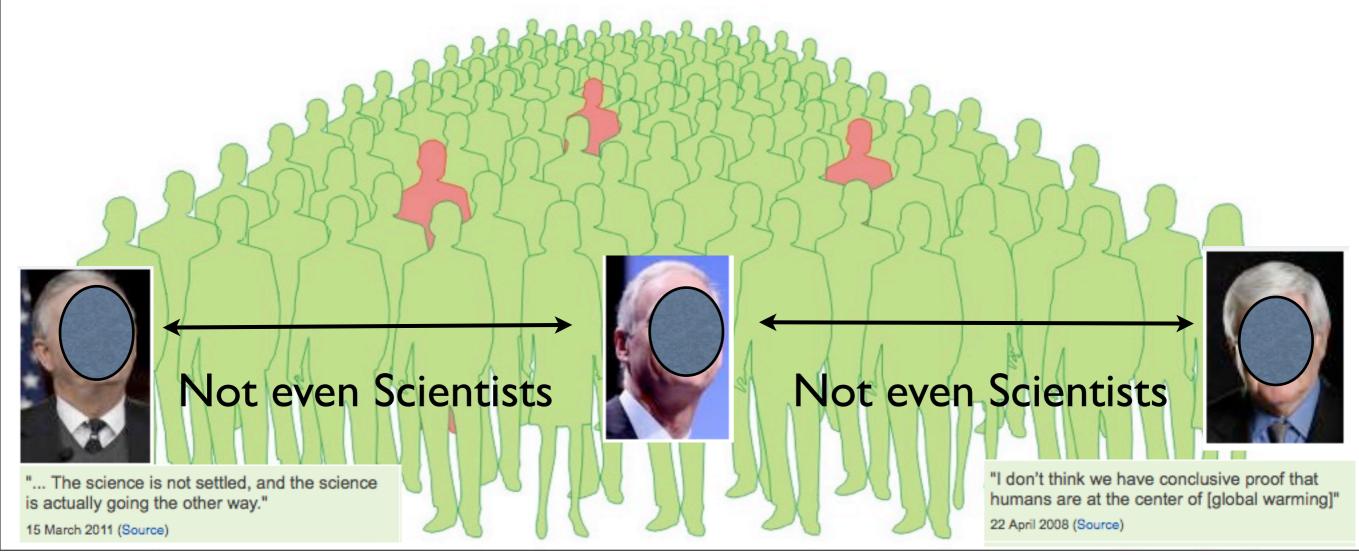


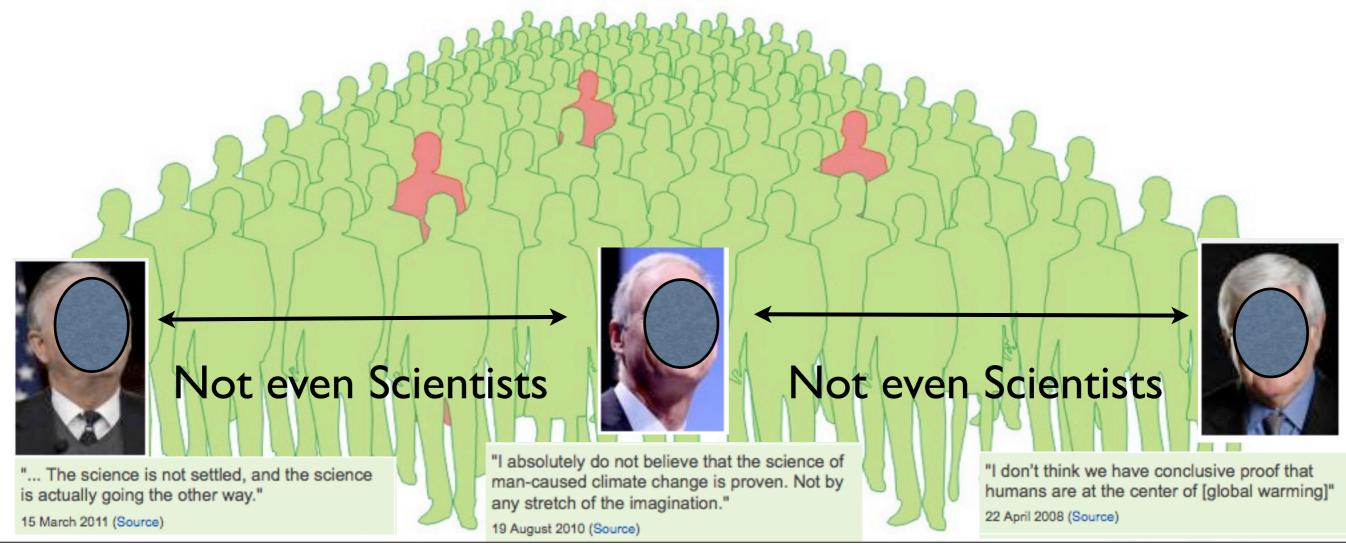
Extreme events

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.

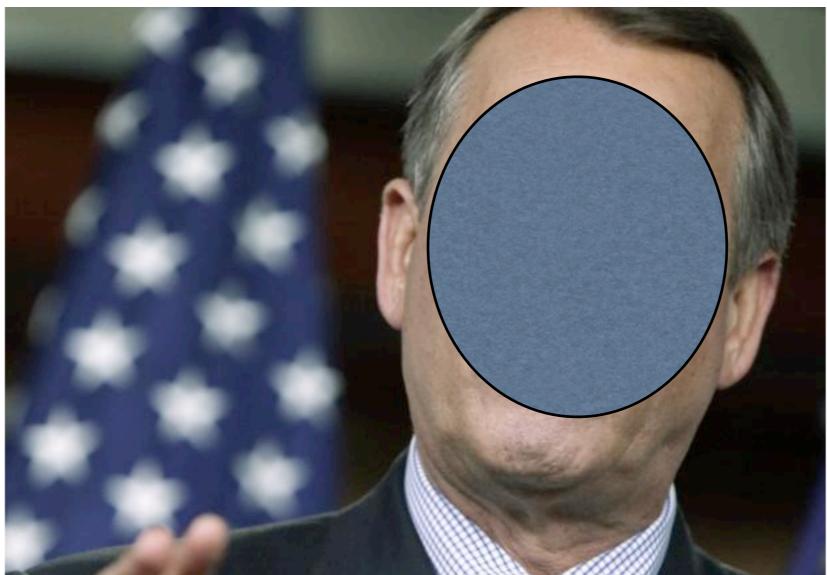








Despite Evidence of Climate Change Skeptics continue to make statements that illustrate their ignorance of science



"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."

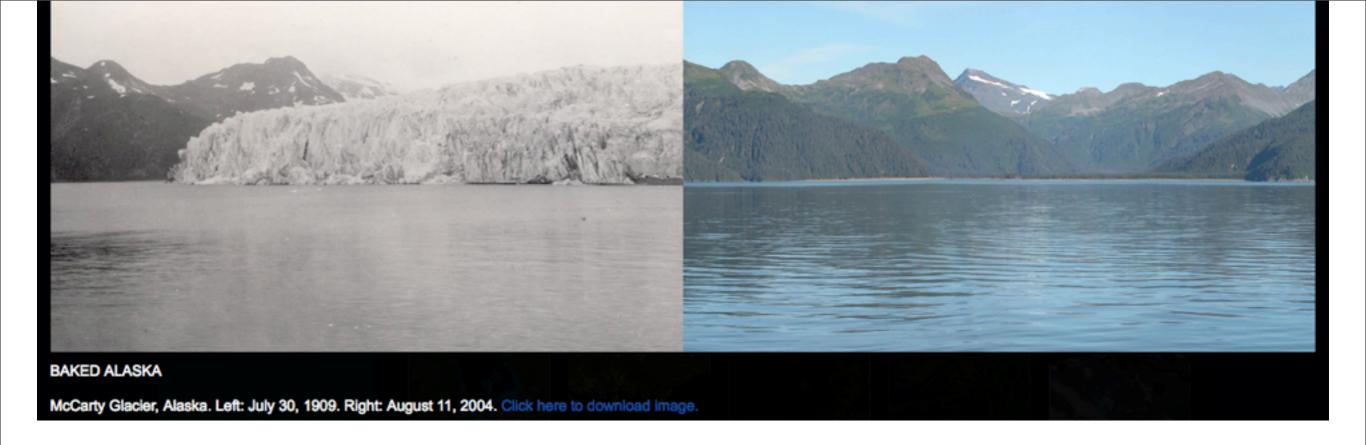
/ ABC's This Week / April 2010

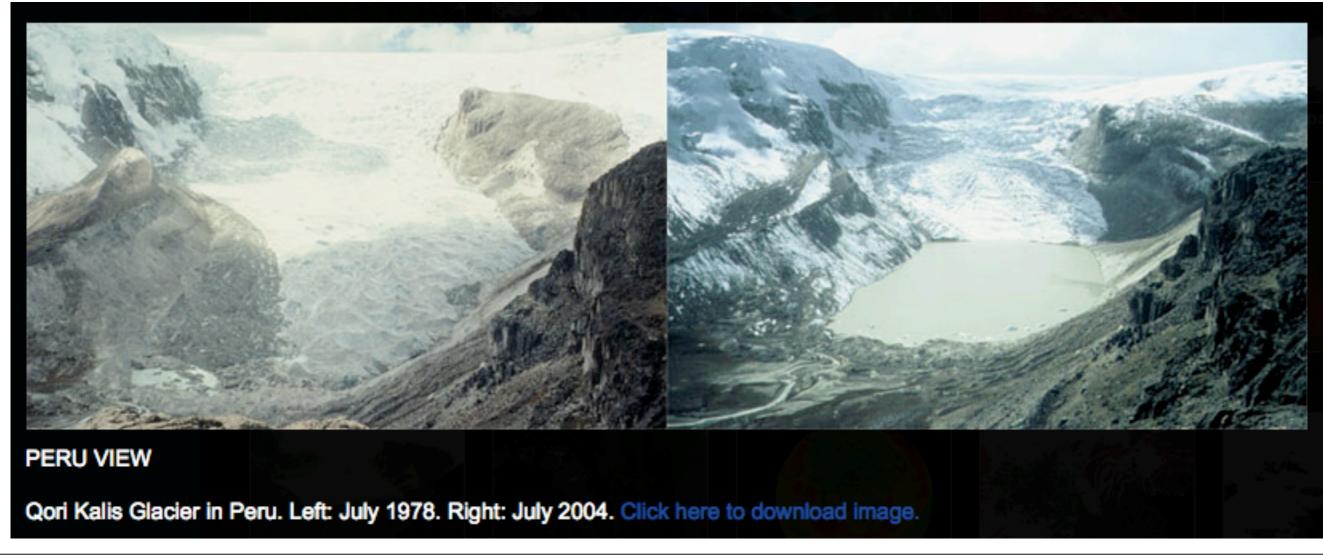
Despite Evidence of Climate Change Skeptics continue to make statements that fly in the face of data



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













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.

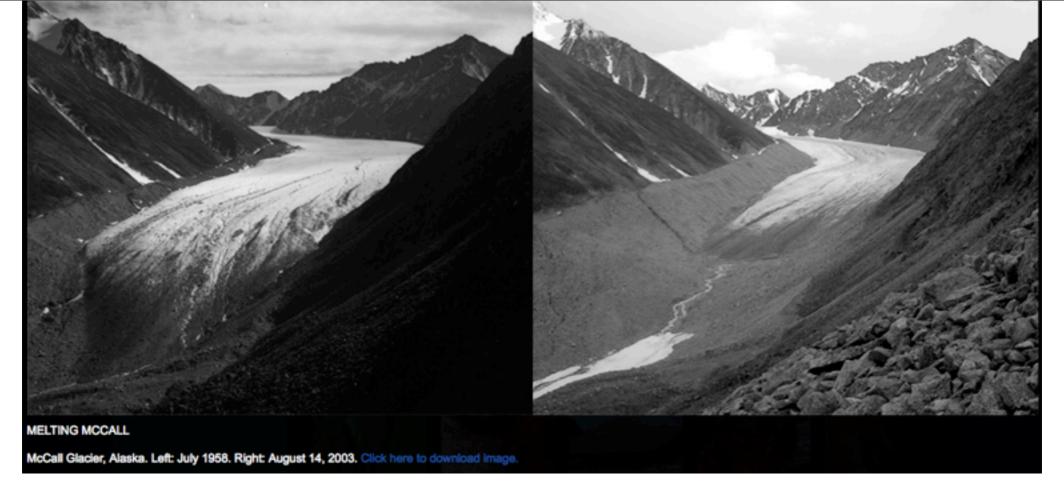
















MOUNT KILIMANJARO, AFRICA

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?!@#?



Satellites indicate shrinking sea ice in the video.

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



Satellites indicate shrinking ice covering Greenland in the video.

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



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

As a footnote consider this...





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

Depletion of Atmospheric Ozone

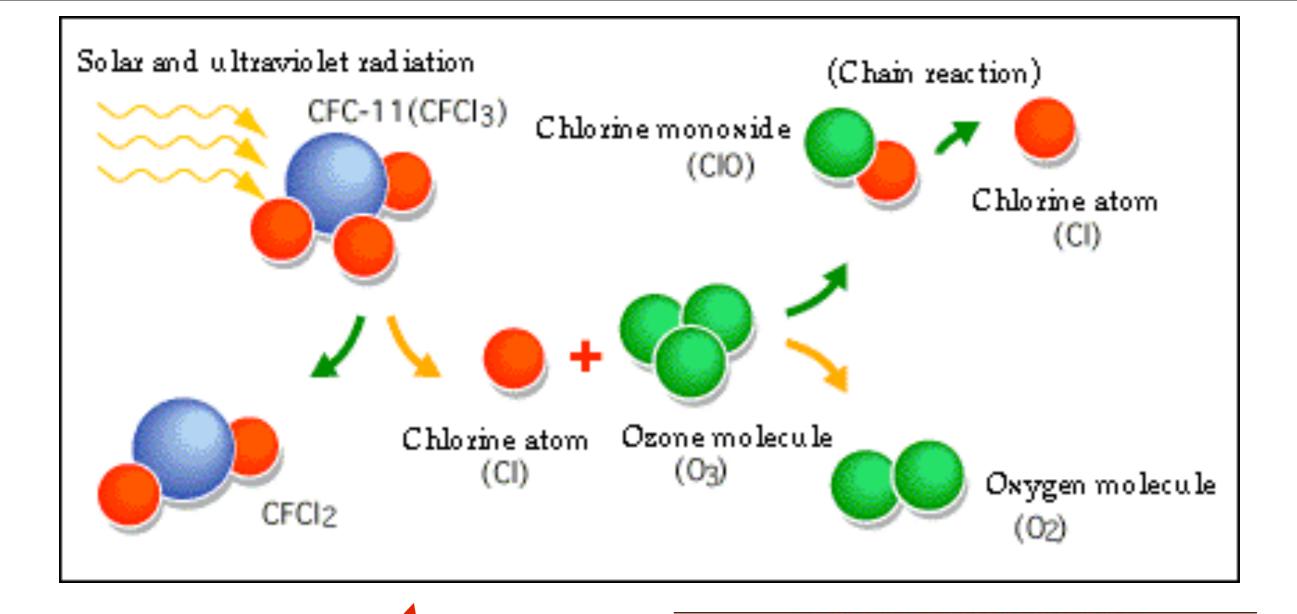
- Like atmospheric levels of CO₂ the levels atmospheric ozone (O₃)
 have been changing as well
 - Life on earth is protected from the damaging effects of UV radiation by layer of ozone located in the stratosphere.
- Ozone has changed as a result of human activities.

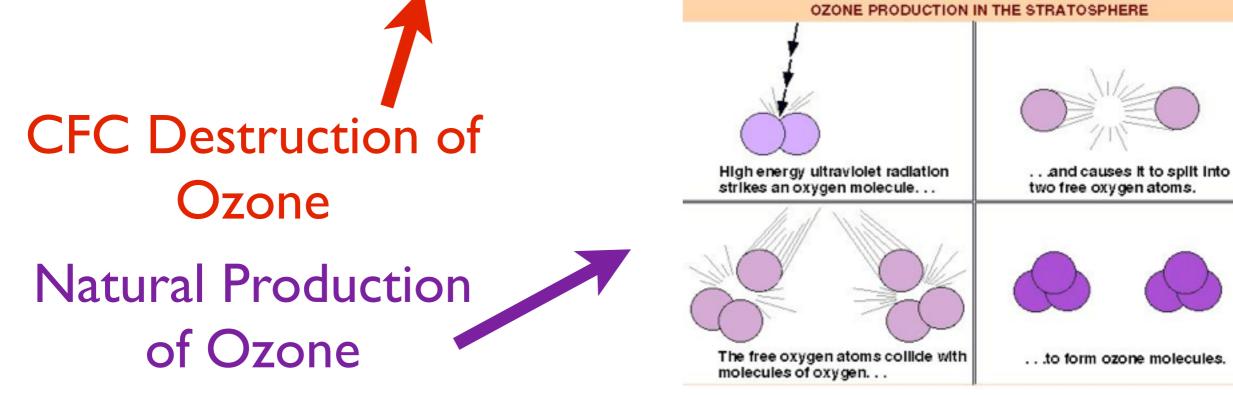
 The destruction of ozone results primarily from the accumulation of chloroflourocarbons (CFC's), chemicals used in refrigeration

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





Essential knowledge 4.A.6: Interactions among living systems and with their environment result in the movement of matter and energy.

g. Many adaptations of organisms are related to obtaining and using energy and matter in a particular environment. [See also 2.A.1, 2.A.2]

The Examples I could use here are "endless" virtually all adaptations of living organisms revolve around obtaining energy and matter OR surviving long enough to reproduce

A worthwhile endeavor might involve YOU brainstorming some ideas of examples that we learned about this year

Learning Objectives:

LO 4.14 The student is able to apply mathematical routines to quantities that describe interactions among living systems and their environment, which result in the movement of matter and energy. [See SP 2.2]

LO 4.15 The student is able to use visual representations to analyze situations or solve problems qualitatively to illustrate how interactions among living systems and with their environment result in the movement of matter and energy. [See SP 1.4]

LO 4.16 The student is able to predict the effects of a change of matter or energy availability on communities.[See SP 6.4]