On T.R.A.C.K.S.

Teaching Resource Activities and Conservation to Kansas Students

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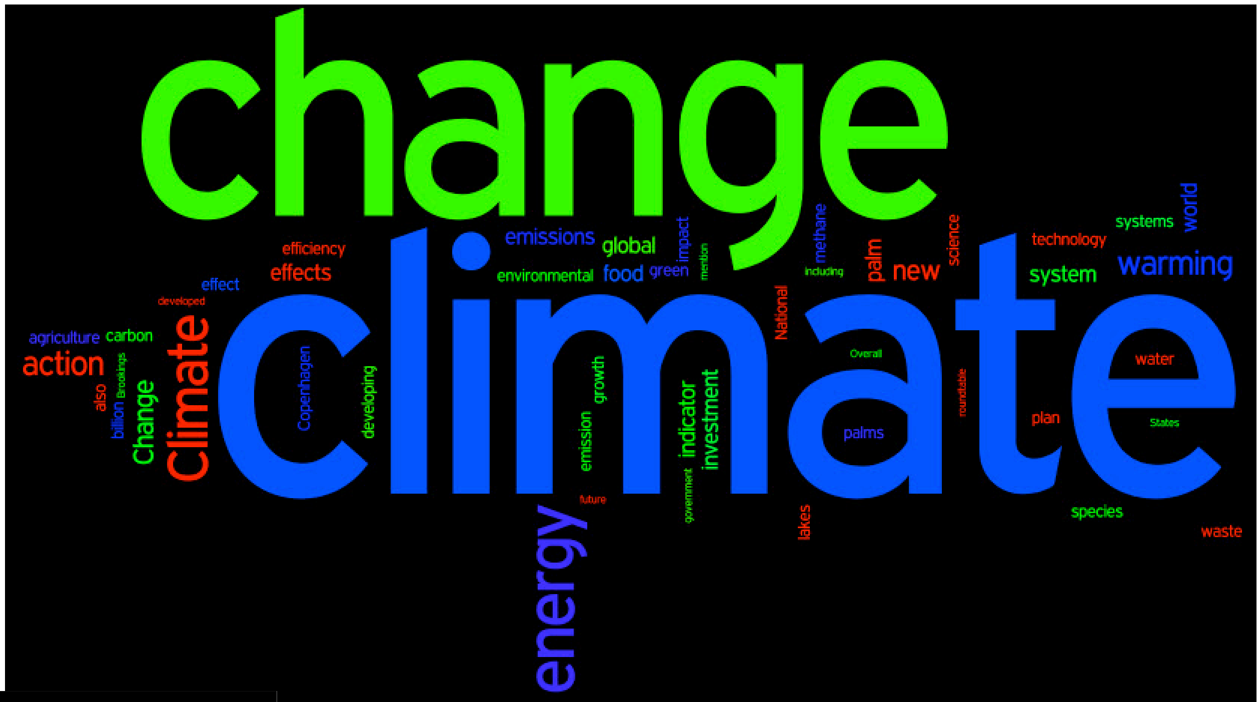


INSIDE...

Don't Miss Our Next Issue:

A Guide to Kansas ECO-Meets

The Scientific World View

There has been a lot of talk about climate change but not much agreement among policy makers and citizens alike. Dispute hangs in the air over even the most basic facts of this issue--that the world is warming and that human activity is the dominant cause. Why?

Scientist have done a lousy job at communicating the facts of this issue because of the understanding gap between what scientists say and how the average American interprets what they say. Too many Americans are not "scientific literate" and scientific training actually works against the scientist when it comes to communication. Words that seem perfectly common to scientists may seem like jargon to the public. Worse yet, scientists use many words that mean something very different to much of the public.

Take the word "theory" for example. To most people, a "theory" is just a hunch, or an opinion, or even just speculation. Someone may have a "theory" about why their car died but they are actually using the word theory to mean "hypothesis". "Theory" to a scientist means something very different.

As used in science, a theory is an explanation or model based on observation, experimentation, and reasoning

As used in science, a theory is an explanation or model based on observation, experimentation, and reasoning, especially one that has been tested and confirmed as a general principle helping to explain and predict natural phenomena. A theory explains an entire group of related phenomena. Einstein's theory of relativity or Darwin's theory of evolution explain the observations made by many different scientists, not just one, and fit the facts observed to date. The theory of climate change increased by human activity is an explanation based on observations and experimentation to explain and predict this phenomena.

Let's not forget what "science" really is. Science is a process for producing knowledge. The process depends both on making careful observations and deriving theories for making sense out of those observations. It is possible for a theory to be disproven if new evidence comes to light. In science, the testing and improving theories, even occasionally discarding theories, goes on all the time. When someone comes up with a new or improved version of a theory that explains more phenomena or answers more important questions than the previous version, the new one eventually takes its place. Theories are ultimately judged by their results. But, what theories are not, is a guess or a hunch. When scientist propose a theory of climate change, they have volumes of information gathered and the theory proposed fits the information at hand with the best possible correlation.

Scientific knowledge is durable and modifying ideas (rather than outright rejection) is the norm in science. Science, however, cannot provide complete answers to all questions. Some matters cannot be usefully examined in a scientific way, such as beliefs of the existence of supernatural powers or beings. Beliefs, by their very nature, cannot be proved or disproved.

Sooner or later, the truth of a scientific claim is settled by referring to observations of phenomenon. Science always demands evidence and scientists concentrate on getting accurate data. To make their observations, scientists use their own senses, instruments to enhance those senses, or instruments that can detect senses humans can't (such as magnetic fields). The essence of science is validation by observation. But it is not enough for scientific theories to only fit what is already known. Theories should also fit additional observations that were not used in formulating the theories in the first place. That is to say that theories should have *predictive powers.* This is not always about predicting events of the future but it can apply to events of the past such as the building of mountains or the origins of human beings.

In the end, it should be remembered that what we are striving for is a "scientific literate"

America to understand the complexity of the global challenges ahead. *Science for All Americans* defines a science literate person as one who:

- is familiar with the natural world.
- understands some of the key concepts and principles of science and has a capacity for scientific ways of thinking
- is aware of some of the important ways in which mathematics, technology, and science depend on one another.
- knows that science, mathematics, and technol ogy are human enterprises and what that implies about their strength and weaknesses.
- is able to use scientific knowledge and ways of thinking for personal and social purposes.

While this is a worthy goal, we must recognize we are not there in our understanding of science with the average American. Let's go back to re-examine some basic scientific words related to climate change and how they are generally viewed.

The word "enhanced" to lay people sounds good as in to make better or improve but in the discussion about climate change, an "enhanced" greenhouse effect means to intensify. Not a good thing.

Positive to most people means good and negative means bad but when climate scientists talk about positive feedbacks in the greenhouse effect this is an upward trend and an increase in the effect. Not usually a good thing.

Risk usually means something that might happen but is not likely, such as a person's house burning down. Global warming is not a risk but a reality. Uncertainty generally means we do not know if something will happen, so uncertainty about global warming is taken to mean it might not happen at all. This is not what the scientists mean. They mean there is a range of possible warming, depending on the level of emissions and how sensitive the climate is to the emissions.

How about weather verses climate? What is the difference? People often complain that we can't predict the weather two weeks from now so how can we predict climate 50 years from now? Weather is the state of the atmosphere at a specific time and with respect to its effect on life and human activities. It is the short term variations of the atmosphere, as opposed to the long term, or climatic, changes. Climate is the historical record and description of average daily and in seasonal weather events that help describe a region. Statistics are generally drawn over several decades. Climate is a statistical average that is predictable based on large-scale forces, while weather is subject to chaotic forces that make it difficult to predict. (Definition from The Weather Channel for Kids, www.weatherchannelforkids.com)

So, hasn't climate always changed ? Yes it has but to use the argument that this current warming is only natural is to use the flawed logic that because lightning strikes cause forest fires, forest fires cannot also be caused by careless campers. There are many lines of evidence that show that the current warming is due primarily to human activity.

Is global warming responsible for recent streaks of floods, heat waves, wildfires, and hurricanes? The science suggests that it is. We have "loaded" the atmosphere with excess greenhouse gases, therefore, we are loading the dice towards more of these extreme events. The data shows this is already occurring for many phenomena and models have long projected these changes.

Climate change is not a debate. For people to take climate change seriously and support appropriate responses, people need to feel sure it is happening and it is caused primarily by humans. The rise in global temperatures is a fact *(see, e.g. Intergovernmental Panel on Climate Change (IPCC)[2007]*, which calls the warming "unequivcal"). IPCC, 2007 and *American Association for the Advancement of Science, 2006* along with other authoritative scientific bodies, have attributed most of the warming of the past 50 years to human activity. Yet, people still believe there is a debate among scientists and only 41% of Americans believe humanity is the primary cause of global warming.

Our task is to become scientific literate and realize what is fact and contrast that with sensationalism by the media and political agendas. The words of science have very specific meanings and they are not used lightly. Beware of the "psuedo-science" often spouted in political agendas and media frenzies.

Glossary of Climate Change

Carbon Dioxide (CO_2): A colorless, odorless gas that naturally exists in the earth's atmosphere. The major source of manmade CO_2 emissions is from the combustion of fossil fuels. Carbon dioxide is the primary greenhouse gas and is known to contribute to global warming and climate change.

Carbon Footprint: The measure of the impact human activities have on the environment in terms of the amount of greenhouse gases produced, measured in units of carbon dioxide.

Climate Change: According to the EPA, climate change refers "to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer)."

Composting: A process whereby organic wastes—food, paper, and yard wastes—decompose naturally, resulting in a product rich in minerals and ideal for gardening and farming as a soil conditioner, mulch, resurfacing material, or landfill cover.

Eco-friendly: Having little or no impact on the native ecosystem.

Ecological Footprint: The area of land and water needed to produce the resources to entirely sustain a human population and absorb its waste products with prevailing technology.

Fossil Fuels: Carbon-rich deposits in the Earth, such as petroleum (oil), coal, or natural gas, derived from the remains of ancient plants and animals and used for fuel. These are non-renewable resources with a finite supply. They are pollutive, but are so commonly used due to their traditionally low costs.

Fuel Cell: A technology that uses an electrochemical process to convert energy into electrical power. Often powered by natural gas, fuel cell power is cleaner than grid-connected power sources. In addition, hot water is produced as a by-product that can be used as a thermal resource.

Geothermal Energy: Heat that comes from the Earth's interior.

Global Warming: An increase in the global mean temperature of the Earth that is a result of increased emissions of greenhouse gases that are trapped within the Earth's atmosphere. Global warming is believed to have adverse consequences, such as climate change and a rise in sea levels. The scientific community is in general agreement that the Earth's surface has warmed by about 1°F over the past 140 years.

Greenhouse Gases: Any gas that absorbs infrared radiation in the Earth's atmosphere. Carbon dioxide, methane, and nitrogen oxides are of particular concern due to their length of time they remain resident in the atmosphere. Primarily, the emissions of coal-fired power plants and combustion engine automobiles produce carbon dioxide that prevents excess heat from escaping through the atmosphere, thereby raising the surface temperature of the earth. More than 80 percent of all U.S. greenhouse gases are carbon dioxide emissions from energy-related sources.

Green Power: Electricity generated from renewable energy sources. This includes solar, wind, biomass, geothermal, and hydroelectric power. Kyoto Protocol: In December 1997, a delegation from 160 countries came together on climate change and adopted an agreement, under which the industrialized nations agreed to reduce their greenhouse gas emissions by an average of 5.2 % below 1990 emissions levels by 2010.

LEED (Leadership in Energy and Environmental Design): A voluntary, consensus-based national rating system for developing high-performance, sustainable buildings. Developed by the USGBC, LEED addresses all building types and emphasizes state-of-the-art strategies for sustainable site development, water savings, energy efficiency, materials and resources selection, and indoor environmental quality. LEED is a practical rating tool for green building design and construction that provides immediate, measurable results for building owners and occupants.

Non-Renewable Energy Resources: Energy resources that cannot be restored or replenished by natural processes and therefore are depleted through use. Commonly used non-renewable energy resources include coal, oil, natural gas, and uranium.

Off the Grid: A system that runs on renewable energy sources independent of a conventional public utility grid.

Ozone: A form of oxygen found naturally that provides a protective layer shielding the Earth from ultraviolet radiation's harmful effects on humans and the environment. Ground level ozone is the primary component of smog, produced near the Earth's surface through complex chemical reactions of nitrogen oxides, volatile organic compounds, and sunlight.

Recycling: The reprocessing of materials into new products, which generally prevents the waste of potentially useful materials, reduces the consumption of raw materials, lowers energy usage, and decreases greenhouse gas emissions compared to virgin production.

Reuse: To use products, such as glass bottles or shipping crates, repeatedly in the same form.

Renewable Energy: Energy resources, such as wind, solar, hydroelectric, biomass, geothermal, ocean thermal, and wave power, that replenish themselves within a short period. Although non-pollutive, some displace habitats and require large tracts of land.

(Rapidly) Renewable Resource: Organic materials, like bamboo or corn, that have a short regeneration period to full maturation, usually in stark contrast to the material they are replacing.

Sustainability: The practice of meeting the needs of the present without depleting resources or harming natural cycles for future generations.

Volatile Organic Compound (VOC): Any organic compound that evaporates at room temperatures and is hazardous to human health, causing poor indoor air quality. Many VOCs found in homes, such as paint strippers and wood preservatives, contribute to sick building syndrome because of their high vapor pressure. VOCs are often used in paint, carpet backing, plastics, and cosmetics. The United States EPA has found concentrations of VOCs in indoor air to be, on average, two to five times greater than in outdoor air. During certain activities, indoor levels of VOCs may reach 1,000 times that of the outside air.

Wind Power: The conversion of energy from the wind into electricity. Surplus electricity is often stored in a battery storage system for later use, or the power is passed back to the utility, making the electric meter turn in reverse.

Climate Change

(from the Climate and Energy Project)
www.climateandenergy.org/Explore/Climate Change/Index.htm#

Climate change is the result of global warming – and climate science has established that human-generated emissions of greenhouse gases are a big part of the problem. This cycle presents immediate and significant risks for the American Midwest.

How It Works.

Causes. Greenhouse gas (GHG) emissions trap excess heat in the earth's atmosphere. They have many sources, but a disproportionate amount comes from burning fossil fuels for electricity generation and transportation. Emissions also result from poor land use practices, such as overtilling and deforestation.

Effects on weather. When the climate warms, the weather changes. Scientists estimate that the earth's average temperature will rise between 4-7° Fahrenheit this century. A warmer earth is generally less able to regulate temperature shifts, so weather patterns become more extreme.

In particular, the hydrologic cycle intensifies. Droughts become more severe, while rainstorms and floods become longer, more intense, and increasingly occur out of season. Evapotranspiration could increase up to 30%.

Effects on people. When climate and weather change, the environment changes, and humans feel the shock. Increased disease vectors, wildland fire frequency and intensity, sea level rise, species extinction and the loss of biodiversity, rising food and energy prices, water shortages, national security problems, etc. - these impacts affect everyone, but agricultural economies are vulnerable in special ways.

What We Can Do.

Question. Some of these changes are already underway. Others are still projections based on climate models. Many everyday citizens insist that other worrisome changes are occurring, even though science has not yet demonstrated that their observations are connected to global warming.

Prepare. Based on everyday common sense and the scientific evidence, it makes sense to be careful. Even if we can't stop some of these forces, we should still try – but we should prepare for the unexpected as well. Many details of climate change are still uncertain (such as timing, scale, and regional variations), but the trends are unmistakable.

Act. We need to fight climate change by -

lowering human-generated greenhouse gas emissions
reducing our dependence on fossil fuels
developing renewable energy
becoming more energy efficient
using land and natural resources in a sustainable manner
consuming less energy in the first place.

Energy Consumption in the US

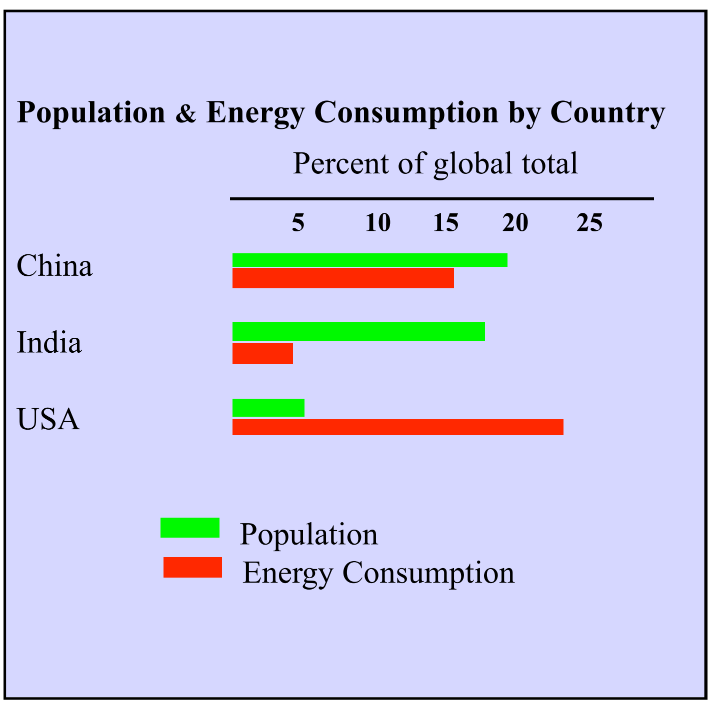
Energy consumption is one measure of our environmental impact, and in my mind, at the heart of the issues of sustainability and global warming. As energy is consumed and depleted, pollution increases. And unlike a lot of environmental factors that are hard to measure, we have very precise records of how much energy is being consumed each year by each country of the world. So we can estimate how much environmental impact each country creates.

You may be surprised to see how much energy people consume... but remember that we're not just looking at their electricity bills! Every time you buy something, you're also buying all the energy that was used to produce that thing. Every time you pay your taxes, you're paying for photocopies, business trips, and air conditioning in government offices. *In fact, on average, every time anyone spends an American dollar, the energy equivalent of half a liter of oil is burned to produce what that dollar buys!*

Let’s focus on the United States. Why? Because it consumes far more energy than any other country -- more than China and Russia put together. Just five percent of the world's population consumes 23% of its energy! That's really extravagant! Imagine if you wasted five times more gasoline than your neighbors... or five times more food... or produced five times more garbage. Your neighbors wouldn't be very happy! Yet, that's what we're doing.

How much energy does the average American consume? Well, if you list the countries of the world in order by their population, the U.S. comes in third... but the combined energy consumption of the other five largest added together doesn't match U.S. energy consumption! *In other words, the 5% of the world's population that lives in the U.S. has more environmental impact than the 51% that live in the other five largest countries.*

That's why we've singled out the United States for comparison here ... our energy consumption is truly extraordinary!



Six Americas on Global Warming

With only five percent of the world's population, the United States produces about 25 percent of the world's greenhouse gas emissions. Thus, Americans' energy use, consumer choices, and support for policies to reduce greenhouse gas emissions will largely influence the success – or failure – of global efforts to limit human-caused climate change. Further, protecting Americans' health and wellbeing from the impacts of climate change will require coordinated and sustained efforts by cities, counties, states, and the nation as a whole. Yet climate change remains a relatively low priority among the American public, many of whom perceive it as a distant problem in both time and space, and who remain largely unaware of the potential threat to the health and welfare of people in the United States and around the world.

To reduce greenhouse gas emissions, avert the worst potential consequences, and prepare for the impacts that can no longer be avoided, the United States and other countries must constructively engage millions of people and thousands of organizations in climate change solutions. Throughout human history, individuals and societies have mobilized to meet and overcome new challenges, but never before has so much rested on the need to change so many so fast.

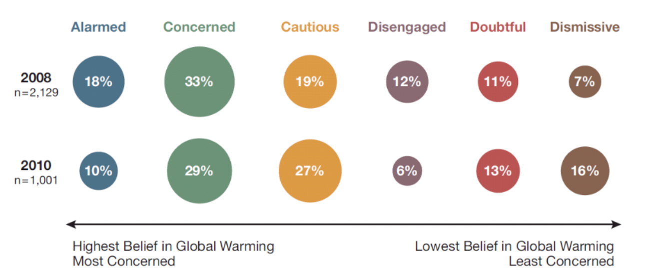
It is critical to recognize, however, that people are different, with widely diverse backgrounds, experiences, knowledge, and values. There is a spectrum from those Americans who know a lot about climate change, to those who have never heard of it. Likewise, some Americans have taken personal action to reduce their own carbon footprint, while others have not. At a deeper level, different groups within American society emphasize different values, which strongly shape their interpretations and preferred solutions to climate change. Thus, the American public does not respond to climate change with a single voice – there are many different groups that each respond to this issue in different ways. Constructively engaging each of these groups in climate change solutions will therefore require tailored approaches.

The report, "Global Warming's Six Americas" describes the six unique audiences within the American public that each respond to this issue in a different way. It is based upon an extensive nationally representative survey of American adults conducted in the fall of 2008 and again in 2010. The survey included questions about Americans' climate change beliefs, attitudes, policy preferences and actions, including energy efficiency and conservation behavior, consumer behavior, and political behavior. The study also measured Americans' commitments to different social values and attitudes, civic engagement, media use, and demographic characteristics.

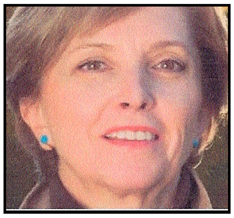
This analysis identifies six distinct groups of American adults. These groups differ dramatically with regard to what they believe about global warming, how engaged they are with the issue, what they are doing about it, and what they would like to see the United States do about it. They also differ dramatically with regard to size: the largest segment represents 29% of the U.S. adult population, and the smallest only 10%. These six audience segments describe a spectrum of concern and action about global warming, ranging from the Alarmed (10% of the population), to the Concerned (29%), Cautious (27%), Disengaged (6%), Doubtful (13%) and Dismissive (16%).

Figure 1: Proportion of the U.S. adult population in the Six Americas, 2008 and 2010

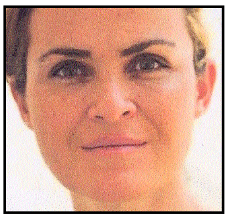
Proportion represented by area



WHICH ONE ARE YOU?



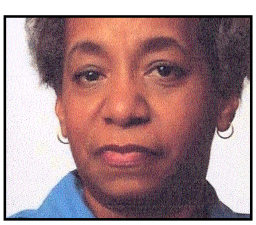
Overall, the **Alarmed** are the segment most engaged in the issue of global warming. They are very convinced it is happening, human-caused, and a serious and urgent threat. The Alarmed are already making changes in their own lives and support an aggressive national response.

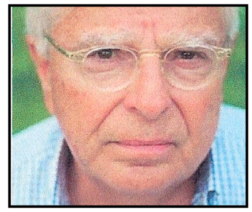


The **Concerned** are also convinced that global warming is a serious problem, but while they support a vigorous national response, they are distinctly less involved in the issue – and less likely to be taking personal action – than the Alarmed. They believe global warming will start harming people in the United States in the next 10 years.

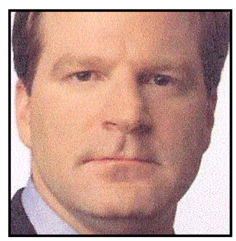
The **Cautious** also believe that global warming is a problem, although they are less certain that it is happening than the Alarmed or the Concerned; they don't view it as a personal threat, and don't feel a sense of urgency to deal with it. They believe global warming will not start to harm people in the United States for roughly 35 years.

The **Disengaged** haven't thought much about the issue at all, don't know much about it, and are the most likely to say that they could easily change their minds about global warming.They believe global warming will not start to harm people in the United States for roughly 30 years.





The **Doubtful** are evenly split among those who think global warming is happening, those who think it isn't, and those who don't know. Many within this group believe that if global warming is happening, it is caused by natural changes in the environment, believe global warming won't harm people for many decades into the future, if at all, and say that America is already doing enough to respond to the threat. They believe global warming will not start harming people in the United States for at least 100 years.



Finally, the **Dismissive**, like the Alarmed, are actively engaged in the issue, but on the opposite end of the spectrum; the majority believe that warming is not happening, is not a threat to either people or non-human nature, and strongly believe it is not a problem that warrants a national response. They believe global warming will never harm people in the United States.

None of the six Americas are fully confident that humans both can and will successfully reduce global warming. They have dramatically different beliefs, however, about the possibility of reducing global warming and in the number of positive and negative outcomes they expect if the United States takes action.

Visit the websites:
http://climatechange.gmu.edu or
http://research.yale.edu/environment/climate/.

Evidence of Climate Change

Remembering that climate refers to average weather over a long period of time (at least 30 years), what evidence do we have that the earth's climate is changing? Plenty. And, most importantly, from many different disciplines of science.

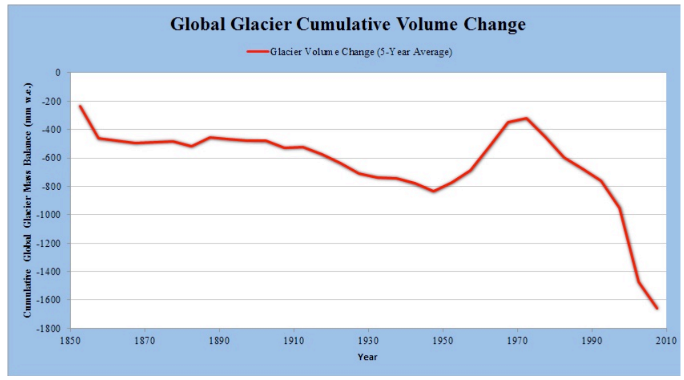
Evidence from Glaciers

Glaciers present some of the most "concrete" evidence that the planet is warming. Nearly all of the planet's glaciers are shrinking and the trend is increasing. Glaciers respond quickly to atmospheric conditions--when air temperatures warm, glaciers retreat--and because they are so sensitive to changes in temperatures, they provide clues to global warming.

Glacier mass balance is measured through a variety of techniques and it is the measurement used to compare a glacier from year to year. Over the period of 1946-2009, World Glacier Monitoring Service (WGMS) has monitored 228 glaciers. There are 30 glaciers in 9 diffent mountain ranges that have been continuously measured since 1976 and 11 of these have been measured since 1960 and earlier. These are considered "reference glaciers". The WGMS report of 2009 stated

> The average mass balance of the glaciers with available long-term observation series around the world continues to be **negative**, with tentative figures indicating a further thickness reduction of 0.5 and 0.6 metres water equivalent (m w.e.) during the hydrological years 2008 and 2009, respectively. The new data continues the global **trend in strong ice loss** over the past few decades and brings the cumulative average thickness loss of the reference glaciers since 1980 at about 12.5 m w.e.

The trend information is the most important piece here. On any given year, you will see a handful of glaciers actually grow--increased moisture in some areas may result in increase snowfall....but the vast majority are shrinking and the trend for glaciers to shrink is increasing. In 2002, 77% of glaciers were shrinking but in 2003, 94% were shrinking.



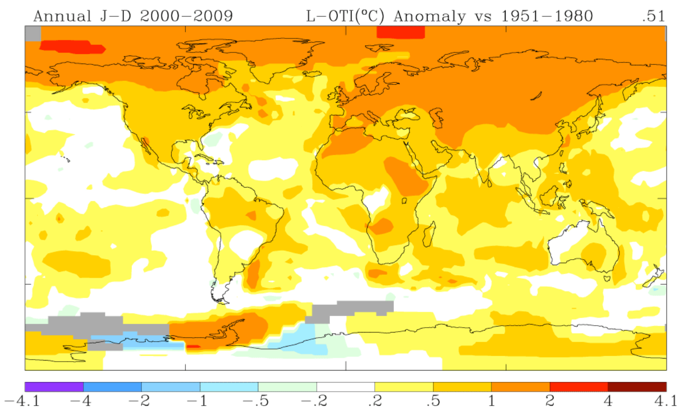
Observations of ice shelves on the edge of the Antartic and ice sheets in Greenland confirm these ice masses are also melting and receding.

Evidence from Temperature Data

January 2000 to December 2009 was the warmest decade on record. For the last three decades, data from the Goddard Institute for Space Studies (GISS) has shown an increase of about 0.2°C (0.36°F) per decade for a total average global temperature increase of 0.8°C (1.5°F) since 1880. (1880 is the year modern scientific instrumentation became available to monitor temperatures precisely.) A clear warming trend is present which is the important message to glean from the information. Annual temperatures may vary substantially due to tropical the El Nino-La-Nina cycle but averaging the temperature over a five to ten year period minimizes the variability.

2009 was tied for the second-warmest year in the modern record despite an unseasonably cool December in much of North America. 2005 is the warmest year on record but 2009 tied with a cluster of other years--1998, 2002, 2003, 2006 and 2007--

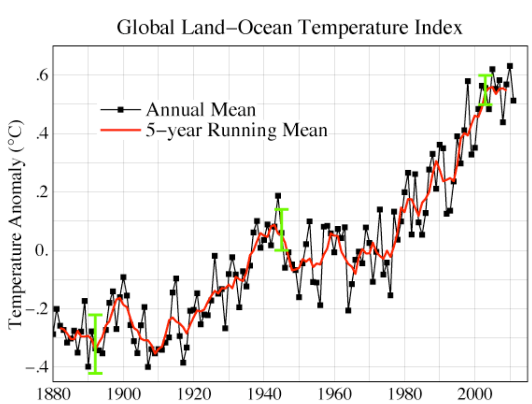
as the second warmest year since recordkeeping began. The year 2011 is the 9th warmest in the GISS analysis. Nine of the ten warmest years are in



This map shows the 10-year average (2000-2009) temperature anomaly relative to the 1951-1980 mean. The largest temperature increases are in the Artic and the Antarctic Peninsula. (Image credit: NASA/GISS)

the 21st century, the only exception being 1998, which was warmed by the strongest El Niño of the past century.

It is important to point out that differences among different years can often lead to alternative analysis with different rankings for the warmest years, however, the magnitude of global temperature change of the past century is in **good** agreement among GISS, NCDC (NOAA national Climatic Data Center), and HadCRUT (UK Met Office Hadley Center).



The graph shows global annual surface temperatures relative to 1951-1980 mean temperatures. (Image credit:NASA/GIFF)

Evidence from Sea Level Rise and Warming Oceans

Global sea level rose about 17 cm (6.7 in) in the last century. The rate in the last decade, however, is nearly double that of the last century.

The total volume of the ocean can change for a variety of reasons, primarily from the addition of water to the ocean from the land or from the expansion/contraction of the ocean water as it warms/cools. The level **does not** change uniformly (like a bathtub) as water is added or taken away. There can be large regions of the ocean with decreasing sea level when the overall Global Mean Sea Level is increasing.

From 1955 to 1995, ocean thermal expansion is estimated to contribute 0.4mm/year to sea level rise. This woud be less than 25% of the observed rise over that time period. For 1993 to 2003, thermal expansion was estimated at 1.6mm/year or about 50% of the observed sea level rise of 3.1mm/year. Since 1969, the upper 2,300 feet of the oceans have warmed by 0.302°F.

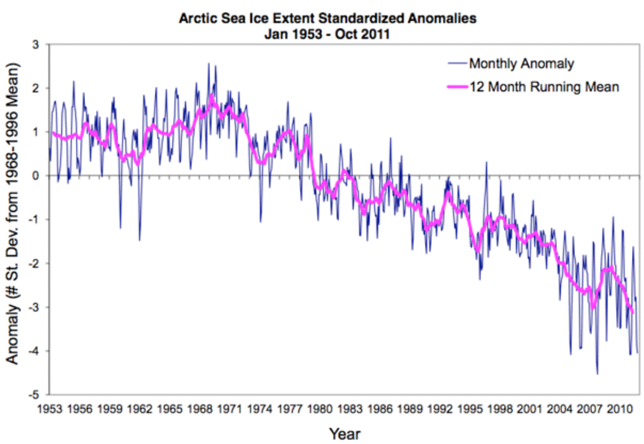
http://www.cmar.csiro.au/sealevel/sl_data_cmar.html

Evidence from Declining Arctic Sea Ice and Shrinking Ice Sheets

The Greenland and Antarctic ice sheets have decreased in mass. Data from NASA's Gravity Recovery and Climate Experiment show Greenland lost 36 to 60 cubic miles of ice per year between 2002 and 2006, while Antarctica lost about 36 cubic miles of ice between 2002 and 2005.

Sea ice is frozen seawater that floats on the ocean surface. In the Arctic, some sea ice persists year after year, whereas almost all Southern Ocean or Antarctic sea ice is "seasonal ice," meaning it melts away and reforms annually. While both Arctic and Antarctic ice are of vital importance to the marine mammals and birds for which they are habitats, sea ice in the Arctic appears to play a more crucial role in regulating climate.Sea ice regulates exchanges of heat, moisture and salinity in the polar oceans. It insulates the relatively warm ocean water from the cold polar atmosphere except where cracks, or leads, in the ice allow exchange of heat and water vapor from ocean to atmosphere in winter. The number of leads determines where and how much heat and water are lost to the atmosphere, which may affect local cloud cover and precipitation.

Passive microwave satellite data reveal that, since 1979, **winter Arctic ice extent has decreased about 3 to 4 percent per decade** The Arctic sea ice (September minimum extent) reached new record lows in 2002 (15.3 percent below the 1979-2000 average), 2005 (20.9 percent below), and 2007 (39.2 percent below). In 2007, Arctic sea ice broke all previous records by early August—a month before the end of melt season. Arctic sea ice set no new records in 2008 through 2010, although sea ice extents remained substantially below the 1979-2000 average in those years. In 2011, Arctic sea ice nearly tied the 2007 record low (34.5 percent below the 1979-2000 average). The 2011 low was significant because, while 2007 had unusually sunny skies and strong winds leading one to think of more melting—2011 saw more normal conditions, yet still reached nearly the same result.



Excerpted from:
http://nsidc.org/sotc/sea_ice.html

Evidence from Ocean Acidification and CO_2 Levels

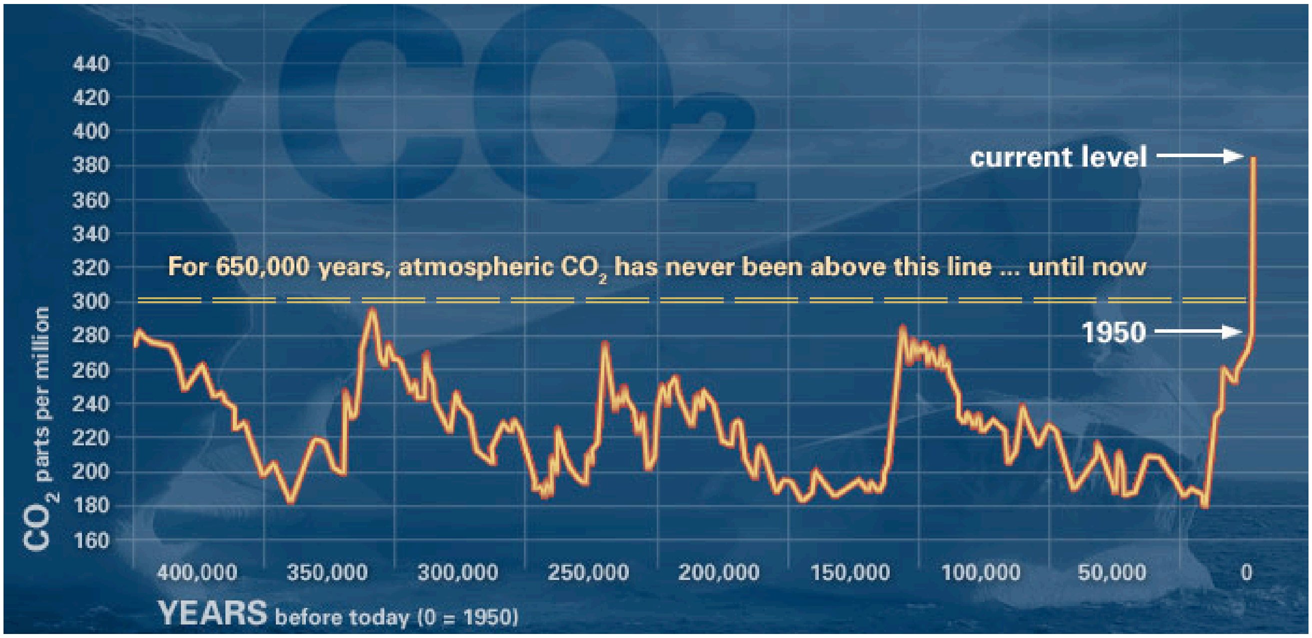
When carbon dioxide (CO_2) is absorbed by seawater, chemical reactions occur that reduce seawater pH, carbonate ion concentration, and saturation states of biologically important calcium carbonate minerals. Since the beginning of the Industrial Revolution, the pH of surface ocean waters has fallen by 0.1 pH units. Since the pH scale is logarithmic, this change represents approximately a 30 percent increase in acidity. Future predictions indicate that the oceans will continue to absorb carbon dioxide and become even more acidic. Estimates of future carbon dioxide levels, based on business as usual emission scenarios, indicate that by the end of this century the surface waters of the ocean could be nearly 150 percent more acidic, resulting in a pH that the oceans haven't experienced for more than 20 million years.

Ocean acidification is expected to impact ocean species to varying degrees. Photosynthetic algae and seagrasses may benefit from higher CO_2 conditions in the ocean, as they require CO_2 to live just like plants on land. On the other hand, studies have shown that a more acidic environment has a dramatic effect on some calcifying species, including oysters, clams, sea urchins, shallow water corals, deep sea corals, and calcareous plankton. When shelled organisms are at risk, the entire food web may also be at risk. Today, more than a billion people worldwide rely on food from the ocean as their primary source of protein. Many jobs and economies in the U.S. and around the world depend on the fish and shellfish in our oceans.

Excerpted from
http://www.pmel.noaa.gov/co2/story/What+is+Ocean+Acidification%3F

CO_2 Levels

The heat-trapping nature of carbon dioxide and other gases was demonstrated by physicist John Tyndall in the mid-19th century and he was the first to recognize the Earth's natural greenhouse effect. This greenhouse effect makes life as we know it possible. Atmospheric gases, a.k.a "greenhouse gases", esentially act as a blanket by trapping some of the heat radiated by the Earth, making the suface warmer than it would be otherwise. During the past century, however, human activities have substantially increased the amount of green-



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)

house gases in the atmosphere, changing the composition of the atmosphere and influencing the climate. Carbon dioxide is one of the principal greenhouse gases that enters the atmosphere because of human activities. Others include methane, nitrous oxide, fluorinated gases and water vapor.

Carbon dioxide is emitted primarily through the burning of fossil fuels (oil, natural gas, and coal), solid waste, and trees and wood products. It is also released through natural processes such as respiration and volcano eruptions.

Humans have increased atmospheric CO_2 concentrations from 280 parts per million to 379 parts per million in the last 150 years. Thirteen thousand independent scientific experts from countries all over the world (Intergovernmental Panel on Climate Change) concluded there's a more than 90% probability that human activities over the past 250 years have warmed our planet and that human-produced greenhouse gases such as carbon dioxide, methane, and nitrous oxide have caused much of the observed increase in Earth's temperatures over the past 50 years.

Panel's summary: **http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf.**

Can the warming be due to the sun?

It is reasonable to assume that changes in the sun's energy output would cause the climate to change, since the sun is the fundamental source of energy that drives our climate system.

A decrease in solar activity is thought to have triggered the Little Ice Age between approximately 1650 and 1850, when Greenland was largely cut off by ice from 1410 to the 1720s and glaciers advanced in the Alps. But several lines of evidence show that current global warming cannot be explained by changes in energy from the sun:

* Since 1750, the average amount of energy coming from the Sun either remained constant or increased slightly.

* If the warming were caused by a more active sun, then scientists would expect to see warmer temperatures in all layers of the atmosphere. Instead, they have observed a cooling in the upper atmosphere, and a warming at the surface and in the lower parts of the atmosphere. That's because greenhouse gasses are trapping heat in the lower atmosphere.

* Climate models that include solar irradiance changes can't reproduce the observed temperature trend over the past century or more without including a rise in greenhouse gases.

Confronting Climate Change

The following is excerpted from Confronting Climate Change in the U.S. Midwest published by the Union of Concerned Scientists July, 2009 and is available at www.ucsusa.org/global_warming

The climate of the Midwest has already changed measurably over the last half century. Average annual temperatures have risen, accompanied by a number of major heat waves in the last few years. There have been fewer cold snaps, and ice and snow are melting sooner in the spring and arriving later in the fall. Heavy rains are occurring about twice as frequently as they did a century ago, increasing the risk of flooding.

The most dangerous effects of climate change are likely to occur if the global average temperature rises more than two degrees Celsius above where it stood in 1850. Science shows we still have a chance of keeping temperatures below this level if we cut heat-trapping emissions deeply and quickly—and limit atmospheric levels of carbon dioxide to 450 parts per million.

Our analysis considers two different possible futures: one with a lower level of global warming pollution and one with a higher level. These futures represent the best and worst cases of the emissions scenarios described by the international scientific community in 2000 and which have been focal points for scientific analysis ever since. However, they by no means encompass the full range of emissions futures that could plausibly unfold.

Dangerously Hot Summers

Our new analysis projects dramatically hotter summers for the Midwest. This is true under both the lower- and higher-emissions scenarios, but the prevalence of extreme heat is much greater under the higher-emissions scenario. During the historical baseline (1961-1990), big cities such as St. Louis averaged more than 36 days per summer with highs over 90°F. That number rises substantially in the next several decades, and toward the end of the century under the higher-emissions scnario, the city is projected to experience around 105 days over 90°F—essentially the entire summer. Under the lower-emissions scenario that number would be cut by more than one-third.

As for the more dangerous days over 100°F, St. Louis averaged only two or three such days each summer during the historical baseline. But toward the end of the century under the higher-emissions scenario, the city is projected to face more than 43 such days—almost a month and a half. That number would be reduced to 11 under the lower-emissions scenario. Compounding matters is the likelihood that Midwest summers will continue to be humid—probably even more humid. Other cities such as Kansas City will face conditions similar to St. Louis.

The severe heat projected for the Midwest poses serious health risks for its residents. Heat waves already kill more people in the United States each year than hurricanes, tornadoes, floods, and lightning combined-- the average annual death toll of nearly 700 may well be an underestimate, since many deaths are probably misclassified. Studies show that deaths from many causes, including cardiovascular and respiratory disease, increase during heat waves.

The health costs associated with heat waves are not limited to deaths; many other people become sick enough to be hospitalized. In 2005, medical costs related to extreme heat and cold totaled $1.5 billion nationwide.

More dangerous air pollution

In areas where there are local sources of fossil fuel emissions, ground-level ozone—a dangerous air pollutant and the main component of smog—increases at temperatures over 90°F. Since our projections show that, under the higher-emissions scenario, St. Louis will experience such temperatures virtually the entire summer toward the end of the century, the city can expect far more days of unhealthy ozone levels than would occur without global warming.

Another air contaminant of particular concern is small particulate pollution (or soot). Small particulates increase the severity of asthma attacks in children, increase the number of heart attacks and hospitalizations related to cardiovascular disease and asthma, and cause early deaths from heart and lung disease (ALA 2009).The leading source of small particulate air pollution is coal-fired power plants, and as demand for electricity increases in response to rising temperatures, power plants generate more emissions. Therefore, climate change threatens to exacerbate particulate air pollution.

Changes in Storm, Flood, and Drought Patterns

Heavy downpours are already twice as frequent in the Midwest as they were a century ago. While scientists cannot attribute any single storm to climate change, more heavy precipitation can be attributed to climate change that has already occurred over the past 50 years

Our analysis indicates that the warming ahead will make the Midwest substantially more vulnerable to natural disasters. Two findings stand out from the research:

• **Precipitation is more likely to arrive in the form of heavy rains** Heavy rainfalls (defined as more than two inches of rain in one day) are projected to increase by more than 40 percent over the next few decades under either emissions scenario. Toward the end of the century, heavy rainfalls are projected to double in frequency under the higher-emissions scenario and increase by 50 percent under the lower-emissions scenario. The maximum amount of precipitation falling within a one-, five-, or seven-day period is also projected to rise under both scenarios.

• **Winters, springs, and falls will be wetter but summers will be drier.** Precipitation is projected to increase more than 20 percent during winters and springs toward the end of the century under the higher-emissions scenario, and 14 percent during autumns. Meanwhile, summers can expect at least 20 percent less rain. As described above, more of the rain that does fall will be in the form of downpours.

More frequent short-term droughts

Paradoxically, the Midwest could face not only the risk of greater flooding but also the risk of greater drought, although climate projections are less consistent in this regard. The more temperatures rise, the more water evaporates from the soil and plants will require more rainfall just to maintain the same soil moisture levels. However, the Midwest is projected to receive less rain in the summer (when temperatures are hottest), not more. As a result, the likelihood of drought in the region will increase, as overall water levels in rivers, streams, and wetlands are likely to decline. In Missouri, short-term droughts are projected to increase, but long-duration droughts (lasting more than two years) are likely to decline.

Threats to water quality

Heavy rains increase runoff that not only washes pollutants into waterways but—in cities —also causes raw sewage to spill from sewers into rivers. The heavier downpours ahead mean the typical overflows of years past are likely to be exceeded. Thus, raw sewage will flow even more frequently into rivers unless authorities invest in new infrastructure designed to prevent this from happening.

New Threats to Midwest Agriculture

The heat and precipitation changes projected for the Midwest have potentially profound implications for agricultural production. Toward the end of the century, growing seasons are likely to lengthen by three weeks under the lower-emissions scenario and by six to seven weeks under the higher-emissions scenario. Also, rising CO_2 levels have a fertilizing effect on crops. These changes by themselves would increase crop production, but they will be accompanied by many other changes that threaten production, such as heat stress, increased drought and flood risks, and an expansion of crop pests' range.

More heat stress for crops

The extreme summer heat projected for the Midwest, particularly under the higher-emissions scenario, puts the region's crops at significant risk. Corn crops, for example, can fail at 95°F, with the risk increasing the longer the heat lasts. When such hot spells coincide with droughts, as they often do, crop losses can be severe.

The United States lost $40 billion from a 1988 heat wave—mostly due to crop losses. Our analysis projects the frequency with which the Midwest would face three- and seven-day periods of crop-damaging temperatures of 95°F or higher. The possibility of crop-damaging heat waves becoming commonplace in the Midwest within a few decades represents a significant threat to the economy. Crops such as wheat and tomatoes that fail at lower temperatures than corn are even more vulnerable, and the risk is magnified by the other risks described below.

More heat stress for livestock

Extreme heat is also projected to cause heat stress for much of the Midwest's livestock. Dairy cattle are particularly vulnerable to high temperatures, and milk production can decline when temperatures exceed 75°F to 80°F, depending on humidity.

Wider spread of pests

The warmer winters ahead mean that crop pests and pathogens normally kept in check by cold temperatures are projected to expand their ranges northward. A recent study warned that the expanding ranges of corn pests could have a substantial economic impact in the form of higher seed and insecticide costs and lower yields. Already, corn pests cost U.S. producers more than $1 billion annually; the corn earworm alone is responsible for destroying about 2 percent of the nation's corn crop every year, and it has shown resistance to a wide range of insecticides.

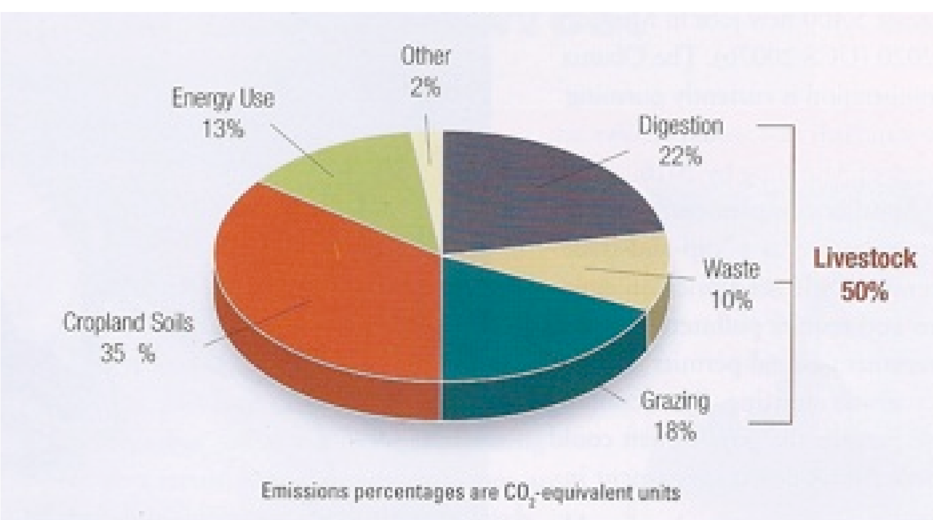
Potentially damaging changes in precipitation

Crops under stress from extreme heat need more rain, but the Midwest is projected to receive less rain in the summer growing season as the climate warms. The projected increase in spring rains could interfere with planting and pose a greater risk of floods like that of 1993, which inundated 20 million acres in nine states Changes in precipitation are likely to limit farmers' ability to take advantage of the longer growing seasons expected to accompany future climate change.

CLIMATE SOLUTIONS

If the Midwest and the world are to avoid the worst consequences of climate change, the Midwest must reduce its emissions by:
• increasing energy efficiency and conservation in industries and homes;
• boosting the use of renewable energy resources such as wind power, advanced biofuels, and geothermal energy;
• improving vehicle fuel efficiency and reducing the number of miles people drive; and
• improving agricultural practices to reduce the release of heat-trapping emissions from soil tilling and fertilizer application.

These actions will also provide benefits such as lower energy costs (after just a few years), new local jobs, and cleaner air and water. A recent analysis by the Union of Concerned Scientists shows that by 2030, businesses and industries in the North Central region would save $8.2 billion by instituting these kinds of changes.



Agriculture generates 7 percent of total U.S. heat-trapping emissions, including three potent global warming gases: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Half of these emissions come from livestock production, one-third from the cultivation and fertilization of cropland (which decreases its ability to absorb carbon), and the rest from energy used for power generation, transportation, and construction (USDA 2008).

Suggested Reading for Teachers on Climate Change

A non-scary, action-oriented, and inspiring look at how scientists do their work, what they are discovering about global warming, and how kids are already learning about this through Citizen Science. Kids can make a difference!

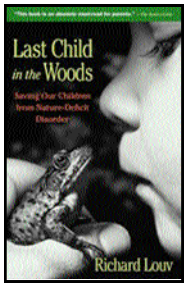
How We Know What We Know About Our Changing Climate is already one of the most honored and recommended science books for kids.

*American Meteorological Assn. Louise J. Batton Authors Award 2009
*Science Magazine/AAAS/Subaru Best Middle School Science Book
*Award Press Release Benjamin Franklin Award (Gold) John Burroughs *2009 Nature Books for Young Readers Winner Book of the Year
Awards, May 2009 --
*National Science Foundation "NSTA Recommends" book by the
National Science Teachers Association Featured in interview on BBC
America, 18 November 2008

*Teacher's Guide is also available. Go to www.howweknowclimatechange.com more information

Last Child in the Woods

A review of Richard Louv's "Last Child in the Wood" by Diane Gordon
Director of Hooked on Nature's Children & Nature Program



For the past few years I have been presenting Children and Nature workshops throughout the San Francisco Bay Area. These workshops, developed under the leadership of Joann Lundgren, a former primary school principal, were inspired by the words of Thomas Berry, "Teaching children about the natural world should be treated as one of the most important events in their lives." Every presentation begins the same way — asking participants to recall and share a treasured childhood memory of their experience with nature. One story inspires another—and then it happens—every time. Someone will shake their head wistfully, sigh, and say, "But our kids can't do that any more." And everyone sadly nods in agreement. It is that regret, "Our kids can't do that any more," that inspired Richard Louv's new book *Last Child in the Woods: Saving Our Children from Nature Deficit Disorder.* Louv, who writes for the San Diego Tribune and serves on the advisory boards of the National Scientific Council on the Developing Child and Parents magazine, spent 10 years traveling around the country gathering material for this book. (The reference section of the book includes seven pages of notes and three pages of suggested reading.) His interviews with child-development researchers, environmentalists, parents, children, college students, teachers, scientists. and religious leaders led him to the conclusion that baby boomers are probably the last generation to have run wild in the woods, freely explored the nearby creek bed, or built dens and tree houses in nearby vacant lots. Children born after 1980 seldom hear the words "Go and play outside." With few exceptions, theirs is a contained and constrained generation, with little or no direct experience of the natural world.

Urban growth and suburban sprawl have swallowed up vast acres of open land. Legal restraints that would have been unthinkable 30 years ago have further restricted children's outdoor play. Trees in parks and playgrounds have been cordoned off to prevent tree climbing and possible lawsuits. Some condominium, cooperative and homeowners' associations even ban private gardens and discourage free outdoor play, and there are local communities that require permits to build even the most primitive tree house.

Louv tells of schools, under pressure from administrators and parents to increase test scores, that have eliminated hands-on nature study from the curriculum and, in some cases, even cancelled outdoor recess. The busy lives of today's over-stretched and over-stressed parents allow little time for outdoor activities, and even good intentions have unintended consequences. Ordinances designed to protect endangered flora and fauna have eliminated access to wide swaths of seashore, marsh, meadowland, and wilderness. No wonder children are driven indoors to the lure of electronic entertainment, ipods, video games, and TV.

Unlike earlier generations, many of today's parents see the outdoors as a dangerous place. Fears— of strangers and kidnappings, of gangs and drug dealers taking over parks and vacant corner lots, of encroaching wildlife from mountain lions to virus-bearing mosquitoes—while genuine, have also been sensationalized by the media. In the author's words, "We have scared children straight out of the woods and fields."

As a result, children are exhibiting what Louv has labeled "Nature Deficit Disorder." Although the term does not appear in any medical lexicon, the author uses the term to describe a set of symptoms linked to our separation from nature. These include an increase in Attention Deficit Hyperactivity Disorder (ADHD) and childhood obesity, lack of creativity and curiosity, ignorance of local flora and fauna, loss of respect for nature and the living world, and a diminishing sense of community.

Fortunately, there is an antidote for nature deficit disorder—getting children back into the wild. The latest research demonstrates that when children have hands-on experiences with nature, even if it is simply in the weed lot at the end of the street, they reap the benefits. Researchers cite diminishment in levels of ADHD, fewer incidents of anxiety and depression, improved self-esteem, enhanced brain development, higher levels of curiosity and creativity, and a sense of connectedness to the community and the environment.

To provide all children with access to nature requires rethinking our current societal and cultural infrastructures. Models already exist, both in Europe and here in the States, and Louv devotes the second half of the book to exploring them. He cites contemporary examples of schools that use the surrounding ecological community as their classroom, often with astoundingly successful outcomes, including improved test scores. He looks at urban planning concepts that incorporate natural corridors for wildlife, energy-self-sufficient urban malls that merge nature into their design, city rooftop gardens, and green public spaces. "Surprisingly, one of the best examples of what the future could hold is the city of Chicago," writes Louv. Under the leadership of Mayor Richard Daley, who aims to make Chicago the greenest city in the nation, the municipality has already restored 28 miles of boulevard gardens, and turned 21 acres of underused city land and abandoned gas stations into pocket parks and 72 community gardens. City parks have incorporated areas of restored prairie land, and City Hall boasts a 30,000-square-foot roof garden that helps insulate the building, absorbs excess storm water, and acts as a giant air purifier. It also houses two beehives and 4,000 honeybees, which yielded 150 pounds of honey in the first year.

Despite the seriousness of its subject, Last Child in the Woods, is a delightful read. Louv is a consummate storyteller, and the book is replete with stories and personal reminisces. He recounts a conversation he had with Robert F. Kennedy, Jr, who serves as senior attorney for the Natural Resources Defense Council and is President of Riverkeeper, an organization that has helped bring the Hudson River back from its watery, polluted grave. "I was known as the family's nature child," recalls Kennedy. "I spent every afternoon in the woods when I was growing up. I loved finding salamanders, crayfish, frogs. My room was filled with aquariums, filled, from the time I was six years old."

Richard Louv is convinced that such early nature experiences are essential if we are to produce tomorrow's creative thinkers and change agents. To help prove his point he asked his teenage son, Matthew, to look up biographies of those he calls "the famously creative." What a wonderful eclectic list he compiled: Science fiction author and futurist Arthur C. Clarke, whose budding cosmic consciousness was awakened by childhood bicycle rides under starry skies: a two-year-old Jane Goodall, sleeping with earthworms under her pillow; Thomas Edison who, as a very young child was found sitting on a clutch of goose eggs, hoping to hatch goslings; and the young Cesar Chavez, inspired by the land, soil, and waters of Arizona's Gila River regions. Others who made Matthew's list were Samuel Clemens, T.S. Elliot, John Muir, and Eleanor Roosevelt.

The work of Louise Chawla, International Coordinator of UNESCO's Growing Up in Cities program, supports Louv's premise. For most environmentalists, it was intense nature experiences in the early years that inspired their later work. Who, she asks, will take on environmental stewardship for our Earth if today's and tomorrow's children are denied these experiences?

If I could, I would put this important book into the hands of everyone whose work in any way touches the lives of today's children and future generations. In Richard Louv's words "Healing the broken bond between our young and nature is in our self interest, not only because aesthetics or justice demand it, but also because our mental, physical, and spiritual health depends on it. The health of the Earth is at stake."

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The purpose of On TRACKS is to disseminate information and educational resources pertaining to the natural, historic, and cultural resources of the prairie, emphasizing Kansas ecology. Information is presented from the perspective of current scientific theory.

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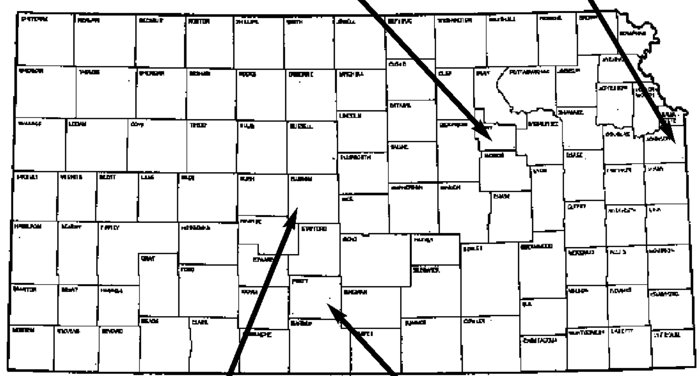

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