**Co2 Bad – PJFC**

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**Warming Real**

**Anthropogenic**

**Warming is anthropogenic and reversible if action is taken now.**

**Pew Center 11**

(The Pew Center on Global Climate Change is as a non-profit, non-partisan, and independent organization dedicated to providing credible information, straight answers, and innovative solutions in the effort to address global climate change, “Climate Change 101: Understanding and Responding to Global Climate Change,”)

The scientific Evidence is unequivocal. Natural climate variability alone cannot explain this trend. Human activities, especially the burning of coal and oil, have warmed the earth by dramatically increasing the concentrations of heat-trapping gases in the atmosphere. The more of these gases humans put into the atmosphere, the more the earth will warm in the decades and centuries ahead. The impacts of warming can already be observed throughout the United States, from rising sea levels to melting snow and ice to more drought and EXTreme rainfall. Climate change is already affecting ecosystems, freshwater supplies, and human health around the world. Although some amount of climate change is now unavoidable, much worse impacts can be avoidedby substantially reducing the amount of heat-trapping gases released into the atmosphere. A study released by the U.S. National Academy of Sciences in 2010 said, “Climate change is occurring, is caused largely by human activities, and poses significant risks for —and in many cases is already affecting—a broad range of human and natural systems.”1 The climate will continue to change for decades as a result of past human activities, but scientists say that the worst impacts can still be avoided if action is taken soon. GLOBAL TEMPERATURES: THE EARTH IS WARMING Global average temperature data based on reliable thermometer measurements are available back to 1880. Over the last century, the global average temperatures rose by almost 1.5°F (see Figure 1), and the Arctic warmed about twice as much.2 Based on data from the U.S. National Climatic Data Center, the 27 warmest years since 1880 all occurred in the 30 years from 1980 to 2009; the warmest year was 2005 followed closely by 1998.3 Over the past 50 years, the data on EXTreme temperatures have shown similar trends of rising temperatures: cold days, cold nights, and frosts occurred less frequently over time, while hot days, hot nights, and heat waves occurred more frequently.4 Warming has not been limited to the earth’s surface; the oceans have absorbed most of the heat that has been added to the climate system, resulting in a persistent rise in ocean temperatures (see Figure 1).5 Over time, the heat already absorbed by the ocean will be released back to the atmosphere, causing an additional 1°F of surface warming; in other words, some additional atmospheric warming is already “in the pipeline.”6 GREENHOUSE GASES: MAKING THE CONNECTION Although global temperatures have varied naturally over thousands of years, scientists studying the climate system say that natural variability alone cannot account for the rapid rise in global temperatures during recent decades.7 Human activities cause climate change by adding carbon dioxide (CO2) and certain other heat-trapping gases to the atmosphere. When sunlight reaches the earth’s surface, it can be reflected (especially by bright surfaces like snow) or absorbed (especially by dark surfaces like open water or tree tops). Absorbed sunlight warms the surface and is released back into the atmosphere as heat. Certain gases trap this heat in the atmosphere, warming the Earth’s surface. This warming is known as the greenhouse effect and the heat-trapping gases are known as greenhouse gases (GHGs) (see Figure 2). CO2, methane (CH4), and nitrous oxide (N2O) are GHGs that both occur naturally and also are released by human activities. Before human activities began to emit these gases in recent centuries, their natural occurrence resulted in a natural greenhouse effect. Without the natural greenhouse effect, the earth’s surface would be nearly 60°F colder on average, well below freezing. However, humans are currently adding to the naturally occurring GHGs in the atmosphere, causing more warming than occurs naturally. Scientists often call this human-magnified greenhouse effect the “enhanced greenhouse effect.” Evidence from many scientific studies confirms that the enhanced greenhouse effect is occurring.8 For example, scientists working at NASA’s Goddard Institute for Space Studies found more energy from the sun is being absorbed than is being emitted back to space. This energy imbalance is direct evidence for the enhanced greenhouse effect.9 Greenhouse Gas Levels Rising. In 2009, the U.S. Global Change Research Program (USGCRP) released the most up to date and comprehensive report currently available about the impacts of climate change in the United States.10 The report says that average global concentrations of the three main greenhouse gases—CO2, CH4, and N2O—are rising because of human activities. Since pre-industrial times, CO2 has increased by 40 percent, CH4 by 148 percent, and N2O by 18 percent. CO2 is the principle gas contributing to theenhanced greenhouse effect. Many human activities produce CO2; the burning of coal, oil, and natural gas account for about 80 percent of human-caused CO2 emissions. Most of the remaining 20 percent comes from changes in the land surface, primarily deforestation. Trees, like all living organisms, are made mostly of carbon; when forests are burned to clear land, the carbon in the trees is released as CO2. The USGCRP report says that the current trajectory of rising GHG concentrations is pushing the climate into uncharted territory**.** CO2 levels are much higher today than at any other time in at least 800,000 years. Through all those millennia, there has been a clear correlation between CO2 concentrations and global temperatures (see Figure 3), adding geological support for the strong connection between changes in the strength of the greenhouse effect and the earth’s surface temperature. Scientists are certain that the burning of fossil fuels is the main source of the recent spike in CO2 in the atmosphere. Multiple, independent lines of evidence clearly link human actions to increased GHG concentrations.11 Moreover, there is strong evidence that this human-induced rise in atmospheric GHGs is the main reason that the Earth has been warming in recent decades. The USGCRP report says, “The global warming of the past 50 years is due primarily to human-induced increases in heat-trapping gases. Human fingerprints also have been identified in many other aspects of the climate system, including changes in ocean heat content, precipitation, atmospheric moisture, and Arctic sea ice.” The U.S. National Academy of Sciences draws the same conclusion: “Many lines of evidence support the conclusion that most of the observed warming since the start of the 20th century, and especially the last several decades, can be attributed to human activities.”12 Looking Ahead. The more GHGs humans release into the atmosphere, the stronger the enhanced greenhouse effect will become. For many years, skeptics of climate change pointed to differences between temperature increases recorded at the earth’s surface and those recorded in the lower atmosphere as a way to challenge scientific claims about climate change. However, a 2006 report from the U.S. Climate Change Science Program reconciled data from surface measurements, satellites, and weather balloons, concluding that “(t)he previously reported discrepancy between surface and the atmospheric temperature trends is no longer apparent on a global scale.”13 Scenarios in which GHGs continue to be added to the atmosphere by human activities could cause additional warming of 2 to 11.5°F over the nEXT century, depending on how much more GHGs are emitted and how strongly the climate system responds to them. Although the range of uncertainty for future temperatures is large, even the lower end of the range is likely to have many undesirable effects on natural and human systems.14 Land areas warm more rapidly than oceans, and higher latitudes warm more quickly than lower latitudes. Therefore, regional temperature increases may be greater or less than global averages, depending on location. For example, the United States is projected to experience more warming than average, and the Arctic is expected to experience the most warming.15 The future climate depends largely on the actions taken in the nEXT few decades to reduce and eventually eliminate human-induced CO2 emissions. In 2005, the U.S. National Academy of Sciences joined with 10 other science academies from around the world in a statement calling on world leaders to take “prompt action” on climate change. The statement was explicit about our ability to limit climate change: “Action taken now to reduce significantly the buildup of greenhouse gases in the atmosphere will lessen the magnitude and rate of climate change.”

**Current warming isn’t due to CO2 and no unprecedented warming now – tree rings prove**

**NIPCC, 12**– Nongovernmental International Panel on Climate Change, 2/21/2012, “Global Warming and Extreme Weather Events”, http://www.nipccreport.org/articles/2012/feb/21feb2012a3.html | JJ)

In the present analysis, Routson et al. used a new tree-ring record derived from living and remnant bristlecone pine wood from the headwaters region of the Rio Grande River in Colorado (USA), along with other regional records, to evaluate what they describe as "periods of unusually severe drought over the past two millennia (268 BC to AD 2009)." Results indicated, according to the three researchers, that the record they derived "reveals two periods of enhanced drought frequency and severity relative to the rest of the record," and that "the later period, AD ~1050-1330, corresponds with medieval aridity well documented in other records," while "the earlier period is more persistent (AD ~1-400), and includes the most pronounced event in the ... chronology: a multi-decadal-length drought during the 2nd century," which "includes the unsmoothed record's driest 25-year interval (AD 148-173) as well as a longer 51-year period, AD 122-172, that has only two years with ring width slightly above the long-term mean," and where "the smoothed chronology shows the periods AD 77-282 and AD 301-400 are the longest (206 and 100 years, respectively, below the long-term average) droughts of the entire 2276-year record." And they note that this 2nd-century drought "impacted a region that extends from southern New Mexico north and west into Idaho." Noting that "reconstructed Colorado Plateau temperature suggests warmer than average temperature could have influenced both 2nd century and medieval drought severity," and that "available data also suggest that the Northern Hemisphere may have been warm during both intervals," Routson et al. go on to suggest that the southwestern United States could well experience similar or even more severe megadroughts in the future, as they suspect it will continue to warm in response to continued anthropogenic CO2 emissions. However, it should be duly noted that studies from all around the globe - which depict both a Medieval Warm Period and a Roman Warm Period that were equally as warm or even warmer than the Current Warm Period has been to date, and at times when there was way less CO2 in the atmosphere than there is today (see both of these items in our Topical Archive) - suggest that there is nothing unusual, unnatural or unprecedented about Earth's current level of warmth, and, in fact, that it must be significantly cooler now than it was during those two prior multi-century warm periods, since we have not yet experienced droughts of anywhere near the severity or duration of those that were experienced in the Roman and Medieval Warm Periods, which further suggests that the planet's current level of warmth is likely not a result of historical anthropogenic CO2 emissions, but rather a result of a milder expression of whatever was the cause of those two earlier stellar warm periods.

**Consensus**

**Scientific consensus goes aff that warming is real and caused by humans**

**EDF 11**

(Environmental Defense Fund, leading national nonprofit organization representing more than 700,000 members.  Citing Science and the IPCC, as well as other multinational climate organizations, “Scientific Consensus on the Basic Facts of Global Warming,”)

The most respected scientific bodies have stated unequivocally that global warming is occurring, and people are causing it by burning fossil fuels and cutting down forests. This conclusion is shared by the national science academies of developed and developing countries (statement [PDF]), plus many other organizations, including the Intergovernmental Panel on Climate Change, which was established by the United Nations and the World Meteorological Organization to provide the world with "a clear scientific view" on climate change. The only real debate is about how fast warming will occur, and how much damage will be done, as a result of human activities that produce heat-trapping CO2 and other greenhouse-gas emissions. Peer review ensures sound science Climate scientists, like all scientists, are professional skeptics. They welcome – in fact, rely upon – rigorous challenges to their work from colleagues. Through this process of peer review and independent verification, scientists critique and double- (and triple- and quadruple-) check each other's work. This can lead to debate and controversy, but over time, solid research is validated, errors are discarded, and a body of reliable facts is created. In addition, science advances by focusing on what is not yet known. In the case of climate change, for example, there is an EXTremely good general understanding of the phenomenon, but many details are not yet understood. These gaps in the research, as they come to light, are systematically tackled by the scientific community. In this contEXT, the kind of material used by climate-change skeptics to cast doubt on global warming – whether it be a handful of emails stolen from an East Anglian research facility or a few errors in an IPCC report – are meaningless.The mountain of climate data assembled over decades by the scientific community as a whole is irrefutable**.** The records collected and analyzed by independent scientists from many disciplines and thousands of locations, paint a consistent, verifiable picture of a rapidly warming world. Make no mistake: Science has given us unequivocal warning that global warming is real. The time to startworking on solutions is now.

**Warming Bad**

### Happens Fast

**Warming will happen way faster than their evidence assumes -- permafrost**

**Torrent, 11** (Danielle, writer for University of Florida News, “UF researcher: Climate change may happen more quickly than expected”, 11/30/11, AD: 6/25/12, [http://news.ufl.edu/2011/11/30/permafrost](http://news.ufl.edu/2011/11/30/permafrost/) | Sina)

As global temperatures continue to rise at an accelerated rate due to deforestation and the burning of fossil fuels, natural stores of carbon in the Arctic are cause for serious concern, researchers say. In an article scheduled to be published Thursday in the journal Nature, a survey of 41 international experts led by University of Florida ecologist Edward Schuur shows models created to estimate global warming may have underestimated the magnitude of carbon emissions from permafrost over the next century. Its effect on climate change is projected to be 2.5 times greater than models predicted, partly because of the amount of methane released in permafrost, or frozen soil. “We’re talking about carbon that’s in soil, just like in your garden where there’s compost containing carbon slowly breaking down, but in permafrost it’s almost stopped because the soil is frozen,” Schuur said. “As that soil warms up, that carbon can be broken down by bacteria and fungi, and as they metabolize, they are releasing carbon and methane, greenhouse gases that cause warmer temperatures.” As a result of plant and animal remains decomposing for thousands of years, organic carbon in the permafrost zone is distributed across 11.7 million square miles of land, an amount that is more than three times larger than previously estimated. The new number is mainly based on evidence the carbon is stored much deeper as the result of observations, soil measurements and experiments. “We know the models are not yet giving us the right answer — it’s going to take time and development to make those better, and that process is not finished yet,” Schuur said. “It’s an interesting exercise in watching how scientists, who are very cautious in their training, make hypotheses about what our future will look like. The numbers are significant, and they appear like they are plausible and they are large enough for significant concern, because if climate change goes 20 or 30 percent faster that we had predicted already, that’s a pretty big boost.” The survey, which was completed following a National Science Foundation-funded Permafrost Carbon Network workshop about six months ago, proposed four warming scenarios until 2040, 2100 and 2300. Researchers were asked to predict the amount of permafrost likely to thaw, how much carbon would be released, and what amount would be methane, which has much more warming potential than carbon dioxide. The occurrence of carbon in northern soils is natural and the chemical does not have an effect on climate if it remains underground, but when released as a greenhouse gas it can add to climate warming. However, humans could slow warming temperatures as the result of greenhouse gas emissions from deforestation and the burning of fossil fuels, which are what speed up the process of permafrost thaw. “Even though we’re talking about a place that is very far away and seems to be out of our control, we actually have influence over what happens based on the overall trajectory of warming. If we followed a lower trajectory of warming based on controlling emissions from the burning of fossil fuels, it has the effect of slowing the whole process down and keeping a lot more carbon in the ground,” Schuur said. “Just by addressing the source of emissions that are from humans, we have this potential to just keep everything closer to its current state, frozen in permafrost, rather than going into the atmosphere.” The survey shows that by 2100, experts believe the amount of carbon released will be 1.7 to 5.2 times greater than previous models predict, under scenarios where Arctic temperatures rise 13.5 degrees Fahrenheit. Some predicted effects of global warming include sea level rise, loss of biodiversity as some organisms are unable to migrate as quickly as the climate shifts and more extreme weather events that could affect food supply and water resources. “This new research shows that the unmanaged part of the biosphere has a major role in determining the future trajectory of climate change,” said Stanford University biology professor Christopher Field, who was not involved in the study. “The implication is sobering. Whatever target we set for atmospheric CO2, this new research means we will need to work harder to reach it. But of course, limiting the amount of climate change also decreases the climate damage from permafrost melting.” When carbon is released from the ground as a result of thawing permafrost, there is no way of trapping the gases at the source, so action to slow its effect must be taken beforehand. “If you think about fossil fuel and deforestation, those are things people are doing, so presumably if you had enough will, you could change your laws and adjust your society to slow some of that down,” Schuur said. “But when carbon starts being emitted from the permafrost, you can’t immediately say, ‘OK, we’ve had enough of this, let’s just stop doing it,’ because it’s a natural cycle emitting carbon whether you like it or not. Once we start pushing it, it’s going to be releasing under its own dynamic.”

### Food Security Impact

#### Climate change is the biggest threat to food security

Perera 12 **–** Amantha Perera is the Sri Lanka correspondent for TIME and [TIME.com](http://www.time.com/). He also contributes to the [Reuters Foundation](http://www.trust.org/alertnet/climate-change), [Inter Press Service](http://www.ipsnews.net/)  and the [Integrated Regional Information Network](http://www.irinnews.org/). He was an international visiting scholar at the Graduate School of Journalism, University of California, Berkeley (2003-2004) and a Jefferson fellow at the East-West Centre, University of Hawaii, Honolulu (2001).[Amantha. 6-5,“SRI LANKA-ENVIRONMENT: CLIMATE CHANGE 'BIGGEST THREAT' TO FOOD SECURITY” Global Information Network < <http://search.proquest.com.proxy.lib.umich.edu/pqrl/docview/1018566119/1377307F5E7114C4934/2?accountid=14667>>] Mili

COLOMBO, Jun. 5, 2012 (IPS/GIN) - When it comes to expressing the threat to food security posed by changing climate patterns and EXTreme weather events in Asia and the Pacific, the Asian Development Bank (ADB) does not mince its words. "The greatest threat to food security is climate change," the Bank said in a 45-page report, 'Food Securityand Poverty in Asia and the Pacific: Key Challenges and Policy Issues', released late last month. The report's findings ring especially true in Sri Lanka, where experts are increasingly expressing concerns about the twin crises of food security and global warming. The ADB study looked at areas that could affect food security, such as trade policies, development, the demand for food and resource management and possible mitigation efforts. It tagged climate change as a key player in determining food security levels, as interventions needed to stem the impacts of global warming go beyond national borders and surpass the authority of any single government. "Problems caused by climate change are much more difficult to resolve in the short term and will require long-term and internationally coordinated solutions," it said. Sri Lankan climate change expert Riza Yehiya, an architect and sustainability consultant, echoed the ADB's sentiments. "The issues of climate change and food security in Sri Lanka are becoming alarming," he told IPS, adding that changing climate patterns combined with a lack of proper policies to mitigate adverse impact have put the South Asian island in a precarious position. Though Sri Lanka is yet to experience protracted and deadly food shortages due to changing weather patterns, recent experiences have shown that its vital rice harvest does fluctuate wildly depending on rainfall. In 2011, close to 20 percent of the harvest was wiped out when devastating floods between January and February were followed by a harsh drought in some flood-hit areas. The worst affected populations of these twin crises struggled hard to make ends meet. United Nations' updates on the impact of floods on the East coast detailed instances of older children dropping out of school in order to help their families who, as a result of a ruined harvest, had lost their only source of income. "Too much rain or too little (ruins) any crop, not only paddy. Rainfall fluctuation, especially in 2011, left crops vulnerable," Malika Wimalasuriya, head of the climate change unit at the Meteorological Department, told IPS. "Sri Lanka, being closer to the equator, is more vulnerable to climate change impacts (than other countries)," Yehiya warned. In fact, the ADB report predicted large crop losses in Asia due to changing climate patterns in the nEXT 100 years primarily due to its proximity to the equator. "Yield losses are expected to be even larger (than the Pacific) in tropical regions such as South and Southeast Asia, and will continue to drop further toward 2100. In Southeast Asia, the rice yield is projected to fall by about 50 percent in 2100 relative to 1990 yields," according to the study. Officials at the climate change unit of the Meteorological Department highlighted that severe water scarcity is also a very real possibility for the Sri Lankan agriculture sector in the future, especially since rising temperatures will exacerbate decreasing rainfall. Yehiya pointed out that overuse of fertiliser has made the land less productive while the demand for food is likely to rise in the future, putting even more pressure on producers. "One of the biggest problems with Sri Lankan agriculture is the lack of water management," observed Mudalihamige Rathnayake, head of the Department of Geography at the southern Ruhunu University. He told IPS that Sri Lankan farmers still rely heavily on the Irrigation Department to release water from reservoirs, rather than taking the initiative on water management themselves. "We still do not have a culture where farmers feel they have to manage their own water resources," he lamented. "Sri Lanka has been identified as one of the world's future water deficit countries," Yehiya remarked. "This deficit is not (only) due to the inadequacy of water resources but due to the lack of efficient water resource management, policies and programmes." As ground water supplies dry up, the threat of rising salinity emerges as yet another obstacle to food production and security. Some of the island's largest rice producing areas in the Digamadulla, Batticaloa and Trincomalee districts along the eastern coast lie very close to the sea, heightening the risk of seawater intrusion due to rising sea levels. Officials at the Coast Conservation Department (CCD) told IPS that Sri Lanka's western and eastern coasts were susceptible to erosion with some areas showing annual erosion levels of five metres. CCD Director Anil Premarathne told IPS that wave height and intensity rose during the monsoon season, which has become shorter but more EXTreme. "Even a small rise in the sea level could increase the salinity in groundwater. You may not see seawater intrusion on the surface, but salinity levels will change below the ground," he said. The CCD official also noted the difficulty of implementing a clear policy on countering erosion, making the coast vulnerable to EXTreme weather.

#### Climate change risks food security

McMicheal and Barnett 12 – Jon is a political geographer whose research investigates the impacts of and responses to environmental change on social systems, with a focus on risks to human security, hunger, conflict, and water stress. He has included field based research in the South Pacific, China, and Timor-Leste. Jon is host convenor of the research network on the social, economic and institutional dimensions of climate change, which is part of the National Climate Change Adaptation Research Facility. He is a Lead Author for the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (Working Group II, Chapter 12), the Executive Editor of the adaptation domain of Wiley Interdisciplinary Reviews Climate Change, and is on the editorial board of Global Environmental Change. Celia McMicheal-MA(Hons) Social Anthropology and Development (Edinburgh); PhD School of Population Health (Melbourne) [Celia and Jon, May, “An III Wind? Climate Change, Migration, and Health”. National Institute of Environmental Health Sciences. <<http://search.proquest.com.proxy.lib.umich.edu/pqrl/docview/1016793869/137731842FF3C184292/24?accountid=14667>>]Mili

The tendency for people to move will be associated particularly with the existence (or perception or expectation) of an increased frequency of serious and EXTreme weather disasters, food shortages (and associated losses of livelihoods), and water shortage**.** Climate change poses risks to food security via reductions in agricultural and fishery yields, especially in already food-insecure regions such as in sub-Saharan Africa and South Asia **(Dinar 2007).** Changes in flooding and drying cycles, hotter summers, and the spread of drought conditions in some regions are likely to greatly increase risks to agricultural productivity, particularly in lower-latitude countries(Battisti and Naylor 2009; Dai 2010; Easterling et al. 2007).Warming oceans and ocean acidification endanger coral ecosystems and the artisanal, pelagic, and aquaculture fisheries upon which hundreds of millions of people depend for food**.** Meanwhile**,** lack of access to safe drinking water is a further major contributor to morbidity and mortality, particularly among children, in developing countries**.** Changes in rainfall and river flows jeopardize human health via impacts on agriculture, daily hydration, cooking, and domestic hygiene. Climate change will also influence the geographic range, seasonality, and incidence rate of various infectious diseases, such as malaria, diarrheal diseases, and cholera (Gonfalonieri et al. 2007). There is some preliminary evidence of climate-related changes in the geographic and seasonal patterns of several infectious diseases over recent decades, including malaria, dengue fever, and tickborne borreliosis and encephalitis (McMichael and Lindgren 201 1; Tanser et al. 2003). In response to the health and physical safety risks posed by climatic-environmental disasters, both acute and sustained, migration can be a survival strategy. Yet populations in low-income countries whose health is most at risk from climate change (Gonfalonieri et al. 2007), and where there are often high preexisting levels of health problems, are used to coping with adverse health outcomes without recourse to migration. It is likely that population movement that is driven substantially by health risks will occur only where those risks are sufficiently serious and widespread. The following example, from the Horn of Africa, is illustrative. Famines are EXTreme health crises that cause people to move to avoid hunger and death (Afolayan and Adelekan 1998). The severe drought in 2011 affecting Somalia, Kenya, Ethiopia, and Djibouti has caused tens of thousands of deaths, with high rates of acute malnutrition, particularly among children. Further, the risk of infectious disease (e.g., cholera, measles, malaria, meningitis) has increased because of the combination of malnutrition (weakened immune system), inadequate health care systems, low immunization coverage, lack of clean water, and poor sanitation (Zarocostas 2011). The event may be an EXTension of a widening regional impact of climate change (Funk et al. 2008). In this region, high rates of migration preexist because of social and political instability and conflict. However, the drought has caused a considerable increase in migration, both within and across international borders. In July 2011, around 1 ,300 Somalis were reportedly arriving each day at the Dadaab complex in northeastern Kenya, and nearly 2,000 Somalis were arriving at the Dolo Ado camps in Ethiopia each week (U.S. Agency for International Development 2011). In this instance, migration rates have increased in part because of the substantial health risks associated with famine.

**Biodiversity Impact**

#### Warming kills biodiversity

Butler 7(Rhett Butler is also co-founder of Tropical Conservation Science, an open-access academic journal that aims to provide opportunities for scientists in developing countries to publish their research, and the Tropical Forest Network, a social network in the San Francisco Bay Area broadly interested in tropical forest conservation and ecology. , 3/26/07, <http://www.mongabay.com/about.htm>.) H.Kenner

Using a variety of climate scenarios, assumptions and methods of analysis, we estimated that somewhere between 5% and50% of the species we analyzed are at risk of extinction , with the central range of estimates falling between 15% and 37%. This is on the basis of warming projected until 2050, so the year 2100 risks of extinction from climate change are likely to lie in the upper half of this range (or above)," he explained. "Our estimates of potential extinction were preliminary values intended to define the order of magnitude of the problem. We found that the extinction risks from climate change are probably similar to those from habitat loss, and conceivably even greater in some regions ." Dr. Thomas cautions that not all the species "committed to extinction" will disappear by 2050 due to the inherent lag time of extinction. "When the climate becomes unsuitable for the long-term survival of a species, it does not meanthat it will die out immediately. For species with long-lived individuals, in particular, it may be many decades or even centuries before the last individuals die out. So, these are the numbers of species that may be declining towards extinction from 2050 onwards, not the numbers that will have died out by that date. "How does climate change affect biodiversity? Climate change can affect species in myriad ways including the expansion, contraction, and "migration" of habitat; increased incidence of disease and invasive species; changes in temperature, precipitation, and other environmental conditions; shifts in food availability; and failure of ecological relationships with other species -- for example the loss of critical pollinators or mutualistic nutrient fixers. In the past some species may have escaped extinction by "migrating" north or southward in response to climate change. Today humans have made it a lot tougher by fragmenting, converting, and destroying habitats and potential migration corridors . Peter Raven, director of the Missouri Botanical Garden and a renowned expert on biodiversity, says that climate change will also make conservation efforts more difficult." As the climate changes, protected areas will not be able to shift due to surrounding urban areas and agricultural zones," he told mongabay.com via telephone. "This makes them all the more susceptible to the impact of climate change, whether it is rising sea levels, a dip in precipitation levels, or warmer temperatures."

#### Loss of biodiversity risks extinction

Diner, 94 [David, Judge Advocate General, Vice Chief of Staff, United States Department of the Army Personnel, Plans and Training Office Chief, 1994 , Colonel David N., United States Army Military Law Review Winter, p. lexis] H. Kenner

By causing widespread extinctions, humans have artificially simplified many ecosystems. As biologic simplicity increases, so does the risk of ecosystem failure. The spreading Sahara Desert in Africa, and thedustbowl conditions of the 1930s in the United States are relatively mild examples of what might beexpected if this trend continues. Theoretically , each new animal or plant extinction, with all its dimlyperceived and intertwined affects, could cause total ecosystem collapse and human extinction. Each new extinction increases the risk of disaster. Like a mechanic removing, one by one, the rivets from anaircraft's wings, n80 mankind may be edging closer to the abyss.

**Sulfide Impact (Turns Food)**

**Warming triggers sulfide poising that risks mass extinctions – turns their food supply arguments**

**Cline 11**

(William, William R. Cline has been a senior fellow at the Peterson Institute for International Economics since 1981. During 1996–2001 while on leave from the Institute, Dr. Cline was deputy managing director and chief economist of the Institute of International Finance (IIF) in Washington, DC. From 2002 through 2011 he held a joint appointment with the Peterson Institute and the Center for Global Development, where he is currently senior fellow emeritus. Before joining the Peterson Institute, he was senior fellow, the Brookings Institution (1973–81); deputy director of development and trade research, office of the assistant secretary for international affairs, US Treasury Department (1971–73); Ford Foundation visiting professor in Brazil (1970–71); and lecturer and assistant professor of economics at Princeton University (1967–70). He graduated summa cum laude from Princeton University in 1963, and received his MA (1964) and PhD (1969) in economics from Yale University, Valuation of Damages from Climate Change, <http://t.iie.com/publications/papers/cline201101.pdf>)

Scientific work in recent years has increased the concern we should have about catastrophic effects of climate change. The three catastrophes usually considered are: collapse of the ocean conveyor belt that causes the Gulf Stream and keeps Northern Europe warm; melting of the Greenland ice sheet or collapse of the West Antarctic ice sheet, either of which would raise sea levels by 7 meters; and a runaway greenhouse effect as methane is released from clathrates on continental shelves and from permafrost. With respect to the conveyor belt, a 2005 study found that “the Atlantic meridional overturning circulation has slowed by about 30 percent between 1957 and 2004” (Bryden, Longworth and Cunningham, 2005). With respect to the Greenland ice sheet, in a 2005 study Meinshausen (2005) found that “the loss of the Greenland ice sheet may be triggered by a local temperature increase of approximately 2.7°C, which could correspond to a global mean temperature increase of less than 2°C.” 2 Perhaps the most disturbing new evidence on catastrophic risks concerns massive EXTinctions as a consequence of an eventual loss of oxygen in the oceans, a buildup in anaerobic bacteria, and the release of hydrogen sulfide from the oceans in amounts toxic for plants and animals. A 2005 study by Kump, Pavlov, and Arthur (2005) found that “fluxes of H2S to the atmosphere … would likely have led to toxic levels …[that served] as a kill mechanism during the end-Permian, late Devonian, and Cenomanian-Turonian EXTinctions” (p. 397). In the first of these, the Permian-Triassic EXTinction event 251 million years ago, some 90 percent of species on land and in the oceans became EXTinct. Volcanic eruptions in the Siberian “traps” (lava-flows) are likely to have caused sharp increases in atmospheric concentrations of CO2, methane releases from clathrates, and an increase in global temperatures by levels 6°C (Benton, 2003). “The evidence at hand

links the mass EXTinctions with a changeover in the ocean from oxygenated to anoxic bottom waters” (Ward, 2010, p. 189). A shutdown in the ocean conveyor belt would have caused this changeover, setting the stage for the buildup of anaerobic bacteria and eventual release of hydrogen sulfide. Similarly, a 2007 study found that over the past 520 million years, EXTinctions were relatively high during warm “greenhouse” phases; four of the five worst mass EXTinctions were associated with such phases (Mayhew and Benton, 2007). The time scale for such a phenomenon is unknown, but is probably on the order of thousands of years.Eventually a world free of ice sheets would mean sea levels 60 to 80 meters higher than today If the H2S hypothesis is correct, humans could probably survive using gas masks out of doors and living in atmosphericcontrolled chambers, or at least those who could afford to do so would. However, food supply would be challenging, because of the likely die-off of livestock animals.

 **Exts – Sulfide Impact**

**Warming triggers hydrogen sulfide poisoning and leads to extinction**

**Ward 10**

(Peter Douglas Ward is a [paleontologist](http://en.wikipedia.org/wiki/Paleontologist) and professor of Biology and of Earth and Space Sciences at the [University of Washington](http://en.wikipedia.org/wiki/University_of_Washington), Seattle, and has written popular science works for a general audience. He is also an adviser to the Microbes Mind Forum. He is also a NASA astrobiologist, Fellow at the California Academy of Sciences, The Flooded Earth: Our Future in a World Without Ice Caps, June 29, 2010)

In the rest of this chapter I will support a contention that within several millennia (or less) the planet will see a changeover of the oceans from their current “mixed” states to something much different and dire. Oceans will become stratified by their oxygen content and temperature, with warm, oxygen-free water lining the ocean basins. Stratified oceans like this in the past (and they were present for most of Earth’s history) have always been preludes to Biotic catastrophe. Because the continents were in such different positions at that time, models we use today to understand ocean current systems are still crude when it comes to analyzing the ancient oceans, such as those of the Devonian or Permian Periods. Both times witnessed major mass EXTinctions, and these EXTinctions were somehow tied to events in the sea. Yet catastrophic as it was, the event that turned the Canning Coral Reef of Devonian age into the Canning Microbial Reef featured at the start of this chapter was tame compared to that ending the 300 million- to 251 million-year-old Permian Period, and for this reason alone the Permian ocean and its fate have been far more studied than the Devonian. But there is another reason to concentrate on the Permian mass EXTinction: it took place on a world with a climate more similar to that of today than anytime in the Devonian. Even more important, it was a world with ice sheets at the poles, something the more tropical Devonian Period may never have witnessed. For much of the Permian Period, the Earth, as it does today, had abundant ice caps at both poles, and there were large-scale continental glaciations up until at least 270 million years ago, and perhaps even later.4 But from then until the end of the Permian, the planet rapidly warmed, the ice caps disappeared, and the deep ocean bottoms filled with great volumes of warm, virtually oxygen-free seawater**.** The trigger for disaster was a short-term but massive infusion of carbon dioxide and other greenhouse gases into the atmosphere at the end of the Permian from the spectacular lava outpourings over an appreciable portion of what would become northern Asia. The lava, now ancient but still in place, is called the “Siberian Traps,” the latter term coming from the Scandinavian for lava flows. The great volcanic event was but the start of things, and led to changes in oceanography**.** The ultimate kill mechanism seems to have been a lethal combination of rising temperature, diminishing oxygen, and influx into water and air of the highly poisonous compound hydrogen sulfide. The cruel irony is that this latter poison was itself produced by life, not by the volcanoes. The bottom line is that life produced the ultimate killer in this and surely other ancient mass EXTinctions. This finding was one that spurred me to propose the Medea Hypothesis, and a book of the same name.5 Hydrogen sulfide poisoning might indeed be the worst biological effect of global warming. There is no reason that such an event cannot happen again, given short-term global warming. And because of the way the sun ages, it may be that such events will be ever easier to start than during the deep past. How does the sun get involved in such nasty business as mass EXTinction? Unlike a campfire that burns down to embers, any star gets ever hotter when it is on the “main sequence,” which is simply a term used to described the normal aging of a star—something like the progression we all go through as we age. But new work by Jeff Kiehl of the University of Colorado shows that because the sun keeps getting brighter, amounts of CO2 that in the past would not have triggered the process result in stagnant oceans filled with H2S-producing microbes. His novel approach was to estimate the global temperature rise to be expected from carbon dioxide levels added to the energy hitting the earth from the sun. Too often we refer to the greenhouse effect as simply a product of the gases. But it is sunlight that actually produces the heat, and that amount of energy hitting the earth keeps increasing. He then compared those to past times of mass EXTinctions. The surprise is that a CO2 level of 1,000 ppm would—with our current solar radiation—make our world the second hottest in Earth history—when the five hottest were each associated with mass EXTinction. In the deep history of our planet, there have been at least five short intervals in which the majority of living species suddenly went EXTinct. Biologists are used to thinking about how environmental pressures slowly choose the organisms most fit for survival through natural selection, shaping life on Earth like an artist sculpting clay. However, mass EXTinctions are drastic examples of natural selection at its most ruthless, killing vast numbers of species at one time in a way hardly typical of evolution. In the 1980s, Nobel Prize-winning physicist Luis Alvarez, and his son Walter Alvarez, first hypothesized that the impact of comets or asteroids caused the mass EXTinctions of the past.6 Most scientists slowly come to accept this theory of EXTinction, further supported by the discovery of a great scar in the earth—an impact crater—off the coast of Mexico that dates to around the time the dinosaurs went EXTinct. An asteroid probably did kill off the dinosaurs, but the causes of the remaining four mass EXTinctions are still obscured beneath the accumulated effects of hundreds of millions of years, and no one has found any credible evidence of impact craters. Rather than comets and asteroids, it now appears that short-term globalwarming was the culprit for the four other mass EXTinctions**.** I detailed the workings of these EXTinctions first in a 1996 Discover magazine article,7 then in an October 2006 Scientific American article, and finally in my 2007 book, Under a Green Sky.8 In each I considered whether such events could happen again. In my mind, such EXTinctions constitute the worst that could happen to life and the earth as a result of short-term global warming. But before we get to that, let us look at the workings of these past events. The evidence at hand links the mass EXTinctions with a changeover in the ocean from oxygenated to anoxic bottom waters. The source of this was a change in where bottom waters are formed. It appears that in such events, the source of our earth’s deep water shifted from the high latitudes to lower latitudes, and the kind of water making it to the ocean bottoms was different as well: it changed from cold, oxygenated water to warm water containing less oxygen. The result was the EXTinction of deep-water organisms. Thus a greenhouse EXTinction is a product of a changeover of the conveyor-belt current systems found on Earth any time there is a marked difference in temperatures between the tropics and the polar regions. Let us summarize the steps that make greenhouse EXTinction happen. First, the world warms over short intervals due to a sudden increase in carbon dioxide and methane, caused initially by the formation of vast volcanic provinces called flood basalts. The warmer world affects the ocean circulation systems and disrupts the position of the conveyor currents. Bottom waters begin to have warm, low-oxygen water dumped into them. The warming continues, and the decrease of equator-to-pole temperature differences brings ocean winds and surface currents to a near standstill. The mixing of oxygenated surface waters with the deeper and volumetrically increasing low-oxygen bottom waters lessens, causing ever-shallower water to change from oxygenated to anoxic. Finally, the bottom water exists in depths where light can penetrate, and the combination of low oxygen and light allows green sulfur bacteria to expand in numbers, filling the low-oxygen shallows. The bacteria produce toxic amounts of H2S, with the flux of this gas into the atmosphere occurring at as much as 2,000 times today’s rates. The gas rises into the high atmosphere, where it breaks down the ozone layer. The subsequent increase in ultraviolet radiation from the sun kills much of the photosynthetic green plant phytoplankton. On its way up into the sky, the hydrogen sulfide also kills some plant and animal life, and the combination of high heat and hydrogen sulfide creates a mass EXTinction on land.9 Could this happen again? No, says one of the experts who write the RealClimate.org Web site, Gavin Schmidt, who, it turns out, works under Jim Hansen at the NASA Goddard Space Flight Center near Washington, DC. I disagreed and challenged him to an online debate. He refused, saying that the environmental situation is going to be bad enough without resorting to creating a scenario for mass EXTinction. But special pleading has no place in science. Could it be that global warming could lead to the EXTinction of humanity? That prospect cannot be discounted. To pursue this question, let us look at what might be the most crucial of all systems maintaining habitability on Planet Earth: the thermohaline current systems, sometimes called the conveyor currents. It is both presumed and observed that current systems that run like a conveyor belt (it runs horizontally until ducking down, reversing direction, and returning up to its original starting point) are among the most important of the many ways that the earth redistributes heat from the sun. Such current systems have been present on Earth whenever there has been ice at the poles, and perhaps when there is no ice at all. In the past, short-term global warming caused perturbations to several of the conveyor current systems. Will the melting of Greenland and Antarctica cause such perturbations in the near, warmed future? Could these changes even be happening now? And if so, what might the consequences be? Today the most important of these currents appears to be the one that moves warm water north and east from the warm Gulf Stream of eastern North America. As that current moves into higher latitudes, its water cools and finally sinks. This cold, highly oxygenated water is a crucial part of maintaining a mix among the ocean’s gaseous elements, rather than allowing them to become stratified, with oxygenated tops and oxygen-free bottoms, like today’s Black Sea, or even totally anoxic from bottom to top. If the Gulf Stream-related current were to change the position where the water sinks, so that less-oxygenated warm water sinks from the surface or so that no water sinks at all, which would be the cessation of the current system, Europe might be immediately cooled, even in a globally warmed world, at least for a while. The result would certainly be a great change in the weather, which would certainly affect agriculture, and probably not for the better. In 2005, for the first time, a research group reported a slowing of the North Atlantic conveyor current, probably due to massive amounts of freshwater already entering the sea in northern areas due to the rapid melting of the northern ice cap.11 As this melt increases in volume, the current will be massively affected. Freshwater is of lower density than seawater, and it will float along the top of the ocean, effectively stopping the conveyor action of the current itself. Just how sensitive is the conveyor current to the sort of change that could lead to a major disturbance in the world’s climate—the kind of dramatic global change that in the past caused mass EXTinction? In other words, what would it take to cause a short-term but radical change in the conveyor current? Some climatologists regard the Atlantic current as robust; they believe that only massive changes in oceanography would be required to perturb it. But a larger number of scientists, including Richard B. Alley, in his now classic and important 2002 book The Two-Mile Time Machine, regard the Atlantic conveyor current system as very finely balanced and hence very susceptible to change .12 The easiest way to activate this change, according to sophisticated computer models, is to pump freshwater into the northern part of the system, and that is just what is happening today. The truly staggering rate at which Arctic ice is melting—a phenomenon not even noticed before about 2003—is introducing massive volumes of freshwater into the most dangerous point for the integrity of the conveyor current. And that input of freshwater is really just the tip of the melting iceberg. However, another way to change the system is by rapid global temperature rise, of sufficient magnitude to significantly reduce the temperature difference between poles and equator. The consequence of perturbation to this system is that the deep, cold, and oxygenated bottom water from high-latitude sinking will change to deep, warm, anoxic water that came from mid-latitude sinking. With that change a relatively cool world gives way to worldwide tropics. But could this happen again and if so, how soon? These questions stimulated an interesting NASA meeting in 2009. In January 2009 I received an unexpected telephone message from Dr. Carl Pilcher, director of the NASA Astrobiology Institute (NAI), summoning me to a spring meeting of the NASA Ames Research Center in Sunnyvale, California, to join a discussion on life and planetary change. It turned out that the director of Ames, former astronaut Pete Worden, had instigated the meeting to discuss the implications of short-term climate change on global biodiversity, past and present. Greenhouse EXTinction, in other words. Thus a small group composed of scientists who have each worked on either past mass EXTinctions or on the consequences of ancient climate change convened in welcome California warmth. We were all glad to meet with NASA, because it had been frustrating to see how little traction this concept had gotten with the public, other scientists, and the national agencies that fund scientific research. The other scientists attending were fellow paleontologist Doug Erwin of the Smithsonian; geochemists Lee Kump of Penn State and Ariel Anbar of Arizona State; biologist Jon Harrison, also of Arizona State; biochemist Roger Summons of MIT; and climate modeler Jeffrey Kiehl of Colorado. In making our presentation to a small cadre of NASA scientists and administrators, Summons, Erwin, and I conveyed data and information supporting the hypothesis that more than one of the past mass EXTinctions might have been caused by short-term global warming, with the devastating Permian mass EXTinction especially featured. NEXT, several scientists reported about the prospect of future greenhouse EXTinctions. Lee Kump of Penn State spoke first, and that was highly appropriate, for in 2005 he and colleagues first published the evidence suggesting that H2S played a major role in mass EXTinction. Kump showed the results of modeling of the Atlantic and Pacific oceans that investigated whether the gigantic thermohaline conveyor currents (integral to keeping the deep ocean oxygenated) could soon be affected by polar warming and the infusion of freshwater. He also added a new and important variable: the effect of enhanced nutrients to the deep ocean at the same time as global warming. He included this factor because the mechanism that he proposed for the Permian EXTinction, while triggered by global warming, had as its real “kill mechanism” the formation of vast quantities of hydrogen sulfide dissolved in the oceans (and at high enough concentrations, leaking into the atmosphere, literally bubbling out of the sea). For H2S to be produced by microbes from a group that used sulfur, not oxygen, for respiration, and to get large enough quantities of H2S to kill things, there would have to be a lot of nutrients down there. To my surprise, his findings indicated that both the Atlantic and Pacific oceans could see the start of oceanic slowdown not millennia hence, but early in the nEXT century. The only factor in his scenario that Kump failed to take into account was rising sea level. It is this mechanism, perhaps more than any other, that would put the necessary nutrients onto the bottom of the sea, for as the many rivers and river mouths drowned**,** vast quantities of organic-rich silt and mud would be carried out to sea, where it would serve as fertilizer, rich in phosphates and nitrates that could stimulate the growth of the H2S-producing microbes, akin to fertilizing a garden bed filled with plants producing deadly poison. Jeffrey Kiehl, who was the day’s final presenter, also used models to look into the near future. He too saw signs that changing oceans are heading toward low oxygen and that warmed ocean bottoms could begin in the current century if current global warming persists. Yet in all of the models he neglected the topic of this book: the effects that rising sea level will have on global temperatures. Water absorbs heat from the sun and generally reflects back into space less energy than land surfaces do. Thus, all else being equal, the larger the ocean area, the greater the warming through reduced albedo (planetary reflectivity). It is a vicious circle, a positive feedback. Snow and ice melt, reducing albedo and raising sea level. As the sea rises, it absorbs ever more heat, causing more ice to melt at the poles, again raising sea level, and on and on. The result of this Ames meeting was a report that NASA said was headed to the desk of President Barack Obama’s science adviser. Whether it got there we never found out. But what we do know is that NASA has seemingly awakened to the vital connection between ancient climates and impending climate change. Although a number of scientists have tried to communicate this argument to the public, at the end of the first decade of the new millennium, few in the nation’s electronic media and print and newspapers allowed us to make our case. They did not disbelieve us; they just responded that the past scenarios were too horrifying for us to contemplate that they could happen again, and soon. Let us hope that a new generation will quickly decide to open their ears and listen.

**AT: CO2 Agriculture (Generic)**

**2AC Generic Cards**

**The harms of CO2 outweigh CO2 ag- independently it causes 5.5 billion people to starve- this card is fantastic**

**Strom, 7** University of Arizona planetary science emeritus professor, studied climate change for 15 years, the former Director of the Space Imagery Center at NASA Regional Planetary Image Facility (Robert, , “Hot House”, SpringerLink, p.<211-216>) H. Kenner

The future consequences of global warming are the least known aspect of the problem. They are based on highly complex computer models that rely on inputs that are sometimes not as well known or factors that may be completely unforeseen. Most models assume certain scenarios concerning the rise in greenhouse gases. Some assume that we continue to release them at the current rate of increase while others assume that we curtail greenhouse gas release to one degree or another. Furthermore, we are in completely unknown territory. The current greenhouse gas content of the atmosphere has not been as high in at least the past 650,000 years, and the rise in temperature has not been as rapid since civilization began sonic 10,000 years ago. What lies ahead for us is not completely understood, but it certainly will not be good, and it could be catastrophic. We know that relatively minor climatic events have had strong adverse effects on humanity, and some of these were mentioned in previous chapters. A recent example is the strong El Niño event of 1997—1998 that caused weather damage around the world totaling $100 billion: major flooding events in China, massive fires in Borneo and the Amazon jungle, and extreme drought in Mexico md Central America. **That event was nothing compared to what lies in store for us in the future if we do nothing to curb global warming.** We currently face the greatest threat to humanity since civilization began. This is the crucial, central question, but it is very difficult to answer (Mastrandea and Schneider, 2004). An even more important question is: “At what temperature and environmental conditions is a threshold crossed that leads to an abrupt and catastrophic climate change?” It is not possible to answer that question now, but we must be aware that in our ignorance it could happen in the not too distant future. At least the question of a critical temperature is possible to estimate from studies in the current science literature**. This has been done by the Potsdam Institute for Climate Impact Research, Germany’s leading climate change research institute (Hare, 2005). According to this study, global warming impacts multiply and accelerate rapidly as the average global temperature rises.** We are certainly beginning to see that now. According to the study, as the average global temperature anomaly rises to i °C within the next 25 years (it is already 0.6°C in the Northern Hemisphere), some specialized ecosystems become very stressed, and in some developing countries food production will begin a serious decline, water shortage problems will worsen, and there will be net losses in the gross domestic product (GDP). At least one study finds that because of the time lags between changes in radiative forcing we are in for a I °C increase before equilibrating even if the radiative forcing is fixed at today’s level (Wetherald et al., 2001). It is apparently when the temperature anomaly reaches 2°C that serious effects will start to come rapidly and with brute force (International Climate Change Taskfòrce, 2005). At the current rate of increase this is expected to happen sometime in the middle of this century. At that point there is nothing to do but try to adapt to the changes. Besides the loss of animal and plant species and the rapid exacerixation of our present problems. there are likely to be large numbers of hungry, diseased and starving people, and at least 1.5 billion people facing severe water shortages. GDP losses will be significant and the spread of diseases will be widespread (see bd ow).We are only about 30 years away from the 440 ppm CO2 level where the eventual 2°C global average temperature is probable. When the temperature reaches 3°C above today’s level, the effects appear to become absolutely critical. At the current rate of greenhouse gas emission that point is expected to be reached in the second half of the century. For example, it is expected that the Amazon rainforest will become irreversibly damaged leading to its collapse, and that the complete destruction of coral reefs will be widespread. **As these things are already happening, this picture may be optimistic. As for humans, there will be widespread hunger and starvation with up to 5.5 billion people living in regions with large crop losses and another 3 billion people with serious water shortages. If the Amazon rainforest collapses due w severe drought it would result in decreased uptake of CO2 from the soil and vegetation of about 270 billion tons, resulting in an enormous increase in the atmospheric level of CO2.** **This, of course, would lead to even hotter temperatures with catastrophic results for civilization.** A Regional Climate Change Index has been established that estimates the impact of global warming on various regions of the world (Giorgi, 2006). The index is based on fi’mr variables that include changes in suthce temperature and precipitation in 2080—2099 compared to the period 1960—1979. All regions of the world are affected significantly, but some regions are much more vulnerable than others. The biest impacts occur in the Mediterranean and northeastern European regions, followed by high—latitude Northern Hemisphere regions and Central America. Central America is the most affected tropical region Íillowed by southern equatorial Africa and southeast Asia. Other prominent mid—latitude regions very vulnerable to global warming are eastern North America and central Asia. **It is entirely obvious that we must start curtailing greenhouse gas emissions now, not 5 or 10 or 20 years from now. Keeping the global average temperature anomaly under 2°C will not be easy according to a recent report (Scientific Expert Group Report on Climate Change, 2007). It will require a rapid worldwide reduction in methane, and global CO2 emissions must level off to a concentration not much greater than the present amount by about 2020.** Emissions would then have to decline to about a third of that level by 2100. Delaying action will only insure a grim Future for our children and grandchildren. If the current generation does not drastically reduce its greenhouse gas emission, then, unfortunately, our grandchildren will get what we deserve.There are three consequences that have not been discussed in previous chapters but could have devastating impacts on humans: food production, health, and the economy. In a sense, all of these topics are interrelated, because they affect each other. Food Production Agriculture is critical to the survival of civilization. Crops feed not only us but also the domestic animals we use for food. Any disruption in food production means a disruption of the economy, government, and health. The increase in CO2 will result in some growth of crops, and rising temperatures will open new areas to crop production at higher latitudes and over longer growing seasons; however**, the overall result will be decreased crop production in most parts of the world.** A 1993 study of the effects of a doubling of CO2 (550 ppm) above pre industrial levels shows that there will be substantial decreases in the world food supply (Rosenzweig et al., 1993). In their research they studied the effects of global warming on four crops (wheat, rice, protein feed, and coarse grain) using four scenarios involving various adaptations of crops to temperature change and CO2 abundance. They found that the amount of world food reduction ranged from 1 to 27%. However, the optimistic value of 1% is almost certainly much too low, because it assumed that the amount of degradation would be offset by more growth from “CO2 fertilization.” We now know that this is not the case, as explained below and in Chapter 7. The most probable value is a worldwide food reduction between 16 and 27%. These scenarios are based on temperature and CO2 rises that may be too low, as discussed in Chapter 7. However, even a decrease in world food production of 16% would lead to large-scale starvation in many regions of the world. Large-scale experiments called Free-Air Concentration Enrichment have shown that the effects of higher C 02 levels on crop growth is about 50% less than experiments in enclosure studies (Long et aL, 2006). **This shows that the projections that conclude that rising CO2 will fully offset the losses due to higher temperatures are wrong**. The downside of climate change will fair outweigh the benefits of increased CO2 and longer growing seasons. One researcher (Prof. Long) from the University of Illinois put it this way: Growing crops much closer to real conditions has shown that increased levels of carbon dioxide in the atmosphere will have roughly half the beneficial 214 What’s in Store for Us? Officials previously hoped for in the event of climate change. In addition, ground—level ozone, which is also predicted to rise but has not been extensively studied before, has been shown to result in a loss of photosynthesis and 20 per cent reduction in crop yield. Both these results show that we need to seriously re-examine our predictions for future global food production, as they are likely to be tàr lower than previously estimated. Also, studies in Britain and Denmark show that only a few days of hot temperatures can severely reduce the yield of major food crops such as wheat, soy beans, rice, and groundnuts if they coincide with the flowering of these crops. This suggests that there are certain thresholds above which crops become very vulnerable to climate change. The European heat wave in the summer of 2003 provided a large-scale experiment on the behavior of crops to increased temperatures. Scientists from several European research institutes and universities found that the growth of plants during the heat wave was reduced by nearly a third (Ciais et al., 2005). In Italy, the growth of corn dropped by about 36% while oak and pine had a growth reduction of 30%. In the affected areas of the mid-west and California the summer heat wave of 2006 resulted in a 35% loss of crops, and in California a 15% decline in dairy production due to the heat-caused death of dairy cattle. It has been projected that a 2°C rise in local temperature will result in a $92 million loss to agriculture in the Yakima Valley of Washington due to the reduction of the snow pack. A 4°C increase will result in a loss of about $163 million. For the first time, the world’s train harvests have fallen below the consumption level fbr the past tour years according to the Earth Policy Institute (Brown, 2003). Furthermore, the shortfall in grain production increased each year, from 16 million tons in 2000 to 93 million tons in 2003. These studies were done in industrialized nations where agricultural practices are the best in the world. In developing nations the impact will be much more severe. It is here that the impact of global warming on crops and domestic animals will be most felt. **In general, the world’s most crucial staple food crops could fall by as much as one-third because of resistance to flowering and setting of seeds due to rising temperatures.** Crop ecologists believe that many crops grown in the tropics are near, or at, their thermal limits. Already research in the Philippines has linked higher night—time temperatures to a reduction in rice yield. It is estimated that for rice, wheat, and corn, the grain yields are likely to decline by 10% for every local 1 °C increase in temperature. **With a decreasing availability of food, malnutrition will become more frequent accompanied by damage to the immune system**. This will result in a greater susceptibility to spreading diseases. For an extreme rise in global temperature ( 6°C), it is likely that worldwide crop failures will lead to mass starvation, and political and economic chaos with all their ramifications (be civilization. Health Rising temperatures will result in the spread of disease (Pata et al., 2005). The incidence of certain diseases depends to a large extent on the climate. Diseases that are now found in the tropics will spread to higher latitudes and greater altitudes as the climate warms. Those that occur in subtropical and temperate regions for only short periods each year will afflict residents for longer durations as warming intensifies. There are a number of tropical diseases that are likely to spread northward as the climate warms (McMichel et al., 2003; Martens et al., 1995). These include malaria, dengue fever, schistomiasis, onchoncercia sis, lymphatic filariasis, sleeping sickness, leishmaniisis, chagas disease, and yellow fever. Currently, these diseases infect a total of about 800 million people, but the disease with the greatest potential for dissemination to higher latitudes is malaria. Figure 12.1 shows the potential risk of malaria epidemics for an increase of the global mean temperature of only 1.2°C compared for the risk during the 1931—1981 baseline climate. According to this projection, much of North America and Europe are at risk of large outbreaks of the disease with only moderate amounts of global warming. As the climate warms, human populations will become far more vulnerable to heat—related mortality, air pollution—related illnesses, infectious diseases, and malnutrition. Areas of increased rainfall will become much more susceptible to the spread of waterborne and foodborne disease. Increased local rainfall will also nuke it easier for the insects and animals that carry some human diseases to flourish. At present about 9 million cases of waterbome disease occur each year in the United States where most people have access to treated water. Global warming will almost certainly increase that number. The World Health Organization estimates that currently 150,000 people die annually from the climate changes that have taken place in the past 30 years, and projects that millions of people will die from climate—rated diseases in the coining decades. In fact, the spread of disease has already begun. Malaria has quadrupled between 1995 and 2000 due, at least in part, to warmer climates. Malaria is reappearing both north and south of the tropics. It is showing up more frequently in the United States, and has returned to the Korean peninsula, parts of southern Europe, Russia, and to the coast of South Africa along the Indian Ocean.

**Studies prove that CO2 hurts plants- prefer recency, qualifications and science**

**Strom 7** [Robert is the Planetary Science Emeritus Professor at the University of Arizona. He studied climate change for 15 years, the former Director of the Space Imagery Center, a NASA Regional Planetary Image Facility, “Hot House”, SpringerLink, p.<96-99 > ] H. Kenner

There is overwhelming evidence that the rapid increase in greenhouse gases is the primary cause of global warming.Recent atmospheric measurements and bubbles of the past atmosphere trapped in ice cores show that the greenhouse gas content increased dramatically during the past 200 years They are increasing 30 times faster dun during the last great Hot House wanning 55 million years ago (see Chapter 5). In more recent times we have been adding man—made chemicals to the atmosphere, some of which are truly horrendous greenhouse gases (22,000 rimes more powerful than CO2). There are a variety ofgreenhouse gases but only four are produced by both nature and humans: carbon dioxide (CO2), methane (C H4), nitrous oxide (N20), and ozone (03). There are a number of other man—made chemicals called halocarbons that are also being emitted into the atmosphere. **However, CO2 is by far the most abundant and is the primary cause of the present global warming.**Often in the literature the emissions will be referred to as just carbon, because this is the atom primarily responsible for the greenhouse effect, and it is also a constituent of methane. The equivalent amount of CO2 for a given amount of carbon is 3.667 times the amount of carbon. Most of the values used here are for CO2 or CO2 equivalent. Table 7.1 lists some of the most common greenhouse gases, their lifetimes in the atmosphere, and their greenhouse warming ability relative to CO2. For example, methane has a lifetime in the atmosphere of 12 years, and over a period of 1 O() years it would take 23 kg of carbon dioxide to have the same warming effect as I kg of methane. The quantity of greenhouse gases is so small compared to the other constituents of the atmosphere (nitrogen, oxygen and argon) that they are measured in parts per million (ppm), or parts per billion (ppb) or, in some cases, parts per trillion (ppt). For instance, the current amount of CO2 in the atmosphere is 383 ppm, or 383 parts of CO2 for each million parts of air. As it is measured by volume of air, it is often written as ppmv, where “y” stands for volume. Carbon dioxide (CO2) is produced naturally by vegetation, decaying organisms, forest fires, exhaled by animals, and volcanic eruptions. It is also produced by humans burning fossil fuels, making cement, and land use. Most carbon dioxide is taken up by forests, grasslands, and oceans. Lind plants take up the equivalent of about 220 billion metric tons of CO2 each year (33.3%), while oceans take up about 330 billion metric cons each year (66.7%). Currently the terrestrial biosphere sequesters about 20 to 3ŒN of global human CO2 emissions (Gurney et al., 2002; Sarniiento and Gruber, 2002). Hansen and Sato (2004) have estimated that about 42% of CO2 emitted by human activity is absorbed by the oceans and land. **Of all the greenhouse gases, CO2 is by far the greatest contributor to global warming** (Hansen and Sato, 2004). Its use is increasing very rapidly, and to date little is being done to reduce human-caused emissions. Table 7.2 lists for the periods 1980—1989 and 1990—1999 the CO2 budgets based on measurements of atmospheric CO2 and oxygen (O), and the estimated ocean emission of 02. **The uptake of CO2 by the ocean and land is decreasing** (Joos et al., 2003) while the amount emitted from land use is increasing. There has been a 29% decrease in ocean uptake and a 43% decrease in land uptake between the 1980—1989 and 1990—1999 periods. Although the fraction of CO2 uptake by the oceans has decreased, the absolute amount bas increased since the 1980s because the yearly emissions have been increasing. The uptake of human-produced CO2 is strongest in regions of “old” upwelling cold water that has spent many years in the ocean’s interior since its last contact with the surface.**Computer models suggest that in the future there will be even more decreases in Carbon sinks**(Winguth et al., 2005). Future increases in oceanic equatorial upwdling will enhance the ourgasing of CO2 from oceans causing the uptake of CO2 to decrease by about 16 to 22%, and increases in soil temperatures will reduce the hunun—caused CO2 uptake from CO2 fertilization up to 43%. Therefore, both the land and marine carbon cycle will eventually have a positive feedback on the Earth’s climate. it has been suggested that the increase in CO2 will be at least partly offset by what is termed “CO2 fertilization.” The concept is that elevated levels of CO, would stimulate plant growth so that plants would take up excess CC)2 to produce carbohydntes, which are their stored energy source. However, **contrary to predictions, increased CO2 only accelerates planet growth to about one-third ofwhat was expected. In fact, increased CO2 may have a positive feedback in that CO2 is absorbed less with increasing CO2 levels (Young et al., 2006). The stomata of leaves are the paris of a plant that “breathe” in CO2 and “exhale” oxygen. A new study shows that the level of CO2 in the atmosphere controls the opening and closing of leaf stomata (Young et al., 2006); the higher the concentration of CO2, the smaller the stomata opening and the less CO2 intake. The lower the CO2 abundance, the larger the opening and the more CO2 intake. A doubling of the CO2 abundance caused leaf stomata to close by about 20—40% in a variety of plant species, thus reducing the CO2 intake. Therefore, the increasing atmospheric abundance of CO2 will result in less CO2 uptake by plants, not more.**

**2AC CO2 Bad for Ag**

#### Excess amounts of CO2 hurt plant growth, and will not allow us to avoid future food shortages

New York Times 11 – Article written by Justin Gills, writer for the New York Times and an environmental specialist (A Warming Planet Struggles to Feed Itself, http://www.nytimes.com/2011/06/05/science/earth/05harvest.html?\_r=2&pagewanted=1)

For decades, scientists believed that the human dependence on fossil fuels, for all the problems it was expected to cause, would offer one enormous benefit. Carbon dioxide, the main gas released by combustion, is also the primary fuel for the growth of plants. They draw it out of the air and, using the energy from sunlight, convert the carbon into energy-dense compounds like glucose. All human and animal life runs on these compounds. Humans have already raised the level of carbon dioxide in the atmosphere by 40 percent since the Industrial Revolution, and are on course to double or triple it over the coming century. Studies have long suggested that the extra gas would supercharge the world’s food crops, and might be especially helpful in years when the weather is difficult. But many of those studies were done in artificial conditions, like greenhouses or special growth chambers. For the past decade, scientists at the University of Illinois have been putting the “CO2 fertilization effect” to a real-world test in the two most important crops grown in the United States. They started by planting soybeans in a field, then sprayed extra carbon dioxide from a giant tank. Based on the earlier research, they hoped the gas might bump yields as much as 30 percent under optimal growing conditions. But when they harvested their soybeans, they got a rude surprise: the bump was only half as large. “When we measured the yields, it was like, wait a minute — this is not what we expected,” said Elizabeth A. Ainsworth, a Department of Agriculture researcher who played a leading role in the work. When they grew the soybeans in the sort of conditions expected to prevail in a future climate, with high temperatures or low water, the extra carbon dioxide could not fully offset the yield decline caused by those factors. They also ran tests using corn, America’s single most valuable crop and the basis for its meat production and its biofuel industry. While that crop was already known to be less responsive to carbon dioxide, a yield bump was still expected — especially during droughts. The Illinois researchers got no bump. Their work has contributed to a broader body of research suggesting that extra carbon dioxide does act as plant fertilizer, but that the benefits are less than previously believed — and probably less than needed to avert food shortages. “One of the things that we’re starting to believe is that the positives of CO2 are unlikely to outweigh the negatives of the other factors,” said Andrew D. B. Leakey, another of the Illinois researchers.

#### Global Warming has been leading to a decrease in food supplies, increase in prices, and instability to form in poorer nations

New York Times 11 – Article written by Justin Gills, writer for the New York Times and an environmental specialist (A Warming Planet Struggles to Feed Itself, http://www.nytimes.com/2011/06/05/science/earth/05harvest.html?\_r=2&pagewanted=1)

CIUDAD OBREGÓN, Mexico — The dun wheat field spreading out at Ravi P. Singh’s feet offered a possible clue to human destiny. Baked by a desert sun and deliberately starved of water, the plants were parched and nearly dead. Dr. Singh, a wheat breeder, grabbed seed heads that should have been plump with the staff of life. His practiced fingers found empty husks. “You’re not going to feed the people with that,” he said. But then, over in Plot 88, his eyes settled on a healthier plant, one that had managed to thrive in spite of the drought, producing plump kernels of wheat. “This is beautiful!” he shouted as wheat beards rustled in the wind. Hope in a stalk of grain: It is a hope the world needs these days, for the great agricultural system that feeds the human race is in trouble. The rapid growth in farm output that defined the late 20th century has slowed to the point that it is failing to keep up with the demand for food, driven by population increases and rising affluence in once-poor countries. Consumption of the four staples that supply most human calories — wheat, rice, corn and soybeans — has outstripped production for much of the past decade, drawing once-large stockpiles down to worrisome levels. The imbalance between supply and demand has resulted in two huge spikes in international grain prices since 2007, with some grains more than doubling in cost. Those price jumps, though felt only moderately in the West, have worsened hunger for tens of millions of poor people, destabilizing politics in scores of countries, from Mexico to Uzbekistan to Yemen. The Haitian government was ousted in 2008 amid food riots, and anger over high prices has played a role in the recent Arab uprisings. Now, the latest scientific research suggests that a previously discounted factor is helping to destabilize the food system: climate change. Many of the failed harvests of the past decade were a consequence of weather disasters, like floods in the United States, drought in Australia and blistering heat waves in Europe and Russia. Scientists believe some, though not all, of those events were caused or worsened by human-induced global warming. Temperatures are rising rapidly during the growing season in some of the most important agricultural countries, and a paper published several weeks ago found that this had shaved several percentage points off potential yields, adding to the price gyrations. For nearly two decades, scientists had predicted that climate change would be relatively manageable for agriculture, suggesting that even under worst-case assumptions, it would probably take until 2080 for food prices to double. In part, they were counting on a counterintuitive ace in the hole: that rising carbon dioxide levels, the primary contributor to global warming, would act as a powerful plant fertilizer and offset many of the ill effects of climate change. Until a few years ago, these assumptions went largely unchallenged. But lately, the destabilization of the food system and the soaring prices have rattled many leading scientists. “The success of agriculture has been astounding,” said Cynthia Rosenzweig, a researcher at NASA who helped pioneer the study of climate change and agriculture. “But I think there’s starting to be premonitions that it may not continue forever.”

#### Global warming and increase CO2 emissions and lowering crop yields around the world

New York Times 11 – Article written by Justin Gills, writer for the New York Times and an environmental specialist (A Warming Planet Struggles to Feed Itself, http://www.nytimes.com/2011/06/05/science/earth/05harvest.html?\_r=2&pagewanted=1)

Other recent evidence suggests that longstanding assumptions about food production on a warming planet may have been too optimistic. Two economists, Wolfram Schlenker of Columbia University and Michael J. Roberts of North Carolina State University, have pioneered ways to compare crop yields and natural temperature variability at a fine scale. Their work shows that when crops are subjected to temperatures above a certain threshold — about 84 degrees for corn and 86 degrees for soybeans — yields fall sharply. This line of research suggests that in the type of climate predicted for the United States by the end of the century, with more scorching days in the growing season, yields of today’s crop varieties could fall by 30 percent or more. Though it has not yet happened in the United States, many important agricultural countries are already warming rapidly in the growing season, with average increases of several degrees. A few weeks ago, David B. Lobell of Stanford University published a paper with Dr. Schlenker suggesting that temperature increases in France, Russia, China and other countries were suppressing crop yields, adding to the pressures on the food system. “I think there’s been an under-recognition of just how sensitive crops are to heat, and how fast heat exposure is increasing,” Dr. Lobell said. Such research has provoked controversy. The findings go somewhat beyond those of a 2007 report by the Intergovernmental Panel on Climate Change, the United Nations body that episodically reviews climate science and advises governments. That report found that while climate change was likely to pose severe challenges for agriculture in the tropics, it would probably be beneficial in some of the chillier regions of the Northern Hemisphere, and that the carbon dioxide effect should offset many problems. In an interview at the University of Illinois, one of the leading scientists behind the work there, Stephen P. Long, sharply criticized the 2007 report, saying it had failed to sound a sufficient alarm. “I felt it needed to be much more honest in saying this is our best guess at the moment, but there are probably huge errors in there,” Dr. Long said. “We’re talking about the future food supply of the world.”

**2AC Warming Bad for Ag**

**Increased temperatures wreak havoc on yields**

**Stebbins 11** [Catherine is a correspondent for Thomsen Reuters Chicago an online news source. “Crop scientists in the United States, the world's largest food exporter, are pondering an odd question: could the danger of global warming really be the heat?” http://www.reuters.com/article/2011/10/24/us-climate-crops-idUSTRE79N07420111024]H. Kenner

(Reuters) - Crop scientists in the United States, the world's largest food exporter, are pondering an odd question: could the danger of global warming really be the heat? For years, as scientists have assembled data on climate change and pointed with concern at melting glaciers and other visible changes in the life-giving water cycle, **the impact on seasonal rains and irrigation has worried crop watchers most**. What would breadbaskets like the U.S. Midwest, the Central Asian steppes, the north China Plain or Argentine and Brazilian crop lands be like without normal rains or water tables? Those were seen as longer-term issues of climate change. But scientists now wonder if a more immediate issue is an unusual rise in day-time and, especially, night-time summer temperatures being seen in crop belts around the world. Interviews with crop researchers at American universities paint the same picture: high temperatures have already shrunken output of many crops and vegetables. "We don't grow tomatoes in the deep South in the summer. Pollination fails," said Ken Boote, a crop scientist with the University of Florida. The same goes for snap beans which can no longer be grown in Florida during the summer, he added. "As temperatures rise we are going to have trouble maintaining the yields of crops that we already have," said Gerald Nelson, an economist with the International Food Policy Research Institute (IFPRI) who is leading a global project initially funded by the Bill and Melinda Gates Foundation to identify new crop varieties adapted to climate change. "When I go around the world, people are much less skeptical, much more concerned about climate change," said David Lobell, a Stanford University agricultural scientist. Lobell was one of three authors of a much-discussed 2011 climate study of world corn, wheat, soybean and rice yields over the last three decades (1980-2008**). It concluded that heat, not rainfall, was affecting yields the most.** "The magnitude of recent temperature trends is larger than those for precipitation in most situations," the study said. "We took a pretty conservative approach and still found sizable impacts. They certainly are happening already and not just something that will or might happen in the future," Lobell told Reuters in an interview.CONCERNS GROWING Scientists at an annual meeting of U.S. agronomists last week in San Antonio said the focus was climate change. "Its impact on agriculture systems, impacts on crops, mitigation strategies with soil management -- a whole range of questions was being asked about climate change," said Jerry Hatfield, Laboratory Director at the National Soil Tilth Laboratory in Ames, Iowa. **"The biggest thing is high night-time temperatures have a negative impact on yield," Hatfield added, noting that the heat affects evaporation and the life process of the crops.** "One of the consequences of rising temperatures ... is to compress the life cycle of that plant. The other key consequence is that when the atmosphere gets warmer the atmospheric demand for water increases," Hatfield said. "These are simple things that can occur and have tremendous consequences on our ability to produce a stable supply of food or feed or fiber," he said. Boote at the University of Florida found that rice and sorghum plants failed to produce grain, something he calls "pollen viability," when the average 24-hour temperature is 95 degrees Fahrenheit (35 Celsius). That equates to highs of 104 F during the day and 86 F at night, he said. The global seed industry has set a high bar to boost crop yields by 2050 to feed a hungry world. **Scientists said that the impact of heat on plant growth needs more focus and study.**"If you look at a lot of crop insurance claims, farmers say it is the lack of water that caused the plant to die," said Wolfram Schlenker, assistant professor at Columbia University. "But I think it's basically different sides of the same coin because the water requirement of the plant increases tremendously if it's hot," he said. "The private sector understands the threats coming from climate change and have significant research programs in regards to drought tolerance. They focus less on higher temperatures, but that's a tougher challenge," Nelson said. "We are responding with a number of initatives...the primary one is focusing on drought tolerance," said John Soper, vice president in charge of global seed development for DuPont's Pioneer Hi-Bred, a top U.S. seed producer. Pioneer launched a conventionally bred drought-tolerant corn hybrid seed in the western U.S. Corn Belt this spring, selected for its yield advantage over other varieties. "We have some early results in from Texas that show that is exactly how they are behaving. They currently have a 6 percent advantage over normal products in those drought zones," Soper said. Roy Steiner, deputy director for agricultural development for the Bill & Melinda Gates Foundation, said the foundation is focused on current agricultural effects of climate change. "It's amazing that there are still people who think that it's not changing. Everywhere we go we're seeing greater variability, the rains are changing and the timing of the rains is creating a lot more vulnerability," Steiner said. "Agriculture is one of those things that needs long-term planning, and we are very short-cycled thinking," he said. "There are going to be some real shocks to the system. Climate is the biggest challenge. Demand is not going away."

 **Exts – Warming Bad**

**Warming is bad for ag – recent trends prove**

**Sendax 10** August 19 2010 “Are Plants Around the World Really Dying?” Anneliese Sendax, writer for Popular Mechanics, referencing a study by Maosheng Zhao and Steven Running <http://www.popularmechanics.com/science/environment/climate-change/are-plants-around-the-world-really-dying>

According to a new study published in *Science*, global plant growth has decreased in the past decade, reversing trends observed over the past 20 years. The authors of the study, Maosheng Zhao and Steven Running, found a significant reduction in the global terrestrial net primary production (NPP), a measure of global plant growth that is calculated by a measure of estimated photosynthesis activity. Ultimately, the study reveals that plant productivity is decreasing, which means plants are taking less carbon dioxide out of the atmosphere as biomass, and there is, therefore, more CO2 in the air to reinforce current warming trends. The Methods By analyzing digital photographs of the earth in the visible and near-infrared spectrum accumulated from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite, along with global meteorological data, Zhao and Running were able to take daily measurements of plant productivity for every square mile of the earth, which amounts to about 68,350,830 square miles daily. They used equations based on solar radiation, day length, temperatures, water-stress levels, and drought to infer photosynthesis activity within each area of the earth. Though Zhao and Running found that the high temperatures of the past decade resulted in longer growing seasons in the northern hemisphere and recorded an increase in plant growth there, the droughts caused by globally rising temperatures in the southern hemisphere resulted in a decrease in growth, which overwhelmed the increase in the northern hemisphere. The end result: an estimated 1 percent decrease in global plant productivity over the past decade. The authors' findings are only made more significant by the fact that in the 20 years before the beginning of their study, global plant productivity was still increasing despite the global warming trends and corresponding droughts that have continued to the current day. The Conclusion Currently, terrestrial plants absorb 4.5 percent of fossil-fuel emissions every year, and, Running says, "if our biospheric uptake decreases, the carbon-dioxide concentration in the atmosphere will increase even faster than it already is." Though further decreases of global plant productivity are not inevitable, if the observed trend continues, it will hold enormous significance for future food security, our ability to turn to biofuel as an alternative energy source and the strength of terrestrial carbon sinks. As for further ecosystem disturbances, we can expect more accelerated wildfires, like those we are seeing in Russia, as well as large-scale insect epidemics, like those observed in the western U.S., which kill enormous numbers of trees, Running says.

**There’s a distinction – even if there is benefits in the short term, long term trends prove warming is bad**

**NSF 12**

(The National Science Foundation (NSF) is an independent federal agency that supports fundamental research and education across all fields of science and engineering. In fiscal year (FY) 2012, its budget is $7.0 billion. NSF funds reach all 50 states through grants to nearly 2,000 colleges, universities and other institutions, “Climate Change Boosts Then Quickly Stunts Plants, Decade-long Study Shows”, <http://www.nsf.gov/news/news_summ.jsp?cntn_id=123798>)

Global warming may initially make the grass greener, but not for long, according to new research results. The findings, published this week in the journal Nature Climate Change, show that plants may thrive in the early stages of a warming environment but then begin to deteriorate quickly. "We were really surprised by the pattern, where the initial boost in growth just went away," said scientist Zhuoting Wu of Northern Arizona University (NAU), a lead author of the study. "As ecosystems adjusted, the responses changed." Ecologists subjected four grassland ecosystems to simulated climate change during a decade-long study. Plants grew more the first year in the global warming treatment, but this effect progressively diminished over the nEXT nine years and finally disappeared. The research shows the long-term effects of global warming on plant growth, on the plant species that make up a community, and on changes in how plants use or retain essential resources like nitrogen. "The plants and animals around us repeatedly serve up surprises," said Saran Twombly, program director in the National Science Foundation (NSF)'s Division of Environmental Biology, which funded the research. "These results show that we miss these surprises because we don't study natural communities over the right time scales. For plant communities in Arizona, it took researchers 10 years to find that responses of native plant communities to warmer temperatures were the opposite of those predicted." The team transplanted four grassland ecosystems from a higher to lower elevation to simulate a future warmer environment, and coupled the warming with the range of predicted changes in precipitation--more, the same, or less. The grasslands studied were typical of those found in northern Arizona along elevation gradients from the San Francisco Peaks down to the Great Basin Desert. The researchers found that long-term warming resulted in loss of native species and encroachment of species typical of warmer environments, ultimately pushing the plant community toward less productive species. The warmed grasslands also cycled nitrogen more rapidly. This should make more nitrogen available to plants, scientists believed, helping plants grow more. But instead much of the nitrogen was lost, converted to nitrogen gases in the atmosphere or leached out by rainfall washing through the soil. Bruce Hungate, senior author of the paper and an ecologist at NAU, said the study challenges the expectation that warming will increase nitrogen availability and cause a sustained increase in plant productivity. "Faster nitrogen turnover stimulated nitrogen losses, likely reducing the effect of warming on plant growth," Hungate said. "More generally, changes in species, changes in element cycles--these really make a difference. It's classic systems ecology: the initial responses elicit knock-on effects, which here came back to bite the plants. These ecosystem feedbacks are critical--you can't figure this out with plants grown in a greenhouse." The findings caution against EXTrapolating from short-term results, or from experiments with plants grown under artificial conditions, where researchers can't measure the feedbacks from changes in the plant community and from nutrient cycles. "The long-term perspective is key," said Hungate. "We were surprised, and I'm guessing there are more such surprises in store."

#### Warming stunts plant growth in the long term – loss of nitrogen and native species

Phys.org, 12 (References study by Bruce Hungate, Northern Arizona University biological sciences professor, “Climate change helps then quickly stunts growth, decade-long study shows”, 4/10/12, AD: 6/25/12, <http://phys.org/news/2012-04-climate-quickly-stunts-growth-decade-long.html> | Sina)

The study, published this week in Nature Climate Change, shows that plants may thrive in the early stages of a warming environment but begin to deteriorate quickly. “We were really surprised by the pattern, where the initial boost in growth just went away,” said Zhuoting Wu, NAU doctoral graduate in biology. “As the ecosystems adjust, the responses changed.” Researchers subjected four grassland ecosystems to simulated climate change during the decade-long study. Plants grew more the first year in the global warming treatment, but this effect progressively diminished over the next nine years, and finally disappeared. The research reports the long-term effects of global warming on plant growth, the plant species that make up the community, and the changes in how plants use or retain essential resources like nitrogen. The team transplanted four grassland ecosystems from higher to lower elevation to simulate a future warmer environment, and coupled the warming with the range of predicted changes in precipitation—more, the same, or less. The grasslands studied were typical of those found in northern Arizona along elevation gradients from the San Francisco Peaks down to the Great Basin Desert. The researchers found that long-term warming resulted in loss of native species and encroachment of species typical of warmer environments, pushing the plant community toward less productive species. The warmed grasslands also cycled nitrogen more rapidly, an effect that should make more nitrogen available to plants, helping them grow more. But instead much of the nitrogen was converted to nitrogen gases lost to the atmosphere or leached out with rainfall washing through the soil. Bruce Hungate, senior author of the study and NAU biological sciences professor, said the research findings challenge the expectation that warming will increase nitrogen availability and cause a sustained increase in plant productivity. “Faster nitrogen turnover stimulated nitrogen losses, likely reducing the effect of warming on plant growth,” Hungate said. “More generally, changes in species, changes in element cycles—these really make a difference. It’s classic systems ecology: the initial responses elicit knock-on effects which here came back to bite the plants. These ecosystem feedbacks are critical. You just can’t figure this out with plants grown in a greenhouse. ” The findings caution against extrapolating from short-term experiments, or experiments in a greenhouse, where experimenters cannot measure the feedbacks from changes in the plant community and from nutrient cycles. The research will continue at least five more years with current funding from the National Science Foundation and, Hungate said, hopefully for another five years after that. “The long-term perspective is key. We were surprised, and I’m guessing there are more surprises in store.” Additional coauthors include George Koch, NAU professor of biological sciences, and Paul Dijkstra, assistant research professor of biological sciences. Wu completed the study as part of her doctoral thesis in biology and earned her degree in 2011.

**2AC AT: CO2 Helps Ag**

**Plants have adapted to low CO2, more decreases dependency and kills ag**

**Tissue and Lewis ‘12**

[David, international expert on the effects of climate change on ecosystems, He has worked at Free Air CO2 Exchange (FACE) sites, University of Western Sydney, [Hawkesbury Institute for the Environment](http://www.uws.edu.au/hie) and James, PhD Fordham University in Biological Studies, February 24th, 2012. “Learning from the past: how low [CO2] studies inform plant and ecosystem response to future climate change”, http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full] DHirsch

Low [CO2] has been proposed as a strong evolutionary selective agent, including contributing to the origin of agriculture ([Sage, 1995](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b11)) and the evolution of C4 plants in association with high temperature and drought ([Osborne & Sack, 2012](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b8)). More specifically, low [CO2] has generated substantial changes in leaf traits associated with CO2 and water exchange, such as reduced stomatal density, greater vein density and megaphyll leaves (see review by [Leakey & Lau, 2012).](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b5) Given the duration of very low [CO2] over geologic time and the relatively recent rise in [CO2] over the past 20 000 yr, selection pressure must have been strongly exerted by low [CO2]. For example, [Ward*et al.* (2000)](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b15) found that biomass production in *Arabidopsis* was increased 35% after only five generations of selection in low [CO2], but not at high [CO2], suggesting rapid and strong selective effects in low [CO2]. It is therefore, reasonable to assume that plants are still adapted to low [CO2], which may constrain responses to rising [CO2] predicted to occur over the nEXT century ([Sage & Coleman, 2001](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b12)).

In a future warmer, high [CO2] world, the primary resource limiting plant function will continue to transition from [CO2] to other resources, such as temperature, nutrients and water availability. In controlled environment studies to date, there is little evidence that adaptive evolutionary responses to elevated [CO2] have occurred, even over many generations, despite changes in plant phenotypes ([Leakey & Lau, 2012](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b5)). Longer term exposure (thousands of years) to elevated [CO2] at natural CO2 springs also generally find minimal adaptive change despite some alterations in photosynthetic performance and biochemistry (e.g. [Cook *et al.*, 1998](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b1)). Interestingly, even the evolution of Rubisco appears constrained, with Rubisco specificity optimal for light-saturated photosynthesis at *c*. 200 ppm [CO2] ([Zhu *et al.*, 2004](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b17)), which is the mean [CO2] over the last 400 000 yr ([Luthi *et al.*, 2008](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b7)). A potential explanation for the general lack of evidence for adaptive responses to elevated [CO2] is that (e.g. nutrient, water, temperature) over multiple generations ([Leakey & Lau, 2012](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b5)). Given that these environmental conditions co-vary, and that selection is strongest under stressful conditions, this research direction should be pursued in the near future.

Reduced terrestrial carbon storage, net primary production and forest cover during glacial periods, which are characterized by very low atmospheric [CO2], may be more accurately predicted when the impact of low [CO2] on physiological processes is included in palaeoclimate models ([Prentice & Harrison, 2009](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b9)). Utilizing findings from studies that address the impact of low [CO2] on physiological performance in C3 and C4 plants, it has been demonstrated that physiological effects may scale up to the ecosystem level ([Prentice & Harrison, 2009](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b9)). For example, changes in [CO2] and their resultant effect on plant photosynthesis and water use efficiency in low [CO2] have been used to accurately explain changes in the composition of plant communities (C3 vs C4) over the LGM, as well as account for changes in the woody component in savannas, relative forest cover, and most recently tree–grass competition during the transition from LGM to pre-industrial Holocene ([Prentice *et al.*, 2011](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04081.x/full#b10)). Overall, we should utilize our improved understanding of plant adaptation and response to low and variable [CO2] over historic time periods to better predict ecosystem response to rising [CO2] and future climate change.

**2AC Photosynthesis**

**Hurts Photosynthesis**

**Cook 11 –** [April 18, 2011. John is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He studied physics at the University of Queensland, Australia. After graduating, he majored in solar physics in his post-grad honors year. <http://www.skepticalscience.com/Increasing-Carbon-Dioxide-is-not-good-for-plants.html>] H. Kenner

3. Too high a concentration of CO2 causes a [reduction of photosynthesis](http://resources.metapress.com/pdf-preview.axd?code=32370807846477k5&size=largest) in certain of plants. There is also [evidence from the past of major damage](http://www.pnas.org/content/105/6/1960) to a wide variety of plants species from a sudden rise in CO2 (See illustrations below). Higher concentrations of CO2 also reduce the nutritional quality of some staples, [such as wheat.](http://www.sciencemag.org/content/328/5980/899.abstract)

**Even if elevated CO2 is beneficial to start, plants eventually acclimate — results in net decrease of productivity**

**Shimono et al., 10** – Research Fellow of the Japan Society for the Promotion of Science, Tokyo, Japan, andNational Agricultural Research Center for Tohoku Region, Shimokuriyagawa, Iwate, Japan (Hiroyuki, Effect of panicle removal on photosynthetic acclimation under elevated CO2 in rice”, Photosynthetica, 2010**,** [http://www.springerlink.com/content/972001j051245113/)//BI](http://www.springerlink.com/content/972001j051245113/%29//BI)

Elevated atmospheric CO2 concentrations ([CO2]) can stimulate photosynthesis of C3 plants in a short term, but after prolonged exposure to elevated [CO2], plants could acclimate. Acclimation to elevated [CO2] has been reported for many C3 plant species, including rice (Nakano et al. 1997, Makino et al. 2000, Seneweera et al. 2002, Shimono and Bunce 2009, Shimono et al. 2009), wheat (Farage et al. 1998, Wall et al. 2000), soybean (Xu et al. 1994, Sawada et al. 2001, Ainsworth et al. 2004), barley (Fangmeier et al. 2000), cotton (Delucia et al. 1985) and other plant species (Moore et al. 1998). It is generally accepted that the balance between sink and source strengths plays a pivotal role in regulating photosynthetic down-regulation under elevated [CO2]. At elevated [CO2], carbohydrate can accumulate in leaves due to the higher source strength, leading to a feedbackbased inhibition of photosynthesis (Moore et al. 1999). Considering a sink-source balance, plants with a relatively limited sink strength can therefore suffer from more severe photosynthetic down-regulation than those with stronger sinks (Arp 1991, Ainsworth et al. 2004). However, N levels in leaves can also affect the magnitude of photosynthetic down-regulation under elevated [CO2] (Makino et al. 1997, Farage et al. 1998, Fangmeier et al. 2000, Seneweera et al. 2002). With increasing sink strength as growth progresses, the N demand by the large reproductive organs such as panicles and pods increases N translocation out of leaves and can therefore lead to photosynthetic down-regulation under elevated [CO2] as a result of N limitations (Farage *et al*. 1998, Sims *et al*. 1998).

 **AT: Plants Migrate/Adapt**

**They can’t adapt fast enough**

**Reynolds, 5/17 –** has an associate's degree in horticulture and is a member of the Garden Writers' Association of America (Charles, “Global Warming Scary for Plants”, The Ledger, 17 May 2012, [http://www.theledger.com/article/20120517/COLUMNISTS0403/120519411)//BI](http://www.theledger.com/article/20120517/COLUMNISTS0403/120519411%29//BI)

The organizations mentioned are, of course, worried about their bottom lines. It's the world's biologists, botanists and scientists who are distressed over the effects of climate change on hundreds of thousands of species of plants and animals. If you're an avid gardener, you probably know that the latest planting zone map issued by the Department of Agriculture reflects major changes due to rising temperatures. Beginning in 2013, even seed packets will bear the new map, indicating that gardeners can, or may have to, cultivate different plants than they did before. Boston University biology professor Richard Primack, quoted in the April 2012 issue of "Natural Awakenings," said, "There are a lot of things you can grow now that you couldn't grow before. People don't think of figs as a crop you can grow in the Boston area. You can do it now." While local gardeners may be delighted to learn that cold-sensitive plants like royal palms and poinciana trees might become commonplace here, the outlook for species in the wild is terrible. Although some plants imperiled by rising temperatures and reduced rainfall can migrate upward onto hillsides and mountain slopes via wind or animal dispersal of their seeds, most plants move too slowly to cope with climate change. And even plants that can shift to new ground relatively quickly are inevitably confronted by competition with species already there and with an ever-narrowing area for colonization: Think of the tapering shape of mountains, and you'll understand why. But assisted colonization -- moving plants to higher elevations that, due to climate change, might soon be suitable for long-term survival -- is already being done by botanists desperate to stave off plant EXTinctions.

**2AC Limiting Factors**

**Limiting factors hinder CO2 induced agriculture – negative effects outweigh**

* Increased Deserts
* Lack of Water
* Lack of Fertilizer
* Soil Conditions

**Cook 11** [April 18 2011. John is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He studied physics at the University of Queensland, Australia. After graduating, he majored in solar physics in his post-grad honors year. <http://www.skepticalscience.com/Increasing-Carbon-Dioxide-is-not-good-for-plants.html>] H. Kenner

An argument, made by those who deny man made Global Warming, is that the Carbon Dioxide that is being released by the burning of fossil fuels is actually good for the environment. Their argument is based on the logic that, if plants need CO2 for their growth, then more of it should be better. We should expect our crops to become more abundant and our flowers to grow taller and bloom brighter. However, this "more is better" philosophy is not the way things work in the real world. There is an older, wiser saying that goes, "Too much of a good thing can be a bad thing." For example, if a doctor tells you to take one pill of a certain medicine, taking four is not likely to heal you four times faster or make you four times better. It's more likely to make you sick. It is possible to help increase the growth of some plants with EXTra CO2, under controlled conditions, inside of greenhouses. **It is based on this that 'skeptics' make their claims**. However, such claims are simplistic. They fail to take into account that once you increase one substance that plants need, you automatically increase their requirements for other substances**. It also fails to take into account that a warmer earth will have an increase in deserts and other arid lands which would reduce the area available for crops**.Plants cannot live on CO2 alone. They get their bulk from more solid substances like water and organic matter. This organic matter comes from decomposing plants and animals or from man made fertilizers. It is a simple task to increase water and fertilizer and protect against insects in an enclosed greenhouse but what about doing it in the open air, throughout the entire Earth? What would be the effects of an increase of CO2 on agriculture and plant growth in general? The following points make it clear. 1. CO2 enhanced plants will need EXTra water both to maintain their larger growth as well as to compensate for greater moisture evaporation as the heat increases. Where will it come from? **Rainwater is not sufficient for current agriculture and the aquifers they rely on are running dry throughout the Earth** ([1](http://www.economist.com/node/17199914), [2](http://www.naturalnews.com/031658_aquifer_depletion_Ogallala.html)). On the other hand, as predicted by Global Warming, we are receiving intense storms with increased rain throughout of the world. One would think that this should be good for agriculture. Unfortunately, when rain falls down very quickly, it does not have time to soak into the ground. Instead, it builds up above the soil then starts flowing to the lowest level. It then quickly floods into creeks, then rivers, and finally out into the ocean carrying off large amounts of soil and fertilizer. 2. Unlike Nature, **our way of agriculture does not self fertilize** by recycling all dead plants, animals and their waste. **Instead we have to be constantly producing artificial fertilizers from natural gas which will eventually start running out.** By increasing the need for such fertilizer you will shorten the supply of natural gas creating competition between the heating of our homes and the growing of our food. This will drive the prices of both up. 3. Too high a concentration of CO2 causes a [reduction of photosynthesis](http://resources.metapress.com/pdf-preview.axd?code=32370807846477k5&size=largest) in certain of plants. There is also [evidence from the past of major damage](http://www.pnas.org/content/105/6/1960) to a wide variety of plants species from a sudden rise in CO2 (See illustrations below). Higher concentrations of CO2 also reduce the nutritional quality of some staples, [such as wheat.](http://www.sciencemag.org/content/328/5980/899.abstract) 4. The worse problem, by far, is that increasing CO2 will increase temperatures throughout the Earth. This will make deserts and other types of dry land grow. While deserts increase in size, other eco-zones, whether tropical, forest or grassland will try to migrate towards the poles. However, soil conditions will not necessarily favor their growth even at optimum temperatures. 5. When plants do benefit from increased Carbon Dioxide, it is only in enclosed areas, strictly isolated from insects. However, when the growth of Soybeans is boosted out in the open, it creates major changes in its chemistry that makes it more vulnerable to insects In conclusion, **it would be reckless to keep adding CO2 to the atmosphere. Assuming there are any positive impacts on agriculture in the short term, they will be overwhelmed by the negative impacts of climate change.** It will simply increase the size of deserts and decrease the amount of arable land. It will also increase the requirements for water and soil fertility as well as plant damage from insects. Increasing CO2 levels would only be beneficial inside of highly controlled, enclosed spaces like greenhouses.

 **Exts – Water Limitation**

**Water is limited – turns agriculture**

**Dinar and Mendelsohn 12** – [Ariel, Robert. “Handbook on Climate Change and Agriculture” <http://books.google.com/books?hl=en&lr=&id=vMyaQ_DWu2wC&oi=fnd&pg=PA9&dq=%22carbon+dioxide%22+%22temperature%22+%22plants%22+%22negative%22&ots=b6GyJ6tS7u&sig=D3L0mTSkdI58DnOh5XE1b3TtjLk#v=onepage&q&f=false>]Mili

Overall, the global population of -7 billion is possible only because of large EXTernal inputs of water and fertilizer as well as climate stability. How then are physical (abiotic) aspects of global climate likely to disrupt crop production? Water The agricultural sector that is likely to be most impacted by climate change is irrigation. One ton of cereal grain requires between 500 to 1000 tons of water to produce. At present, about 67 per cent of the current global water withdrawal, and 87 per cent of the consumptive water use (withdrawal minus return flow) is for irrigation purposes (Shiklomanov, 2000). Although irrigated agricultural land comprises less than one fifth of the total cropped area, it produces about two-fifths of the world’s food (DOll. 2002). For example, rice is a subsistence crop that supplies the majority of calories for 1.5 billion people. Although the area planted with rice is roughly equivalent between irrigated and non-irrigated fields, it is the irrigated rice that accounts for 75 per cent of total rice production (Bouman et al., 2007). If we are to feed an additional 2 billion people in the nEXT 30 years, irrigated agriculture will have to expand. Yet, at present, it is unclear how these demands will be met in the contEXT of water availability and climate change. In a warmer world, with the possibility of greater climatic EXTremes (e.g. drought, flooding), uncertainty of water supply in agriculture is also likely to rise, aside from any change in population. Long-term average irrigation requirements indicate that approximately two-thirds of the area currently under irrigation globally will experience greater water requirements by 2070 (DOll, 2002). Agriculture could shift poleward to regions where climate change will decrease per hectare in irrigation demand (e.g. USA to Canada); however, this is not always practical from a geopolitical or edaphic point of view (e.g. India to Nepal). As demand for water shifts, climate change is also likely to negatively impact supply. Much of the surface runoff used in irrigation is derived from snow and ice melt from mountain sources. These sources may be particularly vulnerable to warmer and drier conditions (IPCC, 2007; Imrncrzeel et al., 2010). For example, Hayhoe et al. (2004) evaluated general trends for agriculture in California, which leads the USA in agricultural production and is highly dependent on snowpack in the Sierra Nevada for irrigation water. This analysis indicated that climate-induced demand was likely to be accompanied by a significant reduction in snowpack and a shift to earlier runoff. Such shifts are already apparent not only in California, but in historical records of the western USA (Kerr, 2007; Barnett et al., 2008). A similar response may have already occurred in Australia’s Murray—Darling River complex (CSIRO, 2008). Groundwater supplies from aquifers are also likely to be affected in arid regions, due in part to declining water tables (overdrafts) and increasing pumping costs. At present, regions supplied by the Ogallala aquifer (including parts of Nebraska, Oklahoma, Texas, Colorado and New Mexico) may be taken out of irrigation due to excessive overdrafts (McGuire, 2007). In addition to climate change, assessments of water supply and demand are complicated by other factors. For example, water demands will increase not only because of agriculture, but also because of expanding human populations and economic development (Vorosmarty et al., 2000). Competition between urban areas and agriculture over existing supplies are likely to be particularly exacerbated in arid regions (e.g. Australia, American West) with projections of increased desertification (IPCC, 2007). Overall, the warming aspect of anthropogenic climate change dominates much of the environmental focus. Yet quantifying the impact of climate change on irrigation and crop production in the contEXT of existing competition for available water resources remains elusive, with only a handful of global assessments. In addition, evaluation of the other EXTreme, flooding, is rarely considered in global climate models regarding agricultural productivity.

 **AT: Rain solves water**

**Climate induced rain water isn’t good for plants**

**Cook 11 –** [April 18, 2011. John is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He studied physics at the University of Queensland, Australia. After graduating, he majored in solar physics in his post-grad honors year. <http://www.skepticalscience.com/Increasing-Carbon-Dioxide-is-not-good-for-plants.html>] H. Kenner

On the other hand, as predicted by Global Warming, we are receiving intense storms with increased rain throughout of the world. One would think that this should be good for agriculture. Unfortunately, when rain falls down very quickly, it does not have time to soak into the ground. Instead, it builds up above the soil then starts flowing to the lowest level. It then quickly floods into creeks, then rivers, and finally out into the ocean carrying off large amounts of soil and fertilizer.

 **AT: Efficiency**

**O3** (another GHG) **decreases water yield efficiency**

**Ainsworth et al. 11**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. [[Betzelberger, A. M.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Betzelberger,+A&fullauthor=Betzelberger,%20A.%20M.&charset=UTF-8&db_key=PHY); [VanLoocke, A. D.](http://adsabs.harvard.edu/cgi-bin/author_form?author=VanLoocke,+A&fullauthor=VanLoocke,%20A.%20D.&charset=UTF-8&db_key=PHY); [Ainsworth, E. A.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Ainsworth,+E&fullauthor=Ainsworth,%20E.%20A.&charset=UTF-8&db_key=PHY); [Bernacchi, C. J.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Bernacchi,+C&fullauthor=Bernacchi,%20C.%20J.&charset=UTF-8&db_key=PHY)] “Ozone decreases soybean productivity and water use efficiency”. American Geophysical Union, Fall Meeting 2011, abstract #PA33B-1822. <<http://adsabs.harvard.edu/abs/2011AGUFMPA33B1822B>> Mili

The combination of population growth and climate change will increase pressure on agricultural and water resources throughout this century. An additional consequence of this growth is an increase in anthropogenic emissions that lead to the formation of tropospheric ozone (**O3), which in concert with climate change, poses a significant threat to human health and nutrition**. In addition to being an important greenhouse gas, **O3 reduces plant productivity**, an effect that has been particularly pronounced in soybean, **which** provides over half of the world's oilseed production. Plant productivity **is linked to feedbacks in the climate system, indirectly through the carbon cycle, as well as directly through the partitioning of radiation into heat and moisture fluxes.** Soybean, along with maize, comprises the largest ecosystem in the contiguous U.S. Therefore, **changes in productivity and water use under increasing O3 could impact human nutrition as well as the regional climate**. Soybean response to increasing O3 concentrations was tested under open-air agricultural conditions at the SoyFACE research site. During the 2009 growing season, eight 20 m diameter FACE plots were exposed to different O3 concentrations, ranging from 40 to 200 ppb. Canopy growth (leaf area index) and physiological measurements of leaf photosynthesis and stomatal conductance were taken regularly throughout the growing season. Canopy fluxes of heat and moisture were measured using the residual energy balance micrometeorological technique. Our results indicate that **as O3 increased from 40 to 200 ppb, rates of photosynthesis and stomatal conductance decreased significantly.** Further, the **seed yield decreased by over 60%, while water use decreased by 30% and the water-use-efficiency (yield/water-use) declined by 50%.** The growing season average canopy temperatures increased by 1°C and midday temperatures increased by 2°C compared to the control. Warmer and drier canopies may result in a positive feedback on O3 as temperature and humidity affect the production/destruction rate of O3. In order to broaden these experimental results, time series modeling is being used to evaluate the historical statistical relationship between soybean production and tropospheric O3 variations at the regional level. A multiple linear regression approach is being taken to understand the effects that O3 has had on soybean yields in Illinois, Iowa, and Indiana over the past 30 years. By combining county yield data with EPA and NASA O3 data, and controlling for variation in temperature and moisture, the O3-exposure relationship for the Midwestern U.S. will be determined. Together, **these results indicate the critical need to understand the response of other crops to O3 and to put in place policies that mitigate the emissions of O3 precursors.**

**2AC Nitrogen/Phosphorus Limitation**

#### Nitrogen Blocks CO2 Ag

Smithsonian Institution 10 [ S.I is an educational and research institute and associated museum complex, administered and funded by the government of the United States and by funds from its endowment. 5-30, “Scientists find excess nitrogen favors plants that respond poorly to rising CO2.” <http://smithsonianscience.org/2010/06/scientists-find-nitrogen-pollution-alters-global-change-scenarios-from-the-ground-up/>] H. Kenner

As atmospheric carbon dioxide levels rise, so does the pressure on the plant kingdom. The hope among policymakers, scientists and concerned citizens is that plants will absorb some of the EXTra CO2 and mitigate the impacts of climate change. For a few decades now, researchers have hypothesized about one major roadblock: nitrogen. Plants build their tissue primarily with the CO2 they take up from the atmosphere. The more they get, the faster they tend to grow—a phenomenon known as the “CO2 fertilization effect.” However, plants that photosynthesize greater amounts of CO2 will also need higher doses of other key building blocks, especially nitrogen. The general consensus has been that if plants get more nitrogen, there will be a larger CO2 fertilization effect. Not necessarily so, says a new paper published in the July 1 issue of Nature. Adam Langley and Pat Megonigal, two ecologists at the Smithsonian Environmental Research Center, conducted a four-year study on plants growing in a brackish Chesapeake Bay marsh. In 2006 they began feeding sedge-dominated plots a diet rich in CO2 and nitrogen. Just as atmospheric CO2 levels are rising, so is nitrogen pollution in estuaries due farming, wastewater treatment and other activities. Because the sedge has previously shown a large CO2 fertilization effect, Langley and Megonigal expected that adding nitrogen could only enhance it.The sedge, Schoenoplectus americanus, initially reacted as expected. However, after the first year something unanticipated happened. Two grass species that had been relatively rare in the plots, Spartina patens and Distichlis spicata, began to respond vigorously to the excess nitrogen. Eventually the grasses became much more abundant. Unlike sedges, grasses respond weakly to EXTra CO2 and do not grow faster. Thus, the nitrogen ultimately changed the composition of the ecosystem as well as its capacity to store carbon. The experiment unfolded on the Smithsonian Global Change Research Wetland, located on the Chesapeake’s western shore in Maryland. The Smithsonian site has a history of climate change research that dates back to the 1980s. For this study, Megonigal and Langley placed 20 open-top chambers over random plots of plants. The chambers were 6 feet in diameter and had 5-foot-tall transparent plastic walls. The large, plastic pods allowed the scientists to manipulate CO2 concentrations in the air and nitrogen levels in the soil. Half of the plots grew with normal, background CO2 levels; the other half were raised in an environment with CO2 concentrations roughly double that amount. Similarly, half of the chambers were fertilized with nitrogen and the other half were untreated. Langley and Megonigal began and ended each growing season with a census of the plants in each chamber. They noted the individual plant species, measured the above-ground biomass and the root growth. In the chambers that received the high-nitrogen diet, the plant composition changed dramatically; it went from 95 percent sedge in 2005 to roughly half grass in 2009. “It’s a fact that not all plants will be able to respond optimally to all changes,” said Megonigal. “The things they do respond to reflects their strategy for making a living in the environment.”

 “The study underscores the importance of considering the mix of species when you’re trying to predict how terrestrial ecosystems will react to global climate change factors,” said Langley. Rising CO2 levels will favor some plants and excess nitrogen will favor others. This lesson will be important to understand as scientists consider additional global change factors such as precipitation, temperature and, in tidal wetlands, sea-level rise. The plant species that gain a competitive edge under these evolving conditions will determine how ecosystems respond to global change.

#### Elevated CO2 prevents creation of useful nitrogen in C3 crops and hinders photosynthesis, stunting their growth

Bloom et al., 12 – Professor in the Department of Vegetable Crops at the University of California at Davis, USA, “CO2 enrichment inhibits shoot nitrate assimilation in C3 but not C4 plants and slows growth under nitrate in C3 plants”, Ecology, February 2012, [http://www.ncbi.nlm.nih.gov/pubmed/22624317)//BI](http://www.ncbi.nlm.nih.gov/pubmed/22624317%29//BI)

The results of these gas flux and growth experiments support the hypothesis that atmospheric CO2 enrichment interferes with the ability of C3 species to assimilate NO3 into organic N compounds in their shoots and that this impedes their growth. In a diverse collection of C3 species and C3-C4 intermediates, CO2 enrichment severely decreased photosynthetic O2 evolution associated with NO3 assimilation (Fig. 1a, c). There are obviously alternative mechanisms for NO3 assimilation because plants under CO2 enrichment and NO3 nutrition continued to grow, albeit often at a slower pace (Figs. 2 and 3). One such mechanism is root NO3 assimilation, which may be enhanced under CO2 enrichment (Kruse et al. 2003). Unfortunately, relatively little is known about the EXTent to which the balance between root and shoot NO3 assimilation varies within and among species (Epstein and Bloom 2005, NunesNesi et al. 2010). In several species measured at ambient CO2 concentration, shoots account for the majority of whole-plant NO3 assimilation over the entire day (Bloom et al. 1992, Cen and Layzell 2003). This study establishes that CO2 enrichment inhibits shoot nitrate assimilation in a wide variety of C3 plants and that this phenomenon influences whole-plant growth; therefore, shoot nitrate assimilation provides an important contribution to the performance of the entire plant.

#### Limited nitrogen means plant productivity in response to elevated CO2 is restricted—affects grasslands which are important for agriculture and carbon sinks

Newton et al., 10 – PhD, Principal Scientist and Team Leader in the Land & Environment group of AgResearch based at Grasslands, Palmerston North, New Zealand, studied agricultural botany at the University College of North Wales, Bangor where he received a BSc (Hons) and subsequently a PhD (Paul C. D., “The rate of progression and stability of progressive nitrogen limitation at elevated atmospheric CO2 in a grazed grassland over 11 years of Free Air CO2 enrichment”, Plant Soil, 15 July 2010, [http://www.springerlink.com/content/d348812u73171461/)//BI](http://www.springerlink.com/content/d348812u73171461/%29//BI)

Understanding and quantifying biogeochemical feedbacks that may modify the CO2-fertilisation effect in terrestrial ecosystems are key steps in understanding and predicting the future sink strength of the biosphere and thus atmospheric CO2 concentration (Thompson et al. 2004; Harrison et al. 2008) and in assessing the impact of global change on managed (e.g. Kimball et al. 2002) and natural ecosystems (Nowak et al. 2004). The best defined of these biogeochemical feedbacks is ‘progressive nitrogen limitation’ (PNL) (Luo et al. 2004); this occurs when “… the labile or mineralizable N pool in soil is depleted below the level needed to support significant plant growth responses to CO2 enrichment” (Hu et al. 2006). A reduction in the labile pool can occur because an increase in net primary productivity at elevated CO2 may cause an increased sink for nitrogen (N) in soil microbes and/or greater storage of N in long-term plant pools. Symptoms of PNL, such as increased storage of high C/N material in woody tissue (e.g. Finzi et al. 2006) or reduced rates of N mineralisation (de Graaff et al. 2006) or declining responses to CO2 (Reich et al. 2006) have been observed in many elevated CO2 experiments as have the direct effect as seen in the N harvested (taken up) in the biomass (Schneider et al. 2004). However, often the PNL response is obscured or constrained by offsetting factors that can include: increased input of N from biological fixation (Zanetti et al. 1996); mobilisation from soil organic matter (e.g. Schneider et al. 2004; Dijkstra et al. 2008); or an increased N use efficiency of plants (Soussana et al. 1996; Zanetti et al. 1997; Ghannoum et al. 2006). Understanding the nature of PNL in grasslands is important; grasslands cover 20% of the terrestrial surface of the world (Hadley 1993) and contain 30% of all terrestrial soil carbon (C) (Gill et al. 2006) thus providing an important potential sink for anthropogenic CO2. Grasslands are also of agricultural importance and the potential for PNL to lead to increased demand for N fertilisers or to reduce the protein harvested in EXTensive livestock systems where protein availability is already marginal are strong motivations to study N limitation under elevated CO2.

#### Phosphorus and Nitrogen come before CO2

Cook 11[April 18 2011. John is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He studied physics at the University of Queensland, Australia. After graduating, he majored in solar physics in his post-grad honors year.

Even within a specific type of photosynthesis—indeed, even within a specific species—the positive responses to enhanced CO2 can vary widely. Nutrient availability in particular can greatly affect a plant’s response to excess CO2, with phosphorous and nitrogen being the most critical (Stöcklin and Körner 2002, Norby et al. 2010, Larson et al. 2010). The ability of plants to maintain sufficient nitrogen under excess CO2 conditions is also reduced for reasons not fully understood (Bloom et al. 2010, Taub and Wang 2008). It has also been found that excess CO2 can make certain agricultural plants less nutritious for human and animal consumption. Zhu 2005, a three-year FACE study, concluded that a 10% decrease in the protein content of rice is expected at 550 ppm, with decreases in iron and zinc contents also found. Similarly, Högy et al. 2009, also a FACE study at 550 ppm, found a 7% drop in protein content for wheat, along with decreased amino acid and iron content. Somewhat ironically, this reduction in nutrient content is partially caused by the very increase in growth rates that CO2 encourages in C3 plants, since rapid growth leaves less time for nutrient accumulation. Increased CO2 has been shown to lead to lower production of certain chemical defense mechanisms in soybeans, making them more vulnerable to pest attack and diseases (Zavala et al. 2008 and Eastburn et al. 2010). Other studies (e.g. Peñuelas and Estiarte 1999) have shown production of phenolics and tannins to increase under enhanced CO2 in some species, as well as many alkaloids (Ziska et al. 2005), all of which may have potential consequences on the health of primary consumers. The decreased nutritional value in combination with increased tannin and phenolic production has been linked to decreased growth rate and conversion efficiency of some herbivores, as well as an increase in their relative demand and consumption of plants (Stiling and Cornelissen 2007). Furthermore, many “cyanogenic” species—plants which naturally produce cyanide, and which include 60% of all known plant species—have been found to increase their cyanide production in an enhanced CO2 world. This may have a benefit to the plants who use cyanide to inhibit overconsumption by pests and animals, but it may in turn reduce their safety as a food supply for both humans and animals (Gleadow et al., 2009a and Gleadow et al. 2009b).

**Both nitrogen and phosphorous are limiting nutrients to productivity in elevated CO2**

**Gentile et al., 11 –** Roberta, PhD at the University of California, Davis, two year post-doctoral fellowship with the Global Change team, AgResearch Grasslands, New Zealand; Mike Dodd, agricultural science undergraduate degree at Massey University, PhD from Colorado State University, New Zealand Certified Professional Agriculturalist since 1997; Mark Lieffering, B.Ag.Sc., a M.Ag.Sci., in Plant Ecology, PhD in Crop Physiology from Lincoln University; Shona C. Brock; Phil W. Theobald; Paul Newton, Principal Scientist and Team Leader in the Land & Environment group of AgResearch based at Grasslands, Palmerston North, New Zealand, PhD. In agricultural botany from the University College of North Wales, Bangor (Effects of long-term exposure to enriched CO2 on the nutrient-supplying capacity of a grassland soil”, 13 September 2011, [http://www.springerlink.com/content/965276h67x3103j1)//BI](http://www.springerlink.com/content/965276h67x3103j1%29//BI)

Plants grown under enriched CO2 were co-limited by N and P, while plants grown under ambient CO2 were primarily limited by N only. According to the classic “law of the minimum”, plant growth will be limited by the essential nutrient that is available in the lowest proportion to plant requirements (Liebig 1855). Nutrient limitation is typically demonstrated by fertilization studies where the addition of a nutrient increases net primary production or similar process (Vitousek and Howarth 1991). Ambient CO2 plants displayed a single nutrient limitation response to N, whereby biomass increased with N but not P fertilizer (Fig. 1). Alternatively, enriched CO2 plants showed a classic co-limitation response (Craine and Jackson 2010), where biomass increased after application of N and P together, but not in response to either nutrient applied alone. Thus, P fertilizer was required to maintain plant biomass response to N under enriched CO2. This result supports our hypothesis that enriched CO2 induces nutrient limitation and increases the fertilizer required to maintain plant growth. Leaf tissue nutrient concentrations further support these observations of P limitation under enriched CO2. Both CO2 treatments had equivalent leaf P concentrations at each P rate. Therefore, the amount of total leaf P uptake reflected the same treatment patterns as leaf biomass production. Enriched CO2 has been proposed to increase the P requirement of Pinus densiflora seedlings, explaining a decrease in biomass with P limitation under enriched but not ambient CO2 concentrations (Norisada et al. 2006). Additionally, plant nutrition studies on Pinus radiata and soybean suggested critical tissue P concentrations for maximum productivity were higher under enriched CO2 (Conroy 1992). Thus, it is possible that enriched CO2 influenced the P requirement for perennial ryegrass in our experiment and restricted plant growth even when leaf P concentrations were not affected. However, the reduced total P uptake in the 0-kg P ha−1 treatment at enriched compared to ambient CO2 indicates that less P was available in our study under enriched CO2. In contrast to P, leaf N concentrations increased under enriched compared to ambient CO2 at 0 kg P ha−1; thus, growth was unlikely to be limited solely by N. Equivalent total leaf N uptake was observed in both CO2 treatments at each P rate, implying that soil N was equally available in each treatment. The leaf N/P ratio, which may be used to indicate nutrient deficiencies (Güsewell 2004; Koerselman and Meuleman 1996), was greater under enriched than ambient CO2 in the absence of P fertilizer (Table 1), implying a limitation of P. In a recent review of N/P ratios in terrestrial vegetation and fertilization experiments, Güsewell (2004) defined critical ratios of <10 for N limitation, 10–20 for co-limitation of N and P and >20 for P limitation. Thus, in our study, mean N/P ratios for perennial ryegrass without P fertilization would indicate N limitation under ambient CO2 (N/P of 7.80) and a co-limitation of N and P under elevated CO2 (N/P of 12.47). These values further support the plant biomass production in response to N and P fertilizer additions.

 **AT: Efficiency**

**No – CO2 makes it harder for plants to process nitrogen**

**Rudolf 10** – Masters in Journalism from NYU, Recipient of the Arthur Carter Fellowship, Bachelors of Arts, English from The Colorado College, [John Collins, Staff Writer for the NYT. “It’s Love-Hate: Plants and Carbon Dioxide.” <http://green.blogs.nytimes.com/2010/05/21/its-love-hate-plants-and-carbon-dioxide/>] H.Kenner

This video, released in 1991 and financed by the Western Fuels Association, a coal supplier, insisted that the unrestrained burning of fossil fuels would be a great thing, ushering in an epoch of bountiful plant growth and soaring grain yields.Its makers earned scorn for their blithe dismissal of the negative consequences of runaway emissions, from melting ice caps and rising seas to ocean acidification and intensified storms. Yet elements of their central thesis – that elevated levels of carbon dioxide would boost plant growth – were widely accepted by the scientific establishment at the time. Two decades later, science takes a far less rosy view. In 2005, Britain’s Royal Society determined that the benefit to crops of added carbon dioxide were far less pronounced under real-world conditions than in laboratory experiments. Other studies have found the nutritional content of crops falling as carbon dioxide levels rose.The promised “greening” of the planet, it seems, is not working out as advertised. “It’s less clear that we’re going to have an overall benefit,” said Arnold J. Bloom, a professor of plant science at the University of California at Davis. “In most cases it seems that the decline in nutrition is going to be greater than anyone expected.”These declines in nutrition content have puzzled investigators. Yet in a study published this month in the journal Science, a team of researchers led by Dr. Bloom may have found a cause. According to their findings, higher levels of carbon dioxide interfere with plants’ ability to process nitrate, a vital soil nutrient, stunting the growth of key proteins. “Nitrogen levels in most plants decline as they are exposed to higher levels of carbon dioxide,” Dr. Bloom said. “That’s a bad thing.” The implications for global food security are profound. If emissions continue to increase at present rates, global yields of wheat and other crops could drop as much as 20 percent by 2050, the study found. Careful adjustments in fertilizer use could blunt these impacts, but would probably be difficult for today’s industrial-scale farms to manage.The steady decline of the earth’s forests – previously linked to increases in air temperature – may also be related to the effect of carbon emissions on nitrogen levels, Dr. Bloom said.

**Studies show that CO2 decreases N production – that turns CO2 ag benefits**

**Newton et al., 10** – PhD, Principal Scientist and Team Leader in the Land & Environment group of AgResearch based at Grasslands, Palmerston North, New Zealand, studied agricultural botany at the University College of North Wales, Bangor where he received a BSc (Hons) and subsequently a PhD (Paul C. D., “The rate of progression and stability of progressive nitrogen limitation at elevated atmospheric CO2 in a grazed grassland over 11 years of Free Air CO2 enrichment”, Plant Soil, 15 July 2010, [http://www.springerlink.com/content/d348812u73171461/)//BI](http://www.springerlink.com/content/d348812u73171461/%29//BI)

Our measurements of plant N harvested demonstrate a declining response to elevated CO2 over a 5–6 year period consistent with PNL. In this experiment we saw two of these periods with a perturbation that appeared to ‘reset’ the response to CO2 during 2003. The reduction can be ascribed to changes in biomass as the mean concentration of the bulk herbage harvested was not different between ambient and elevated CO2 at any stage in the experiment. Note that Allard et al. (2003) have shown a reduced N concentration in individual species in this sward— consistent with the expected response to CO2 (e.g. Poorter et al. 1997)—but no difference in the amount of N harvested in the community because of changes in botanical composition to species with a higher N concentration (although still lower than ambient) such as legumes and forbs at elevated CO2. The botanical composition effect described above is one way that PNL is offset in this system. The increased abundance of legumes at elevated CO2 (Ross et al. 2004; Newton et al. 2006) and the potential for greater N input from biological N fixation is another. Using 15N natural abundance Carran and Bowatte (unpublished data) showed in 2002 that the proportion of N in Trifolium repens and T. subterraneum arising from nitrogen fixation was the same under both elevated and ambient CO2. If this was true for the duration of the experiment it means that legume biomass can be used as a measure of the relative difference in biologically fixed N inputs. In the 1997–2002 period there was 2.0 times as much legume at elevated CO2 and during 2003-7 1.75 times as much; representing a substantial input of additional N from the only de novo source of N input in this system. Clearly, with less diversity, and particularly in the absence of legumes, the ability of grassland to offset PNL through botanical change will be limited with the only recourse being additional fertiliser input (Soussana and Luscher 2007). Recent chemical analysis of T. repens in our system shows reduced molybdenum content at elevated CO2 (M Lieffering personal communication) suggesting the possibility of reduced efficiency of N fixation at elevated CO2 as found by Hungate et al. (2008); this is clearly an important area of research for further study. Despite the offset factors we found that the response to elevated CO2 weakened over time. The perturbation to the system that caused a marked reinstatement of the CO2 response we suggest is due to the exceptional drought during early 2003; when the drought broke, N mineralisation was EXTremely rapid (the ‘Birch’ effect; Birch 1958) leading to a large pulse of mineral N into the system. We suggest that in this temporarily high N situation there was the opportunity for a strong CO2 response; many experiments having shown that the response to CO2 is strongest as N limitation is removed (e.g. Daepp et al. 2000). Soil from this experiment was used by Allard et al. (2006) for a labelling experiment in a glasshouse. Two rates of labelled N fertiliser were applied (0.5 and 10 gN m−2). At the lower fertiliser level—the treatment most closely replicating field conditions— there was less N taken up by the plants at elevated CO2 both from the soil pool and from the fertiliser pool. In addition, there was significantly less N taken up from the soil pool in the soil that had been taken from the elevated CO2 rings after 4 years of enrichment. In another long running FACE experiment on grassland in Switzerland, in this case fertilised with two rates of N (14 or 56 gN m-2); the N harvested at the lower fertiliser rate was reduced under elevated CO2 ( Schneider et al. 2004) and in a labelling experiment de Graaff et al. (2008) saw that more of the fertiliser N was stabilised in soil organic matter pools at elevated CO2 i.e. less was available to the plants; a result that parallels the Allard et al. (2006) findings for our experiment. At the high fertiliser rate in the Swiss experiment (56 gN m-2yr−1) there was a strong stimulation of biomass and N harvested at elevated CO2 (Daepp et al. 2000) showing that removal of N limitation can allow grassland to respond to CO2. However, it should be noted that the rate of N applied in the Daepp et al. experiment was very large; even highly intensive farming systems such as practised in the UK or the Netherlands apply on average 30–45 gN m−2yr−1. In contrast, much of the grazed grassland of the world receives very little fertiliser—the average fertiliser application (N, P and K) on grasslands worldwide being 0.03 gm−2 y−1 (FAO 2009); supplemented in some areas by N deposition for which the global average is 0.035 gN m−2 (Phoenix et al. 2006). Consequently much of the world’s rangelands produce diets for animals that are deficient in protein and therefore EXTremely vulnerable to any further reduction in the N taken up by plants. The interesting result of Dijkstra et al. (2008) should be mentioned here. Contrary, to the generalisation emerging from the review of Hu et al. (2006) and from the previous paragraph that low N systems are prone to PNL, Dijkstra et al. actually found increased mineralisation of N in their low N, semiarid prairie system probably due to greater water availability under high CO2. Although this additional N allowed an increased quantity of N to be taken up by plants (Dijkstra et al. 2008) it is important to note that the overall effect on crude protein quality under elevated CO2 was negative (Milchunas et al. 2005). In addition, while a redistribution of N from soil to plants as found by Dijkstra et al. (2008) and by Gill et al. (2006) acts as a counter to PNL, this response does not involve a net increase in total N in the system and the potential of this mechanism to offset PNL in the long term may be limited (Hungate et al. 2003). In our experiment the rate of decline in the N harvested in the plants at elevated CO2 was matched by an increase in the N stored in the soil (Fig. 1a, b). Given the ephemeral nature of plant material in grazed grasslands the soil is the only place that N can be sequestered and PNL initiated. While a shift in N from plant to soil pools is often a response to elevated CO2 in herbaceous systems (de Graaff et al. 2006) clearly the work of Dijkstra et al. (2008) and Gill et al. (2006) show this is not invariably the case. With increasing duration of exposure to elevated CO2 we saw reduced NO3-N (Fig. 2a) and a nonsignificant decrease in NH4-N (Fig. 2b). A 15N labelling experiment on this system (Rütting et al. 2010) suggest the reduced NO3-N may be due to both reduced nitrification and increased dissimilatory NO3 reduction to NH4; the reduction in NH4-N being driven by an increased immobilisation into recalcitrant organic N reflecting a greater microbial demand. It is worth noting that the labelling experiment involved addition of moisture and N to cores removed from the experiment during summer when the volumetric soil moisture content was <5% suggesting that the conditions might be most similar to the post drought period in 2003 (Fig. 1c) than at other times in the experiment. Clearly, the interaction of CO2induced changes in N cycling and environmental conditions are a key to understanding the dynamics of PNL in grasslands. An important question is how far N availability will decline i.e. what is the equilibrium point at which immobilisation of N balances factors leading to an increase in availability (such as N fixation). The use of mesocosms allowed us to make a controlled test (without variation caused by conditions in individual years) of the effects of the duration of exposure to CO2. For NO3-N the data in Fig. 2a suggest that after 6 years of exposure the system had come to a new equilibrium or, to put it another way there was no further progression in nitrogen limitation. Over a 6– 10 year period we can see from Fig. 1a that it is quite possible that the N harvested under FACE may fall below that of ambient, so in our system at least, the new equilibrium of nutrient supply and demand will result in a reduced supply of protein for animals. Our results therefore support the view of Reich et al. 2006 that “… in sites with low to moderate soil N availability, N limitation probably constrains the stimulation of biomass accumulation by elevated CO2”. For the first time we have shown this effect in grassland under grazing; over a long period of exposure; and importantly, have shown that the N limitation while having an underlying progressive characteristic is also dynamic and can be manipulated by perturbation. This result has important consequences for natural grasslands where responses are controlled by climatic events and also managed grasslands where management intervention might be tailored to maximise the fertilisation effect of CO2.

 **AT: Fertilizer Solves**

**Not viable**

**Bloom et al., 12** – Professor in the Department of Vegetable Crops at the University of California at Davis, USA, “CO2 enrichment inhibits shoot nitrate assimilation in C3 but not C4 plants and slows growth under nitrate in C3 plants”, Ecology, February 2012**,** [http://www.ncbi.nlm.nih.gov/pubmed/22624317)//BI](http://www.ncbi.nlm.nih.gov/pubmed/22624317%29//BI)

C3 plants under CO2 enrichment can avoid CO2 acclimation and sustain enhanced photosynthesis and growth for very long periods of time if they receive N fertilizer applications that far exceed natural mineralization rates and standard agricultural practices (Curtis and Wang 1998, Wand et al. 1999, Ainsworth and Long 2005, de Graaff et al. 2006). These applications of N fertilizer most likely enhance the availability of soil NH4 and thus compensate for lower rates of shoot NO3 assimilation. Such fertilizer practices, however, are neither economically nor ecologically viable on a larger scale. This study highlights a general problem: the difficulty in determining, much less trying to control, the forms and amounts of N available to plants from the rhizosphere. The inorganic forms NH4 and NO3 are highly disparate, differing in such fundamental characteristics as charge, oxidation state, toxicity, production rates in the rhizosphere, and mobility through the soil. Here we show that the response of C3 species to CO2 enrichment depends on N form, NH4 vs. NO3, but relatively few studies consider this. As atmospheric CO2 levels continue to rise, the distinction between NH4 and NO3 as plant N sources will gain in ecological importance.

 **Nitrogen + CO2 = Decline in Species**

#### Nitrogen and temperature interact with elevated CO2, changing plants’ characteristics and preventing adequate pollination, thus causing decline in species

Hoover et al., 12 – School of Biological Sciences, University of Canterbury, New Zealand (Shelley E. R., “Warming, CO2, and nitrogen deposition interactively affect a plant-pollinator mutualism”, Ecology Letters, 6 January 2012, [http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2011.01729.x/abstract)//BI](http://onlinelibrary.wiley.com/doi/10.1111/j.1461-0248.2011.01729.x/abstract%29//BI)

Ecosystems worldwide are undergoing unprecedented environmental change (MEA 2005) caused by habitat fragmentation, nitrogen (N) deposition, biotic invasions, increasing atmospheric carbon dioxide (CO2) and climatic changes. Each of these drivers threatens biodiversity (Sala et al. 2000), but disruptions to crucial interactions between species may even precede biodiversity loss (Tylianakis et al. 2008), even though the arrangement of interactions within a whole community can confer system stability. Moreover, it is becoming increasingly apparent that important interaction effects cannot be predicted from the independent effect of each driver (Tylianakis et al. 2008; Schweiger et al. 2010). For example, N and temperature both affect plant physiological responses to elevated CO2 (Reich et al. 2006; Zvereva & Kozlov 2006), with potential cascading effects on species that interact with plants (Tylianakis et al. 2008). Species interactions underpin numerous ecosystem services on which human well-being depends. For example, animal pollination of plants is crucial for maintaining plant diversity (Ollerton et al. 2011), and provides an essential ecosystem service through pollination of three quarters of global food crops (Klein et al. 2007). However, studies have shown that changes such as habitat modification and pesticide use (Aguilar et al. 2006; Brittain et al. 2010), plant and pollinator invasions (Lopezaraiza-Mikel et al. 2007; Aizen et al. 2008), or phenological mismatches due to climate change (Memmott et al. 2007) can potentially threaten this mutualism, either by reducing pollinator diversity or by altering the ability of native pollinators to encounter and successfully pollinate plants. Consequently, the decline of pollinators may be paralleled by declines in the wild and agricultural plants that rely on them (Biesmeijer et al. 2006; Potts et al. 2010). Despite widespread evidence of pollinator decline due to the above drivers, the results of previous studies are surprisingly variable (Tylianakis et al. 2008; Winfree et al. 2011). This may be due to the correlative, non-experimental approaches used (of around 670 studies recently reviewed by Winfree et al. (2011), only a handful were experimental), which cannot reveal mechanisms behind pollinator responses. Furthermore, studies testing effects of a single driver cannot detect interactions. Yet, these and other examples of the effects of single global change drivers on plant-pollinator mutualisms and pollinator fitness (Rusterholz & Erhardt 1998; Mevi-Schutz & Erhardt 2005; Schweiger et al. 2010) raise concerns that a suite of drivers acting simultaneously could further alter this relationship, and that altered attractiveness of flowers or nutritional rewards to pollinators could dramatically alter pollinator fitness and plantpollinator mutualisms.

**2AC Malnutrition**

**Rising CO2 levels cause malnutrition**

**Dinar and Mendelsohn, 12**. [Ariel, Robert. “Handbook on Climate Change and Agriculture” p.15-17] Ariel Dinar= Ph.D. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1984 M.Sc. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1974 B.Sc. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1972. Robert Mendelsohn got his B.A. at Harvard University and Ph.D. at Yale University and is now the Edwin Weyerhaeuser Davis Professor of Forest Policy; Professor of Economics; and Professor, School of Management. Mili

Management of pests, particularly weeds, is also likely to be affected. For many industrialized countries, chemical application of herbicides allows for cheap, effective weed control in crop production. In fact, a single herbicide, glyphosate (commercially sold as ‘Round Up’), is so effective in controlling weeds that more than three-quarters of the US soybean crop and over one-third of the US corn crop have been genetically modifies to be glyphosate resistant (Gaskell et all., 1999). However, there are several studies indicating a decline in herbicide efficacy as a function of increasing atmospheric CO2 and/or temperature (Archambeault, 2007; Ziska and Teasdale, 2000). Globally, there are several additional means of weed management, most notably mechanical, biological, and cultural. Although data are scarce, there are cogent reasons for anticipating potential changes in these management strategies in response to changing climate and CO2 concentrations. For example, tillage (physical cultivation to remove weeds in the field) could be affected by precipitation EXTremes that could limit field operations. Rising CO2 levels could also increase root or rhizomes in the field. The efficacy of weed biocontrol agents (e.g. insects) is dependent on synchrony between various aspects of the plant community. As climate and/or CO2 levels change, differential responses among host and biocontrol agents could occur. Yet it is also clear that water supply and demand are likely to be impacted by climate change too. Nutrition Researchers are obviously concerned regarding the impact of CO2 and climate change on crop production and food security. However, it is equally important to consider the quality of nutritional aspects of the food supply. A study of major food crops including barley, wheat, soybean, and potato indicated a significant decline (about 10 to 15%) in protein content if atmospheric CO2 increases to between 540-960 ppm (Taub et al. 2007), a range anticipated by the end of this century (IPCC, 2007). This due, at least in part, to the fact that as CO2 increases, photosynthesis requires less nitrogen (i.e nitrogen use efficiency, the ratio of C to N, typically increases). In addition to this dilution of protein levels, rising CO2 may also reduce a result, uptake of key macro and macro nutrients from the soil (e.g. iron, zinc, manganese) may also be negatively impacted with respect to human health (Loladze, 2002). The UN Food and Agriculture Organization estimates that more than 1 billion people worldwide are malnourished (FAO, 2009). Malnutrition generally results from a lack of either protein, which is needed for muscle development and maintenance, or micronutrients such as iodine, Vitamin A or iron, which boost immunity and healthy development. If, as we expect, rising CO2 levels affect the nutritional quality of crops, then it is possible that impoverished areas of the world already threatened by shortages in food supply may face an additional burden of ‘hidden hunger’.

**2AC Pests**

#### Best studies prove harm caused by pests outweighs benefits

S. Deka et. al. No Date[Sri is a lecturer at the Patkai Chrisitan College. He led a report submitted to the Division of environmental science in New Delhi. “ Climate Change and Impacts on Crops- A Critique”. <http://www.isprs.org/proceedings/XXXVIII/8-W3/b2/13-B13-48.pdf>] H.Kenner

Climatic variability, together with increase in atmospheric temperature and carbon dioxide do have lot of implication in agriculture sector. Latest assessment report from the Intergovernmental Panel on Climate Change (IPCC) predicts an increment in mean atmospheric temperature from 1.1 to 6.4°C toward the year 2100 with equally increasing atmospheric carbon dioxide (CO2). Such climatic changes could profoundly affect insects both directly i.e. seasonal shifts of insects and indirectly i.e. changing plant productivity and quality, changing predators increasing insect pests population. A detailed investigation was done by analyzing various studies carried out around the globe on impact of increasing atmospheric temperature and carbon dioxide on crop pests population and crop-pest interaction. **Studies reported both harmful and beneficial impacts, however benefits are least reported**. A substantial expansion in high latitude and elevation of various crop insect pest distributions and is critical in temperate part of the world. Increased frequent insect outbreaks had been observed where changing climate may interfere with the induction of extended diapauses. Increase in atmospheric temperature resulted in reduction in survival and increase in developmental rate, resulting in more generations (and more crop damage) per year. New studies show that insect species living in warmer areas are more likely to undergo rapid population growth because they have higher metabolic rates and reproduce more frequently, thus climate change would create favorable conditions for growth in insect populations. Other environmental parameters like relative humidity and CO2 is potentially important, more CO2 in the atmosphere make plants to take up more carbon and leaves become less nutritious and results in voluminous feeding. **Further studies on crop-pest interaction focusing on spatio-temporal variations are needed to have a better understanding and to quantify its future impacts.**

#### Elevated CO2 increases temperature and pests — we cite 7 studies

S. Deka et. al. No Date(Sri is a lecturer at the Patkai Chrisitan College. He led a report submitted to the Division of environmental science in New Delhi. “ Climate Change and Impacts on Crops- A Critique”. <http://www.isprs.org/proceedings/XXXVIII/8-W3/b2/13-B13-48.pdf>] H.Kenner)

The atmosphere temperature rise is not a new phenomenon and it has started million of years ago. Scientists were analyzing the fossilized remains of leaves of trees about 55 millions years ago and they reached a conclusion that planet was undergoing a period of warming. They believe rise in global temperatures caused by a tripling of CO2 levels during the palaeocene age and this result in soaring insect number. Climate, temperature and precipitation in particular, have a very strong influence on the development, reproduction and survival of insect pests and as a result it is highly likely that these organisms will be affected by any changes in climate. Milder and shorter winters mean that warm weather pests will start breeding sooner (Bale et al. 2002). Other changes include expanded pest ranges, disruption of synchrony between pests and natural enemies, and increased frequency of pest outbreaks and upheavals (Parmesan 2007). Many major insects are contributors to global warming because of the CO2 they emit. Bugs and all termites are major contributor global warming. The termite will emit CO2 from their gut because when they consume the wood and its digestion resulting emission. With every degree the global temperature rises, the life cycle of each bug will be shorter. The quicker the life cycle, the higher will be the population of pests. The general prediction is that if global temperatures increase, the species will shift their geographical ranges closer to the northern pole or to higher elevations, and increase their population size. In temperate regions, most insects have their growth period during the warmer part of the year. Due to this species whose niche space is defined by climatic regime will respond more predictably to climate change while those in which the niche is limited by other a biotic or biotic factor will be less predictable. A key factor regulating the life history pattern of insect pests is temperature. Because insects are poikilothermic (coldblooded) organisms - the temperature of their bodies is approximately the same as that of the environment. Therefore, the developmental rates of their life stages are strongly dependent on temperature. Indeed, almost all insects will be affected to some degree by changes in temperature, and there may be a multitude of intertwined effects upon insect life histories. Porter et al (1991) in the study mentioned the effects of temperature upon insects, including limitation of geographical range, over wintering, Temperature can impact insect physiology and development directly or indirectly through the physiology or existence of hosts. Depending on the development “strategy” of an insect species, temperature can exert different effects (Bale et al 2002). Some insects take several years to complete one life cycle – these insects (cicadas, arctic moths) will tend to moderate temperature variability over the course of their life history. Some crop pests are “stop and go” developers in relation to temperature – they develop more rapidly during periods of time with suitable temperatures. It has been estimated that with a 2o C temperature increase insects might experience one to five additional life cycles per season (Yamamura & Kiritani 1998). Warming could decrease the occurrence of severe cold events, which could in turn expand the overwintering area for insect pests. In-season effects of warming include the potential for increased levels of feeding and growth, including the possibility of additional generations. Degree-day or phenology based models are often used to predict the emergence of insects (like cabbage maggot, onion maggot, European corn borer, Colorado potato beetle etc.) and their potential to damage crops. Increased temperatures will accelerate the development of crop affecting maggots and borers – possibly resulting in more generations (and crop damage) per year.

#### Pests outcompete each other — decreases biodiversity

S. Deka et. al.[Sri is a lecturer at the Patkai Chrisitan College. He led a report submitted to the Division of environmental science in New Delhi. “ Climate Change and Impacts on Crops- A Critique”. <http://www.isprs.org/proceedings/XXXVIII/8-W3/b2/13-B13-48.pdf>] H.Kenner

Climate change has been recognized globally as the most impending and pressing critical issue affecting mankind survival in the 21st century. The last assessment report from the Intergovernmental Panel on Climate Change predicted an increment in mean temperature from 1.1 – 6.4 °C by 2100 (IPCC, 2007). The global atmospheric concentration of green house gases (GHG) viz., carbon dioxide (CO2), methane (CH4) and nitrous oxide (NO2) has increased tremendously as a result of human activities from pre-industrial era. Increasing concentration of these gases is expected to have great effect on global climate change and thereby affect on agriculture (Cannon 1998). Climate change will be an additional challenge to produce enough food grain for the ever-growing populations when crop production will have to be boosted to feed an extra three billion people living at the end of 21st century. Considering all the anticipated or expected changes, global researchers are deeply engaged in analyzing the effect of insect pest on agriculture crop. Climate change related factors such as rise of temperature, carbon dioxide atmospheric concentration rise are the major cause of concern. An attempt was done to analyze various major studies undertaken across the globe on crop insect pest and how it influences the crop. Generally, Climate change impacts on pest population include change in phenology, distribution, community composition and ecosystem dynamics that finally leads to extinction of species (Walther et al 2002). Climate change effects could either be direct, through the influence that weather may have on the insects’ physiology and behavior (Berrigan 2001). In addition, indirect effects can occur through the influence of climates on the insect’s host plants, natural enemies and interspecific interactions with other insects.

**Pests kill**

**Cook 11 –** [April 18, 2011. John is the Climate Communication Fellow for the Global Change Institute at the University of Queensland. He studied physics at the University of Queensland, Australia. After graduating, he majored in solar physics in his post-grad honors year. <http://www.skepticalscience.com/Increasing-Carbon-Dioxide-is-not-good-for-plants.html>] H. Kenner

5. When plants do benefit from increased Carbon Dioxide, it is only in enclosed areas, strictly isolated from insects. However, when the growth of Soybeans is boosted out in the open, it creates major changes in its chemistry that makes it more vulnerable to insects In conclusion

**Elevated CO2 decreases nutrients in vegetation, causing malnutrition in insects and more destruction of plants**

**Robinson et al., 12** – School of Environmental Sciences, University of Guelph, Guelph, Ontario, Canada, “A meta-analytical review of the effects of elevated CO2 on plant–arthropod interactions highlights the importance of interacting environmental and biological variables”, New Phytologist, April 2012, [http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04074.x/abstract;jsessionid=E73C6C3FF9E28C026FB82BBE11C673D0.d04t04)//BI](http://onlinelibrary.wiley.com/doi/10.1111/j.1469-8137.2012.04074.x/abstract%3Bjsessionid%3DE73C6C3FF9E28C026FB82BBE11C673D0.d04t04%29//BI)

When the data from all of the insect orders and feeding guilds were combined, there was a significant decrease in relative growth rate (-4.5%) and a significant increase in relative consumption rate (+14%) under elevated CO2 (Fig. 1). Conversion efficiencies for both ingested and digested food also decreased under elevated CO2 (-17% and -12%, respectively). While there was no change in larval ⁄ nymphal weight, there were decreases in both pupal weight and adult weight (-5.5%). However, the fail-safe number for adult weight was less than Rosenthal’s critical value (Rosenthal, 1979). Herbivores exposed to elevated concentrations of CO2 had longer development times (+3.5%). Even though there was no effect of CO2 on survival or abundance, relative damage to plants was greater (+22%) under elevated CO2. Some of the responses reported in Fig. 1 are based on too few studies to enable meaningful statistical inferences to be made, most notably life span and rate of parasitism ⁄ predation. See Table S1(a) for complete results.

**2AC Ozone**

**Anthropogenic ozone is toxic and kills plant productivity**

**Ainsworth et al. 12**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. [June, “The Effects of Tropospheric Ozone on Net Primary Productivity and Implications for Climate Change”.Annual Review of Plant Biology.Craig R. Yendrek- 1Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois. Stephen Sitch- Department of Geography, College of Life and Environmental Sciences, University of Exeter, Exeter. Lisa D. Emberson- Stockholm Environment Institute, Environment Department, University of York, York. <<http://www.annualreviews.org.proxy.lib.umich.edu/doi/full/10.1146/annurev-arplant-042110-103829#h20>>] Mili

Tropospheric ozone (O3) is a global air pollutant that causes billions of dollars in lost plant productivity annually. It is an important anthropogenic greenhouse gas, and as a secondary air pollutant, it is present at high concentrations in rural areas far from industrial sources. It also reduces plant productivity by entering leaves through the stomata, generating other reactive oxygen species and causing oxidative stress, which in turn decreases photosynthesis, plant growth, and biomass accumulation. The deposition of O3 into vegetation through stomata is an important sink for tropospheric O3, but this sink is modified by other aspects of environmental change, including rising atmospheric carbon dioxide concentrations, rising temperature, altered precipitation, and nitrogen availability. We review the atmospheric chemistry governing tropospheric O3 mass balance, the effects of O3 on stomatal conductance and net primary productivity, and implications for agriculture, carbon sequestration, and climate change. INTRODUCTION Tropospheric ozone (O3) is a damaging air pollutant that significantly impacts human and ecosystem health, and is also an important greenhouse gas responsible for direct radiative forcing of 0.35–0.37 W m−2on the climate (52, 136). It is estimated to have been responsible for 5%–16% of the global temperature change since preindustrial times (52) and is the second-most-important air pollutant (after particulate matter) in causing human mortality and morbidity impacts to human health; globally, an estimated 0.7 million deaths per year are attributed to anthropogenic O3pollution (8; see sidebar Ozone Effects on Human Health). The damaging effects of O3 on photosynthetic carbon assimilation, stomatal conductance, and plant growth feed forward to reduce crop yields (3, 10, 46, 49, 57), with current global economic losses estimated to cost from $14 billion to $26 billion (151). Forests and natural ecosystems are also negatively impacted by current O3 concentrations ([O3]) (66, 162), which have downstream consequences for ecosystem goods and services (126). Experimental and modeling approaches are currently being used to understand plant responses to elevated [O3] and to predict their impacts on global net primary productivity (NPP); however, significant gaps in knowledge remain about the interactions of rising tropospheric [O3] and other environmental factors, including drought, soil nutrient status, and variables associated with climate change [e.g., elevated carbon dioxide concentration ([CO2]) and rising temperature]. In addition to being a direct driver of global warming, tropospheric [O3] can also induce indirect effects. For example, increasing atmospheric [O3] will negatively impact plant production, reducing the ability of ecosystems to sequester carbon, and thus indirectly feed back on atmospheric [CO2], enhancing climate change (31, 138). In this review, we outline the processes that govern tropospheric O3 mass balance in the atmosphere and the effects of O3 on NPP, crop yield, and other ecosystem services. We also discuss the interaction of plant responses to O3 and other stresses caused by environmental change, with particular consideration of the implications for future climate change. Globally, the majority of tropospheric O3 comes from photochemical reactions of methane (CH4), volatile organic compounds (VOCs), and NO*x*, which are largely from anthropogenic emissions. A minor component (approximately 10%) of tropospheric O3 comes from stratospheric influx (139). Background [O3] has risen from less than 10 ppb before the industrial revolution (155) to daytime summer concentrations exceeding 40 ppb in many parts of the Northern Hemisphere (53, 139). Future [O3] will depend upon O3 precursor emissions, which are expected to change significantly with population growth, economic development, technological progress and its adoption, policy changes, land use changes, and climate and other environmental changes over this century (126).

 **Exts – Ozone Bad**

**O3 decreases crop yield**

**Ainsworth et al. 12**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. [June, “The Effects of Tropospheric Ozone on Net Primary Productivity and Implications for Climate Change”.Annual Review of Plant Biology.Craig R. Yendrek- 1Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois. Stephen Sitch- Department of Geography, College of Life and Environmental Sciences, University of Exeter, Exeter. Lisa D. Emberson- Stockholm Environment Institute, Environment Department, University of York, York. <<http://www.annualreviews.org.proxy.lib.umich.edu/doi/full/10.1146/annurev-arplant-042110-103829#h20>>] Mili

Current estimates for global crop yield losses are determined by linking O3-crop yield response functions defined from the NCLAN and EOTC campaigns to global chemistry transport models that predict hourly [O3] over the globe. Outputs from these models predict current yield losses ranging from 3% to 5% for maize, 6% to 16% for soybean, 7% to 12% for wheat, and 3% to 4% for rice, representing economic losses of $14 billion to $26 billion (151). Globally, there are a number of agricultural production areas that are vulnerable to increasing O3 pollution. The Midwest “Corn Belt” in the United States produces 40% of the world's corn and soybean crops, and this region is already potentially losing 10% of its soybean production to O3 (50, 146). In the United States as a whole, agronomic crop loss to O3 is estimated to range from 5% to 15%, with an approximate cost of $3 billion to $5 billion annually (49) owing to the O3 sensitivity of a number of important crop species grown in North America, including potato (Solanum tuberosum), bean, barley (Hordeum vulgare), canola (Brassica napus), grape (Vitis vinifera), soybean, wheat, and rice (for recent reviews, see 23, 45). In Europe, crop losses to O3 estimated for 23 crops in 47 countries was €6.7 billion per year ($9.6 billion) based on year 2000 emissions (72). The negative effects of O3 on crop production in Asia and Africa may have even greater relevance for food security because a large proportion of grains are consumed locally and the economies are centered upon agriculture (33). Significant production losses to O3 are predicted to be occurring in the Indo-Gangetic Plain, one of the most important agricultural regions in the world, indicating that O3 may be an important contributing factor to the yield gap that currently exists across much of Asia (40). A recent comparison of the O3 response of Asian and North American crops and cultivars also showed that Asian lines were more sensitive to O3 than their North American counterparts (40). Because previous modeling studies have relied on North American or European DRs to assess the yield losses caused by O3, current estimates for Asia may also be significantly too low (40). This is of even greater concern given the results of recent analyses suggesting that there is little potential for crop management practices to adapt to rising [O3] (140). There is much less O3monitoring on the African continent, and the O3 response of many important African crops has not been tested; therefore, there is a critical gap in knowledge about the effects of current [O3] on African crop production (130).

**O3 substantially reduces crop yields**

**Mauzerall et al. 11**.- Professor of environmental engineering and international affairs at Princeton University and director of the PhD program in the Science, Technology and Environmental Policy program at the Woodrow Wilson School.  [[Mauzerall, D. L.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Mauzerall,+D&fullauthor=Mauzerall,%20D.%20L.&charset=UTF-8&db_key=PHY); [Liu, J.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Liu,+J&fullauthor=Liu,%20J.&charset=UTF-8&db_key=PHY); [Horowitz, L. W.](http://adsabs.harvard.edu/cgi-bin/author_form?author=Horowitz,+L&fullauthor=Horowitz,%20L.%20W.&charset=UTF-8&db_key=PHY)] “Global Crop Yield Reductions due to Surface Ozone Exposure: CropProduction Losses and Economic Damage in 2000 and 2030 under Two Future Scenarios of O3 Pollution” <<http://adsabs.harvard.edu/abs/2011AGUFM.B23B0407A>> Mili

Field studies demonstrate that exposure to elevated concentrations of surface ozone (O3) may cause substantial reductions in the agricultural yields of many crops. As emissions of O3 precursors rise in many parts of the world over the nEXT few decades, yield reductions from O3 exposure may increase the challenges of feeding a global population projected to grow from approximately 6 to 8 billion people between 2000 and 2030. This study estimates global yield reductions of three key staple crops (soybean, maize, and wheat) due to surface ozone exposure in 2000 and 2030 according to two trajectories of O3 pollution: the Intergovernmental Panel on Climate Change Special Report on Emissions Scenarios (IPCC SRES) A2 and B1 storylines, which represent upper- and lower-boundary projections, respectively, of most O3 precursor emissions in 2030. Our results indicate that year 2000 O3-induced global yield reductions ranged, depending on the O3 exposure metric used, from 3.9-15% for wheat, 8.5-14% for soybean, and 2.2-5.5% for maize. Global crop production losses totaled 79-121 million metric tons, worth 11-18 billion annually (USD2000). In the 2030-A2 scenario we find global O3-induced yield loss of wheat to be 5.4-26% (a further reduction in yield of +1.5-10% from year 2000 values), 15-19% for soybean (reduction of +0.9-11%), and 4.4-8.7% for maize (reduction of +2.1-3.2%) depending on the metric used, with total global agricultural losses worth 17-35 billion USD2000 annually (an increase of +6-17 billion in losses from 2000). Under the 2030-B1 scenario, we project less severe but still substantial reductions in yields: 4.0-17% for wheat (a further decrease in yield of +0.1-1.8% from 2000), 9.5-15% for soybean (decrease of +0.7-1.0%), and 2.5-6.0% for maize (decrease of+ 0.3-0.5%), with total losses worth 12-21 billion annually (an increase of +$1-3 billion in losses from 2000). Because our analysis uses crop data from the year 2000, which likely underestimates agricultural production in 2030 due to the need to feed a growing population, our calculations of crop production and economic losses are conservative. Our results suggest that O3 pollution poses a growing threat to global food security even under an optimistic scenario of future ozone precursor emissions. Further efforts to reduce surface O3 concentrations and adapt crops to elevated O3 thus provide an excellent opportunity to increase global grain yields without the environmental degradation associated with additional fertilizer application or land cultivation.

**O3 exposure reduces tree productivity**

**Ainsworth et al. 12**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. [June, “The Effects of Tropospheric Ozone on Net Primary Productivity and Implications for Climate Change”.Annual Review of Plant Biology.Craig R. Yendrek- 1Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois. Stephen Sitch- Department of Geography, College of Life and Environmental Sciences, University of Exeter, Exeter. Lisa D. Emberson- Stockholm Environment Institute, Environment Department, University of York, York. <<http://www.annualreviews.org.proxy.lib.umich.edu/doi/full/10.1146/annurev-arplant-042110-103829#h20>>] Mili

An alternative experimental approach recently used to understand the effects of current fluctuations in O3 on growth of mature trees coupled high-resolution measurements of stem growth, sap flow, and soil moisture to high-resolution O3 monitoring (103). High-[O3] episodes (i.e., daily maximum values >100 ppb) caused a periodic disturbance to growth patterns that was attributed to amplification of diurnal patterns of water loss. These daily events culminated into large seasonal losses in stem growth of 30%–50% for most species investigated (103). Another experimental approach, using a chamberless, open-air exposure system, was used to investigate the effects of O3 on mature sugar maple trees (143, 144). Sunlit and shaded branches were exposed to double ambient [O3] (95 ppb on average), which reduced photosynthesis and impaired stomatal function. This experiment was among the first to investigate the effects of elevated [O3] on mature branches, but it was limited to individual branches on a tree. A different open-air canopy O3 fumigation system was established in the Kranzberg forest in Germany to investigate the response of mature beech and spruce (*Picea abies*) trees that were approximately 60 years old and located in a 28-m closed canopy (101). This system consisted of 150 Teflon tubes vertically suspended approximately 0.5 m from the foliated canopy of the mature beech trees. O3 was emitted through pressure-calibrated capillary outputs, and trees were accessed via scaffolding and a research crane. After 8 years of O3 exposure, beech stem productivity was reduced by 44% (124). In 2003, drought-induced stomatal closure uncoupled O3 uptake from O3 exposure, and drought rather than O3 limited tree growth (101). Although these open-air experiments largely confirm the data from decades of controlled-environment studies, they also revealed that environmental conditions, competition, ontogeny, and plant history can alter tree responses to O3and decouple O3 exposure from O3 uptake (101). Therefore, there is a critical need for research investigating how O3 will interact with other environmental changes and impact forest productivity.

 **AT: CO2 Offsets**

**O3 damage outweighs CO2 gains**

**Ainsworth et al. 12**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. [June, “The Effects of Tropospheric Ozone on Net Primary Productivity and Implications for Climate Change”.Annual Review of Plant Biology.Craig R. Yendrek- 1Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois. Stephen Sitch- Department of Geography, College of Life and Environmental Sciences, University of Exeter, Exeter. Lisa D. Emberson- Stockholm Environment Institute, Environment Department, University of York, York. <<http://www.annualreviews.org.proxy.lib.umich.edu/doi/full/10.1146/annurev-arplant-042110-103829#h20>>] Mili

As previously described, leaf-level O3 response data can be combined with ecosystem models to predict O3 effects on canopy- and stand-level processes. Such modeling studies estimate that O3 is currently reducing temperate forest biomass accumulation and NPP by 1%–16% (44, 112, 129). A mechanistic model of plant-O3 interactions was implemented into the Hadley Centre land-surface model and run with O3 scenarios from the Met Office Lagrangian tropospheric chemistry transport model (132) to estimate the impact of current [O3] on global NPP (138). This model defined five plant functional types—broad-leaved trees, conifers, C3grasses, C4 grasses, and shrubs—and uses a different O3 sensitivity function for each plant functional type. Using scenarios of both “lower” and “high” plant sensitivity to O3, the model estimated that current [O3] may be reducing NPP over parts of North and South America, Europe, Asia, and Africa by 5%–30% (Figure 2), which broadly agrees with estimates from recent meta-analyses (66, 162). This model has also been used to estimate future impacts of O3 on global productivity, and the results suggest that O3 may offset potential gains in global gross primary productivity from rising atmospheric CO2 by 18%–34% (138). These results were overlaid with the World Wildlife Foundation Global 200 priority conservation areas to assess future threats of O3 to biodiversity (126). Key biodiversity areas in south and east Asia, central Africa, and Latin America were identified as being at risk from elevated [O3] (Figure 3).

**Elevated CO2 doesn’t boost plant growth in the long term**

**Australasian Science, 11 -** Australia's longest-running scientific publication, it has been Australia's authority on science since 1938; it has the most experienced team of science journalists in Australia, and also publishes a broad range of articles from scientists writing about their own work using their own words (“CO2 Won't Boost Plant Growth”, January/February 2011, search.proquest.com/docview/822171418)//BI

An ambitious experiment has undermined the idea that rising carbon dioxide levels will stimulate enough tree growth to bring global warming under control. A favourite argument of those who oppose reducing emissions of greenhouse gases is that carbon dioxide is plant food, and higher levels will stimulate growth. On the one hand, optimists suggest that this could increase crop production. On the other hand, faster-growing trees could absorb so much carbon dioxide that they could mitigate the warming effect. Experiments run on crops have produced mixed results. Plants grown in greenhouses with elevated CO2 levels do indeed grow much faster, provided they are supplied with plenty of water and other nutrients. However, under field conditions, where one or more nutrient may be in short supply, the benefits of carbon dioxide aremore limited and in some cases there are serious negative effects [AS, Jan/Feb 2010, pp.3133). Prof Ross McMurtrie of the University of NSW School of Biological, Earth and Environmental Sciences is part of an international team exploring the other side of the question. A deciduous forest stand in Tennessee, Swedish conifers, and eucalypts at Hawkesbury near Sydney have been encased in transparent tents and exposed to varying levels of carbon dioxide to witness the effects on their growth. Initially the signs from North America were promising. Trees exposed to 25% higher carbon dioxide levels - similar to predictions for 2050 - grew substantially faster and stored more carbon in their wood. However, a paper published in the Proceedings of the National Academy of Sciences found that the benefits don't last. Once the first 6 years have passed the high carbon forest's productivity declined, an effect that the researchers attribute to insufficient nitrogen in the soil. "We're going to have to learn not to trust in trees to remove as much carbon from the atmosphere as we had hoped," McMurtrie says. The Hawkesbury work is less advanced, but appears likely to lead to similar results. The findings are consistent with Liebig's Law of the Minimum, a 19th century conclusion that growth in plants is limited not by total resources but by the resource in shortest supply. The consequence of this is that increasing a resource other than the most scarce one does not greatly increase growth.

**Increased productivity caused by CO2 isn’t sustainable**

**Norby et al., 10** – Corporate Fellow in the Ecosystem Observations and Experiments group of Oak Ridge National Laboratory, BA in chemistry from Carleton College and PhD in forestry and botany from the University of Wisconsin (Richard J., “CO2 enhancement of forest productivity constrained by limited nitrogen availability”, Proceedings of the National Academy of Sciences of the United States of America [PNAS], 9 November 2011, http://www.pnas.org/content/early/2010/10/21/1006463107)//BI

\*NPP = Net Primary Productivity

\*eCO2 = elevated CO2

Global analyses that assume a sustained CO2 fertilization effect are no longer supported by this FACE experiment.Previous reports from this experiment that were based on observations over 6 y of treatment and combined with results from three other forest FACE experiments indicated that the CO2 fertilization effect on NPP was sustained and consistent across a broad range of productivity (7). Observations over a longer period were necessary to reveal the loss in response reported here, which challenges the use of the previous report as a benchmark for models. The diminishing response of forest NPP to eCO2 must be interpreted in relation to the coinciding decline of NPP in aCO2, although we note that low productivity by itself does not necessarily imply lower relative responsiveness to eCO2 (7). A decline in forest production with age is a pattern normally observed during forest stand development as a consequence of various environmental or internal factors (22, 23). Although the decline can be large and is a near universal phenomenon, the physiological mechanisms responsible for decline are not completely understood; possible explanations include increased respirationto-photosynthesis balance, increased hydraulic resistance, decreased nutrient supply, or various changes in stand structure (22, 23). Generally, more productive stands (including plantations established for short-rotation forestry) reach their peak productivity earlier and productivity declines more steeply (22). Consistent with model projections (24), we attribute the observed decline in NPP in this ecosystem to a constraint imposed by limited and declining N availability. In N-limited forests, the N that is sequestered into perennial tissue during stand development or immobilized into decomposing plant litter and soil organic pools must be replaced with additional N inputs, or tree growth will decline (25). The response to N fertilization in the adjacent sweetgum stand provides direct evidence that the forest stand was N limited. Although N limitation in this stand is established, the question whether the CO2 response was N limited requires further analysis. Our analysis of the relationship between NPP and foliar [N] is guided by the predictions of a simple model of the sweetgum stand’s C–N–water economy (9, 24). Consistent with our analysis that both leaf- and canopy-level characteristics are important determinants of NPP, the model predicts an optimal balance with respect to foliar [N], stomatal conductance, and stand leaf area index (LAI) at which NPP is maximized; the optimum point, which is determined independently for each year, varies as resources change over time. With water and N availability prescribed at levels determined for 1998–2002, the model predicts maximum NPP to occur at a foliar [N] of 16.6 mg·g−1 in aCO2 and 14.4 mg·g−1 in eCO2 (24), which compares well with regression analysis of our data (Fig. 3B). NPP is maximized at a lower value of [N] in eCO2 because of greater photosynthetic N-use efficiency, which permits a reduction in the costs associated with foliar N (24). Also consistent with the optimization model, the slope of the NPP–[N] relationship was steeper in eCO2 than in aCO2 (Fig. 3B), which explains the gradual loss of NPP response to CO2 enrichment. At the somewhat higher levels of foliar [N] observed at the beginning of the experiment, the relationship between foliar [N] and NPP was weaker and other canopy or environmental factors were likely to have been important. These stand-level observations and models have mechanistic support from measurements of leaf-level photosynthesis. The simple optimization model can explain the N constraint on CO2 enhancement from plant physiological considerations (9, 24), specifically the reduced stimulation of photosynthesis by eCO2 as foliar [N] declines. The loss of photosynthetic response to eCO2 was a proximate cause of the decline in NPP response. In contrast, there was no decline in photosynthetic response in Populus tremuloides trees after 11 y in a FACE experiment (26). The long-term relationship among NPP, eCO2, and N cycling was predicted by the progressive nitrogen limitation (PNL) hypothesis (27), whereby increased sequestration of N in long-lived biomass or soil pools under eCO2 causes N availability to decline and induces a negative feedback on further productivity increases in eCO2. PNL, however, has long been recognized as a consequence of normal forest development even without the influence of eCO2 (25), and evidence from N cycling studies on forest plantations suggests that prospects for long-term growth responses are poor unless additional N is supplied by either N fixation or increased atmospheric deposition (10, 25). Similar mechanisms of N sequestration leading to acute N deficiency also pertain to older and unmanaged forests (28), but they may be slower to develop and more difficult to detect than in a faster growing plantation. In our sweetgum forest, annual sequestration of N into wood (20) and soil organic matter (18) exceeded the input of exogenous N into this ecosystem, implying a drawing down of the soil N capital (25). Mechanisms have been proposed whereby eCO2 could increase N availability and compensate for increased N demand, such as stimulation of N mineralization by increased labile C inputs (29) and increased allocation to mycorrhizal fungi (11). However, occasional measurements of N mineralization in the top 10–15 cm of the soil (30–32) have not been sufficient to document a change in N availability through time or with eCO2. A more integrative (spatially and temporally) indicator of N availability is provided by the ratio of 15N to 14N in leaf litter. The isotopic signature of inorganic N in soil that is available for plant uptake depends on the balance between immobilization and nitrification of the NH4 pool. As immobilization increases relative to nitrification, indicating less available N, the available N pool becomes isotopically lighter (33), and this signal is reflected in the 15N/14N ratio (expressed as δ15N) in foliage (34). Although other factors (e.g., mycorrhizae and nitrate leaching) can also affect the isotopic signature, these factors could be discounted in the sweetgum stand (35). Hence, δ15N in leaves and freshly fallen leaf litter is an indicator of N availability in the ecosystem. In this sweetgum stand, δ15N of leaf litter declined linearly from 1998 to 2005 (litter from later years could not be analyzed), and it declined more steeply in eCO2 (Fig. 4A), providing evidence for declining N availability during stand development, which was exacerbated by eCO2 and consistent with the progressive N limitation hypothesis. Annual N uptake into aboveground plant parts (Fig. 4B), which can be considered another measure of the net N availability to trees after the requirement for fine-root production is met, also declined during the experiment. During the course of this experiment, sweetgum trees in eCO2 were able to use the additional C resources for increased fine-root production, especially deeper in the soil profile (17). Deeper roots provided access to more N (32), and total N uptake was greater (11), but after accounting for the additional N required for fine roots, there was no increase in uptake to the aboveground tree. As a result, the decline in aboveground uptake was similar in aCO2 and eCO2 (Fig. 4B). Foliar [N] declined, and with it so did photosynthesis and the C supply for additional fine-root production. Hence, the compensatory mechanism of increased root production, which initially averted an N limitation to CO2 fertilization, could not be sustained in this ecosystem. Responses in other ecosystems would be expected to vary depending on C allocation patterns of the tree species, N fertility of the soil, and the relationship between them. We considered other possible explanations besides declining N availability for the decline in stand NPP and the loss in capacity to respond to eCO2. The effect of eCO2 on NPP was primarily an enhancement of fine-root production (16, 17), so there has been little change in tree size that could account for differences in growth rate. The average basal area of trees in eCO2 in 2008 was just 5.8% greater than in aCO2, and stand basal area was 1.5%less. There has been no effect of eCO2 on tree height that could have created hydraulic constraints to productivity (22), and sap flow did not decline over time as trees grew taller (15). Average soil moisture (0- to 20-cm depth) during the summer growing season (June through September) varied year to year and tended to be greater in eCO2 than in aCO2 (Fig. S1A), but was only weakly associated with NPP (Fig. S1B). Progressively drier summers from 2004 to 2007 may be partially responsible for declining NPP, but NPP continued to decline in 2008 despite more mesic conditions. However, carryover effects of the 2007 drought (Fig. S1A) onLAD in 2008 (Fig. 3C), and indirect effects of soil moisture on N availability, cannot be dismissed. As already discussed, some of the variation in NPP in aCO2 is explained by annual differences in LAD. Other potential causes of forest growth decline such as reproduction, mortality, or crown abrasion (22) do not apply to this stand. N limitation remains the most likely causative factor. The NPP response to eCO2 observed in this FACE experiment contrasts with that of a similar experiment in a Pinus taeda forest stand in North Carolina (Duke FACE), where NPP has remained enhanced in eCO2 (36). Greater nutrient demand of the deciduous sweetgum trees compared with the evergreen pine trees may have caused N deficiency and associated growth decline to occur earlier in the sweetgum stand, but a similar response may eventually occur in the pine stand as well. This hypothesis needs to be explored with ecosystem models. The two forest stands differed in their C allocation patterns in that the productivity gains in the sweetgum trees occurred primarily in fast-turnover pools (fine roots), whereas in the pine trees, the gains were in woody tissue (37). It will be important for models to capture the C allocation patterns correctly because they also have implications for N turnover and availability (38). Furthermore, the observations that rooting depth increased in eCO2 in these and other experiments (38), and that deeper rooting provides access to more available N (32), highlight the need for models to incorporate soil depth in their representation of N availability. Models are essential for projecting the long-term response of diverse and complex forest ecosystems to atmospheric and climatic change because these responses may be beyond the reach of direct experimental manipulation and observation. To gain confidence in model projections, it is important to have benchmarks with which we can challenge the models. We submit that the loss of response to eCO2 observed in this experiment will be captured in models only if there is an adequate representation of the N cycle. The detection of the loss of response and its connection to the developing N limitation was aided by the use of a fast-growing, densely planted, and unfertilized tree plantation in which stand development processes were accelerated compared with a native forest. It is not yet clear whether foliar [N] and CO2 enhancement of NPP in this experimental forest stand would continue to decline or after 11 y reached a new steady state indicative of long-term forest response to eCO2. Growth declines in native, unmanaged forests also have been documented and are sometimes associated with a progressive N limitation (27). However, the evaluation of the persistence of responses to eCO2 and detection of critical feedbacks through the N cycle will be much more difficult in native forests, where the processes observed in a fast-growing plantation will take longer to develop and be obscured by many other influences. The pattern of forest ecosystem N development can vary enormously depending on vegetation and site history (25). Extension of our results to other forests must be made with respect to stand development and include consideration of disturbance effects, species replacements, atmospheric N deposition, and climate change, all of which can alter the N cycle and C–N interactions. Given the importance of the CO2 fertilization effect in coupled climate–C-cycle models that predict future climate change, there is an urgent need for additional long-term experiments focusing on interactions between C and N cycles in forests. Failure to characterize these interactions and incorporate suitable algorithms into models will lead to unreliable predictions of the response of the terrestrial biosphere to atmospheric and climatic change. It may be fortuitous, but ultimately misleading, that models that ignore the N cycle matched the previously reported FACE synthesis data, which preceded the onset of N limitation reported here. A longer record of experimental data, in combination with more sophisticated modeling, will provide more dependable predictions of future responses.

**2AC Weeds**

**Increased levels of CO2 and climate change allow weeds to flourish, while crops suffer**

Cernansky 12

(Rachel is a writer and an enviornmentalist. She received a Master's Degree in journalism from Columbia University in May, and spent the summer in Rwanda writing about AIDS treatment programs. Previously, she was Assistant Editor of Satya, a New York-based magazine focused on the environment, animal rights and social justice, before moving to Kenya, where she worked with Kageno, a community development organization on Lake Victoria's Rusinga Island, Climate Change could cause “zombie weeds” <http://grist.org/author/rachel-cernansky/>)

Climate change may be wreaking havoc on ecosystems and [food supplies](http://www.marketplace.org/topics/business/news-brief/global-climate-change-contributes-shrinking-food-supply) around the world, but there are also some things it's really great for -- like weeds. According to research[published last month](http://www.plosone.org/article/info%3Adoi/10.1371/journal.pone.0037522) in the journal PLoS ONE, weeds love carbon dioxide. Or, more precisely, they're learning to love CO2 because they can adapt quickly to most conditions. Crops grown for food, on the other hand, don't adapt because they're designed not to -- you want things like rice or wheat to have the same reliable taste, right? That's why farmers take great care when they're choosing the kinds of seeds they want to grow.Now, thanks to climate change, that consistency is also a huge risk. The study in PLoS ONE, conducted by some forward-thinking researchers at the U.S. Department of Agriculture (USDA), found that as CO2 levels rise, weeds fare better than their domesticated crop counterparts. That’s because the weeds adapted. But that’s not all: It turns out exposure to CO2 also makes them behave **a little like zombies**. In other words their weed-like qualities were also contagious (via gene transfer), and the actual crops began behaving more like weeds.There's already concern about [genetic contamination from GMO food crops to weeds](http://grist.org/article/food-canola-gone-wild-transgenic-plants-escaping-and-interbreeding/). Now there's evidence that weeds could compromise food crops. (And we're not even talking about "[superweeds](http://grist.org/industrial-agriculture/2011-09-09-superweeds-go-mainstream/)," which are pretty scary in their own right because of their rapid growth and resistance to herbicides.)

 **AT: Weed Management Solve**

**Nope – CO2 makes weed management techniques ineffective**

**Dinar and Mendelsohn, 12**. [Ariel, Robert. “Handbook on Climate Change and Agriculture” p.15-17] Ariel Dinar= Ph.D. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1984 M.Sc. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1974 B.Sc. Agricultural & Natural Resource Economics, Hebrew University of Jerusalem, 1972. Robert Mendelsohn got his B.A. at Harvard University and Ph.D. at Yale University and is now the Edwin Weyerhaeuser Davis Professor of Forest Policy; Professor of Economics; and Professor, School of Management. Mili

Management of pests, particularly weeds, is also likely to be affected. For many industrialized countries, chemical application of herbicides allows for cheap, effective weed control in crop production. In fact, a single herbicide, glyphosate (commercially sold as ‘Round Up’), is so effective in controlling weeds that more than three-quarters of the US soybean crop and over one-third of the US corn crop have been genetically modified to be glyphosate resistant (Gaskell et all., 1999). However, there are several studies indicating a decline in herbicide efficacy as a function of increasing atmospheric CO2 and/or temperature (Archambeault, 2007; Ziska and Teasdale, 2000). The role of climate change and/or rising CO2 in disease and insect biology, as well as the consequences for crop production, are more difficult to quantify. Globally, there are several additional means of weed management, most notably mechanical, biological, and cultural. Although data are scarce, there are cogent reasons for anticipating potential changes in these management strategies in response to changing climate and CO2 concentrations. For example, tillage (physical cultivation to remove weeds in the field) could be affected by precipitation Extremes that could limit field operations. Rising CO2 levels could also increase root or rhizomes in the field. The efficacy of weed biocontrol agents (e.g. insects) is dependent on synchrony between various aspects of the plant community. As climate and/or CO2 levels change, differential responses among host and biocontrol agents could occur. Yet it is also clear that water supply and demand are likely to be impacted by climate change too. Nutrition Researchers are obviously concerned regarding the impact of CO2 and climate change on crop production and food security. However, it is equally important to consider the quality of nutritional aspects of the food supply. A study of major food crops including barley, wheat, soybean, and potato indicated a significant decline (about 10 to 15%) in protein content if atmospheric CO2 increases to between 540-960 ppm (Taub et al. 2007), a range anticipated by the end of this century (IPCC, 2007). This due, at least in part, to the fact that as CO2 increases, photosynthesis requires less nitrogen (i.e nitrogen use efficiency, the ratio of C to N, typically increases). In addition to this dilution of protein levels, rising CO2 may also reduce a result, uptake of key macro and macro nutrients from the soil (e.g. iron, zinc, manganese) may also be negatively impacted with respect to human health (Loladze, 2002). The UN Food and Agriculture Organization estimates that more than 1 billion people worldwide are malnourished (FAO, 2009). Malnutrition generally results from a lack of either protein, which is needed for muscle development and maintenance, or micronutrients such as iodine, Vitamin A or iron, which boost immunity and healthy development. If, as we expect, rising CO2 levels affect the nutritional quality of crops, then it is possible that impoverished areas of the world already threatened by shortages in food supply may face an additional burden of ‘hidden hunger’.

**Positive Feedbacks Plants = M+N**

**Positive feedback — rising CO2 levels cause plants to release much more powerful greenhouse gasses like methane and nitrous oxide**

**Knohl & Veldkamp 11** – \*PhD in Biogeochemistry, Professor of Bioclimatology at the University of Göttingen in Germany AND \*\*professor and section head at the Institute of Soil Science and Forest Nutrition at the University of Göttingen in Germany (Alexander &Edzo, “Global change: Indirect feedbacks to rising CO2,” Nature, 13 July 2011, [http://www.nature.com/nature/journal/v475/n7355/full/475177a.html)//BI](http://www.nature.com/nature/journal/v475/n7355/full/475177a.html%29//BI)

In producing global warming, CO2 is responsible for the largest part of the anthropogenic impact on Earth's energy balance. It is, of course, also an essential nutrient for plant metabolism. Numerous CO2-enrichment experiments over the past two decades have demonstrated the positive effect of elevated CO2 on plant growth — increased biomass and increased carbon storage in soils3. The vegetation response to elevated CO2 might be constrained by various interactions with water and nutrients such as nitrogen4, 5. However, experiments and model projections suggest that accelerated plant growth due to CO2 fertilization could draw down some of this gas from the atmosphere, and hence could weaken future rates of CO2 increase and lessen the severity of climate change6.Van Groenigen et al.2 present evidence that rising levels of CO2 are not only resulting in an increased carbon sink in terrestrial ecosystems, but could also cause increased emissions of other, much more potent, greenhouse gases such as methane (CH4) and nitrous oxide (N2O) from soils. Methane is produced by anaerobic methanogenic microorganisms that thrive in wetlands, including rice paddies, where labile (biologically accessible) carbon is available and diffusion of oxygen into the soil is severely restricted. Nitrous oxide is mainly produced in soils by aerobic nitrifying and anaerobic denitrifying bacteria. The interaction between nitrogen availability and soil water content controls the rate of N2O production. The respective global-warming potentials of CH4 and N2O are 25 and 298 times greater than that of CO2, and thus they influence Earth's energy balance even though they occur in much smaller concentrations.Van Groenigen and colleagues collected information from 49 published studies that reported the effect of atmospheric CO2 enrichment on CH4 and N2O fluxes from soils. Using a meta-analysis, they show that elevated CO2 stimulated N2O emissions by 18.8%, and that CH4 emissions from wetlands increased by 13.2% and from rice paddies by as much as 43.4%. Notably, they also suggest the mechanisms that are probably responsible for these observed increases in greenhouse-gas emissions (Fig. 1).Their suggestion goes as follows. Elevated CO2 led to reduced plant transpiration (the evaporation of water from plant surfaces, leaves in particular), which increased soil water content and promoted the existence of anaerobic microsites in soils. This, together with increasing biological activity, probably stimulated denitrification and consequently N2O production. Also, the CO2-induced increase in root biomass may have contributed by increasing the availability of labile carbon, a crucial energy source for denitrification. The CO2-induced stimulation of CH4 emissions from wetlands and rice paddies was probably the result of higher net plant production, leading to increasing carbon availability for substrate-limited methanogenic microorganisms. Extrapolating their results to the global scale, van Groenigen et al.2 estimate that the combined effect of stimulated N2O and CH4 emissions could be equivalent to at least 1.12Pg CO2 yr−1 (Pg = petagrams = 1015 grams). This is around 17% of the expected increase of the terrestrial CO2 sink as a result of higher CO2 concentrations.

 **Exts – Plants Release Stuff**

#### Even if elevated CO2 makes plants larger, it causes crops like rice to release more methane, creating a positive feedback

**Yun et al. 12 –** Department of Applied Plant Science and Institute of Agricultural Science and Technology, Chonnam National University, Gwangju, Republic of Korea (Seok-In, “Further understanding CH4 emissions from a flooded rice field exposed toexperimental warming with elevated [CO2]”, Agricultural and Forest Meteorology, 15 March 2012, [http://www.sciencedirect.com/science/article/pii/S0168192311003108)//BI](http://www.sciencedirect.com/science/article/pii/S0168192311003108%29//BI)

Elevated Ta combined with elevated [CO2] (ECET) revealed a significant additive effect on CH4 emission from the rice fields (Table 3). This suggested that although elevated Ta (ACET; 1.7 ◦C above ambient Ta) had a minor/insignificant effect on CH4 emission, the effect is significant with elevated [CO2]. The additive effect was largely attributed to the positive interactive effect between [CO2] and Ta on above-ground biomass (P = 0.040) and tiller number (P = 0.053), and, partially to an increase in root biomass by elevated [CO2] (P = 0.110). In the view of C metabolic aspects, the observed [CO2] × Ta effect on above-ground biomass suggested that plants under elevated Ta alone may have greater [CO2] constraint for displaying their potential capacity of photosynthesis. Alternatively, our results suggest that under elevated Ta, additional C expected due to elevated [CO2] might be greater than under ambient Ta, leading to significant increase in above-ground biomass under elevated Ta and [CO2]. This, together with the increased tiller number and root biomass, may lead to the increase in CH4 emission with a concerted manner of elevated Ta and [CO2]. The most obvious increase in CH4 emission has also been documented with co-elevation of [CO2] and Ta. Allen et al. (2003) found an increase in CH4 emission to be 53.2%, 258.4% and 402.4%in elevated [CO2] (660 ppmV) alone, elevated [CO2] combined with rising Ta of 3 ◦C and of 6 ◦C, respectively. These values were overwhelmingly greater than those in the present results, that showed 17.4% and 29.3% in elevated [CO2] (673 ppmV) alone and combined with elevated Ta (1.7 ◦C above ambient Ta), respectively. There are two likely reasons for this variation. First, the large difference in Ta regimes (i.e. +3 to 6 ◦C vs +1.7 ◦C) would most likely lead to huge variation through mechanisms that we discussed earlier. Second, there may be an underlying genotypic variation in the potential for CH4 production and emission between cultivar “IR72” (Indica; Allen et al., 2003) and “Ilmybyeo” (Japonica; in present study) as reported by Luo et al. (2008). Anyhow, at least in terms of relative changes in CH4 emission, the result reported by Allen et al. (2003) appeared to be of the most extreme cases, which would be expected if grain yield lost was >65–80% under higher Ta (see Baker and Allen, 1993). On the other hand, some reports suggested that elevated [CO2] does not lead to further increase in CH4 emission with increasing Ta (4 ◦C above ambient Ta) (Ziska et al., 1998). In addition, the data reported by Ziska et al. (1998) showed that the absence of the combined effect of elevated [CO2] and Ta on CH4 emission may likely be escorted by decelerating total biomass. The increased total biomass was reduced from 26.2 to 37.6% in elevated [CO2] alone to 8.8% in co-elevation of [CO2] and Ta (see Table 1 and Fig. 3 in Ziska et al., 1998). As a result, the plant-derived C and dissolved CH4 in soil under elevated [CO2] and Ta may have less than those in soil under elevated [CO2] alone, accounting for the absence of the combined effect of elevated [CO2] and Ta on CH4 emission (Ziska et al., 1998). Higher nighttime Ta (10 ◦C above control Ta throughout the reproductive phase) caused a significant reduction in [CO2]-induced increase in CH4 emission from 32.2% to 3.5% (Cheng et al., 2008a). A recent finding clearly demonstrates that the [CO2]-induced increase (26%) in CH4 emission was amplified (80%) with 2 ◦C warming of soil/water temperature (Tokida et al., 2010). The additive effect of [CO2] and water/soil temperature, however, was predominantly attributed to the changed soil stoichiometric processes by increasing soil/water temperature, rather than to increased plant biomass (Tokida et al., 2010). This supports our earlier conclusion that the effect of elevated Ta on CH4 emission would be observed via changing plant C metabolic processes, irrespective of whether it is significant. 4.3. Temporal patterns of the [CO]-induced increase in CH4 emission Our results clearly showed that the [CO2]-induced increase in CH4 emission was significantly reduced with advancing plant development (Table 3 and Fig. 4b), i.e. magnitudes (in terms of cumulative CH4 emission) were 37.5%, 23.4% and 17.4% at PI, FH and at MT, respectively. This was even more evident in elevated [CO2] combined with elevated Ta (ECET), with values of 53.2%, 40.1% and 29.3%. Such seasonal dynamics in the effect of elevated [CO2] and Ta on CH4 emissions were mostly associated with those of plant parameters (e.g. tiller number, above-ground and root biomass) (Table 2). We propose two possible mechanisms for the decelerating effect of elevated [CO2] and Ta on CH4 emission. First, the metabolic down-regulation of photosynthetic rates (and thus biomass accumulation) under elevated [CO2] (Kim et al., 2003; Seneweera, 2011; Yang et al., 2006) can most likely lead to comparable reduction in plant-derived C (e.g. root exudates). This may cause a reduction in source strength for methanogens, resulting in a gradual decrease in [CO2]-induced CH4 emission. Second, in relation to CH4 transport capacity, the dramatic reduction in [CO2]induced increase in tiller number, which reduced rapidly after PI (Table 2) could also restrict plant-mediated CH4 transport, even if there would be an abundant amount of dissolved CH4 in soil solution (Luo et al., 2008). In addition, the aerenchyma system, which acts at once as a CH4 escape pathway and its diffusion resistance (Nouchi et al., 1990), would also be aged with plant development, blocking plant-mediated CH4 transport (Luo et al., 2008). 5. Conclusions This study highlights that elevated [CO2] significantly promoted CH4 emission, whereas elevated Ta (1.7 ◦C above ambient Ta) alone had a minor/insignificant effect. More importantly, the elevated Ta effect was significant with an additive effect of [CO2]and Ta on CH4 emission. This suggests that ongoing rising atmospheric [CO2] and Ta would have a positive feedback impact on projected global warming. Nevertheless, the positive effects of elevated [CO2] and Ta on CH4 emission were greatly reduced with advancing plant development. We conclude that such seasonal dynamics of CH4 emission in response to elevated [CO2] and Ta can be attributed to: (i) dwindling response of plant growth to elevated [CO2] probably due to metabolic down-regulation of photosynthetic rates; and as a result (ii) reducing the potential availability of C substrate for methanogens as well as CH4 transport capacity.

#### Elevated CO2 stimulates methane release by rice fields, already one of the largest sources of the powerful greenhouse gas

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Methane (CH4) and carbon dioxide (CO2) are radiatively important trace gases that are currently increasing in their atmospheric concentration at relative rates of 0.6 and 0.5% year1 respectively (IPCC, 2007). Increased anthropogenic activity is generally given as the reason for this increase. Methane is 25 times greater relative to the global warming potential of CO2 for a 100 year time horizon (Forster et al., 2007; IPCC, 2007). Flooded rice fields, mostly in the humid tropics, are considered as one of the largest source of atmospheric CH4 with an estimated contribution of approximately 9-19% of the global budget (IPCC, 2007). In freshwater sediments including flooded paddy, about 70% of the biogenic CH4 produced comes from acetate cleavage by acetoclastic methanogens as compared to CO2 reduction by hydrogenotrophic methanogens (Conrad, 2005). In general, acetoclasticmethanogenicarcheal population predominates in flooded paddy (Conrad, 2007). But in future climate scenario with elevated atmospheric CO2 concentration, hydrogenotrophicmethanogenic population can play a more predominant role. Contrary to CH4 production, microbial CH4 oxidation (methanotrophy) is the only known biological sink for atmospheric CH4. The process contributes approximately w80 percent of the produced CH4 being oxidized at the soil surface (Conrad, 2007), where methanotrophic bacteria are able to oxidize CH4 for energy purpose or building up of microbial biomass (Hanson and Hanson, 1996). Two types of kinetics have been described with respect to the concentration of CH4 in soils and sediments (Bender and Conrad, 1992; Nayak et al., 2007a). The first kinetic pattern of CH4 oxidation, known as “low affinity” CH4 oxidation is observed in all CH4-producing soils. This is performed by type I methanotrophs that display Kmvalue in mMrange and mainly belong to the class gproteobacteria (Reay, 2003). The second kinetic pattern, known as “high affinity” CH4 oxidation, displays Km value in the nM range and enables oxidation of atmospheric CH4. This process is reported to be mediated by methanotrophs belonging to the class a-proteobacteria, also known as type II methanotrophs (Bull et al., 2000; Dunfield et al., 1999; Lau et al., 2007).The concentration of tropospheric CO2 has been progressively increasing from about 280 ppm at the beginning of the industrial revolution to 379 ppm (IPCC, 2007) at present and future estimates of atmospheric CO2 concentration for the year 2050 range between 450 and 600 ppm (Kattenberg et al., 1996). Coupled withthis rise in the concentration of CO2 and other greenhouse gases, an increase in the mean global temperature from 1.4 to 5.8 C by the end of the century (IPCC, 2007) and associated climate change is predicted. There is a strong concern that the climate change will have both direct and indirect effects on terrestrial microbial communities and their functions. The effects of increased CO2 concentrations on microbial communities are often indirect, as they are mediated by effects on plant metabolism, growth and diversity and the associated changes in soil physico-chemical properties such as soil moisture and crop residues (Bardgett and Wardle, 2010). The main direct effect of climate change on soil microorganisms is likely to be caused by changes in temperature and moisture content (Bardgett et al., 2008; Drigo et al., 2009; Garten et al., 2009; Singh et al., 2010).Increasing atmospheric CO2 concentration and rising temperature due to global warming are anticipated to stimulate CH4 emissions from paddy fields. Most studies have shown greater CH4 emissions under high CO2 (Inubushi et al., 2003; Cheng et al., 2006; Lou et al., 2006) and elevated temperature (Inubushi et al., 1984; Ziska et al., 1998; Allen et al., 2003), indicating a positive feedback. Generally speaking, a temperature rise stimulates microbial activity in submerged soils, which may lead to higher rate of CH4 production (Fey and Conrad, 2000). On the other hand several studies from different ecosystems have indicated that CH4 consumption is reduced at elevated levels of CO2 (Phillips et al., 2001a,b; McLain and Ahmann, 2008; Dubbs and Whalen, 2010), but the causative mechanisms are not well known. It is possible that CO2 enrichment affects the size or activity of the CH4-oxidizing microbial community or causes a higher soil C concentration and competition for O2 and therefore suppression of the CH4-oxidizing microbial community (Phillips et al., 2001b). Increased soil moisture under elevated CO2 reduces the rate of diffusion and therefore decreases CH4 oxidation in the soil (Ambus and Robertson, 1999; Phillips et al., 2001a). However, if the rising temperature due to the global climate change makes the soil drier, CH4 oxidation may be enhanced (Dijkstra et al., 2010).

 **AT: Plants Cooling Feedback**

**High CO2 levels diminish the cooling power of plants — causes net more warming**

**CI 10** – Carnegie Institute, a private independent research organization based in Washington DC that supports scientific research for the benefit of humanity (Carnegie Institution for Science, “CO2 Effects on Plants Increase Global Warming,” 2 May 2010, [http://carnegiescience.edu/news/CO2\_effects\_plants\_increase\_global\_warming\_0)//BI](http://carnegiescience.edu/news/co2_effects_plants_increase_global_warming_0%29//BI)

Trees and other plants help keep the planet cool, but rising levels of carbon dioxide in the atmosphere are turning down this global air conditioner. According to a new study by researchers at the Carnegie Institution for Science, in some regions more than a quarter of the warming from increased carbon dioxide is due to its direct impact on vegetation.This warming is in addition to carbon dioxide's better-known effect as a heat-trapping greenhouse gas. For scientists trying to predict global climate change in the coming century, the study underscores the importance of including plants in their climate models."Plants have a very complex and diverse influence on the climate system," says study co-author Ken Caldeira of Carnegie's Department of Global Ecology. "Plants take carbon dioxide out of the atmosphere, but they also have other effects, such as changing the amount of evaporation from the land surface. It's impossible to make good climate predictions without taking all of these factors into account."Plants give off water through tiny pores in their leaves, a process called evapotranspiration that cools the plant, just as perspiration cools our bodies. On a hot day, a tree can release tens of gallons of water into the air, acting as a natural air conditioner for its surroundings. The plants absorb carbon dioxide for photosynthesis through the same pores (called stomata). But when carbon dioxide levels are high, the leaf pores shrink. This causes less water to be released, diminishing the tree's cooling power.The warming effects of carbon dioxide as a greenhouse gas have been known for a long time, says Caldeira. But he and fellow Carnegie scientist Long Cao were concerned that it is not as widely recognized that carbon dioxide also warms our planet by its direct effects on plants. Previous work by Carnegie's Chris Field and Joe Berry had indicated that the effects were important. "There is no longer any doubt that carbon dioxide decreases evaporative cooling by plants and that this decreased cooling adds to global warming," says Cao. "This effect would cause significant warming even if carbon dioxide were not a greenhouse gas."In their model, the researchers doubled the concentration of atmospheric carbon dioxide and recorded the magnitude and geographic pattern of warming from different factors. They found that, averaged over the entire globe, the evapotranspiration effects of plants account for 16% of warming of the land surface, with greenhouse effects accounting for the rest. But in some regions, such as parts of North America and eastern Asia, it can be more than 25% of the total warming. "If we think of a doubling of carbon dioxide as causing about four degrees of warming, in many places three of those degrees are coming from the effect of carbon dioxide in the atmosphere, and one is coming from the direct effect of carbon dioxide on plants."

### 2AC A2: CO2 K2 Biodiversity

**O3 (another GHG) overwhelms any positive effects**

**Ainsworth et al. 12**.- Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois and Department of Plant Biology at University of Illinois at Urbana Champaign. (June, “The Effects of Tropospheric Ozone on Net Primary Productivity and Implications for Climate Change”. Annual Review of Plant Biology.Craig R. Yendrek- 1Global Change and Photosynthesis Research Unit, Agricultural Research Service, U.S. Department of Agriculture, Urbana, Illinois. Stephen Sitch- Department of Geography, College of Life and Environmental Sciences, University of Exeter, Exeter. Lisa D. Emberson- Stockholm Environment Institute, Environment Department, University of York, York. <<http://www.annualreviews.org.proxy.lib.umich.edu/doi/full/10.1146/annurev-arplant-042110-103829#h20>>) Mili

As previously described, leaf-level O3 response data can be combined with ecosystem models to predict O3 effects on canopy- and stand-level processes. Such modeling studies estimate that O3 is currently reducing temperate forest biomass accumulation and NPP by 1%–16% (44, 112, 129). A mechanistic model of plant-O3 interactions was implemented into the Hadley Centre land-surface model and run with O3 scenarios from the Met Office Lagrangian tropospheric chemistry transport model (132) to estimate the impact of current [O3] on global NPP (138). This model defined five plant functional types—broad-leaved trees, conifers, C3grasses, C4 grasses, and shrubs—and uses a different O3 sensitivity function for each plant functional type. Using scenarios of both “lower” and “high” plant sensitivity to O3, the model estimated that current [O3] may be reducing NPP over parts of North and South America, Europe, Asia, and Africa by 5%–30% (Figure 2), which broadly agrees with estimates from recent meta-analyses (66, 162). This model has also been used to estimate future impacts of O3 on global productivity, and the results suggest that O3 may offset potential gains in global gross primary productivity from rising atmospheric CO2 by 18%–34% (138). These results were overlaid with the World Wildlife Foundation Global 200 priority conservation areas to assess future threats of O3 to biodiversity (126). Key biodiversity areas in south and east Asia, central Africa, and Latin America were identified as being at risk from elevated [O3] (Figure 3).

**1AR Overall Analysis Goes Aff**

**Even if there are some benefits – overall impact proves warming is bad**

**IFPRI 09 [**The International Food Policy Research Institute (IFPRI) was established in 1975. IFPRI is one of 15 agricultural research centers that receives its principal funding from governments, private foundations, and international and regional organizations, most of which are members of the Consultative Group on International Agricultural Research. “ Climate Change: Impact on Agriculture and Costs of Adaptation.” <http://www.ifpri.org/sites/default/files/publications/pr21.pdf>] H.Kenner

Theunimpeded growth of greenhouse gas emissions is raising the earth’s temperature. The consequences include melting glaciers, more precipitation, more and more EXTreme weather events, and shifting seasons**. The accelerating pace of climate change, combined with global population and income growth, threatens food security everywhere.** Agriculture is EXTremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. Populations in the developing world, which are already vulnerable and food insecure, are likely to be the most seriously affected. In 2005, nearly half of the economically active population in developing countries—2.5 billion people—relied on agriculture for its livelihood. Today, 75 percent of the world’s poor live in rural areas.1 This Food Policy Report presents research results that quantify the climate-change impacts mentioned above, assesses the consequences for food security, and estimates the investments that would offset the negative consequences for human well-being. This analysis brings together, for the first time, detailed modeling of crop growth under climate change with insights from an EXTremely detailed global agriculture model, using two climate scenarios to simulate future climate. The results of the analysis suggest that agriculture and human well-being will be negatively affected by climate change: • In developing countries, climate change will cause yield declines for the most important crops. South Asia will be particularly hard hit. • Climate change will have varying effects on irrigated yields across regions, but irrigated yields for all crops in South Asia will experience large declines. • Climate change will result in additional price increases for the most important agricultural crops–rice, wheat, maize, and soybeans. Higher feed prices will result in higher meat prices. As a result, climate change will reduce the growth in meat consumption slightly and cause a more substantial fall in cereals consumption. • Calorie availability in 2050 will not only be lower than in the no–climate-change scenario—it will actually decline relative to 2000 levels throughout the developing world. • By 2050, the decline in calorie availability will increase child malnutrition by 20 percent relative to a world with no climate change. Climate change will eliminate much of the improvement in child malnourishment levels that would occur with no climate change. • Thus, aggressive agricultural productivity investments of US$7.1–7.3 billion2 are needed to raise calorie consumption enough to offset the negative impacts of climate change on the health and well-being of children.

**AT: CO2 Agriculture (Specific Plants)**

**AT: Soybeans**

**CO2 destroys soybean crops**

**Spectrum, 7** (Spectrum is the official publication of Adventist Forums and a non-official publication of the Adventist church, published four times a year. It was established "to encourage Seventh-day Adventist participation in the discussion of contemporary issues from a Christian viewpoint, to look without prejudice at all sides of a subject, to evaluate the merits of diverse views, and to foster intellectual and cultural growth. “ Carbon Dioxide and Plant Vulnerability.” Accessed 6/20/12 Proquest. [http://search.proquest.com.proxy.lib.umich.edu/docview/224016165/fulltEXTPDF?accountid=14667](http://search.proquest.com.proxy.lib.umich.edu/docview/224016165/fulltextPDF?accountid=14667)) H.Kenner

Elevated levels of atmospheric carbon dioxide (CO2 ) may have negative effects on the relationship between some plants and herbivorous insects, according to researchers from the Institute for Genomic Biology at the University of Illinois at Urbana-Champaign. Researchers exposed soybean plants to more CO2 than usual and observed interactions between the plants and herbivorous Japanese beetles. As the beetles consumed the soybean plants, the plants became weaker and the beetles were undeterred. Soybeans (and many other plants) have enzymatic defense systems that are deployed during insect attacks. These enzymes inhibit further attack when ingested by the invaders. The study determined that exposure to elevated CO2 levels decreased the plants’ ability to regulate its defensive hormones, thereby rendering the plants more vulnerable. According to postdoctoral associate and study author Jorge Zavala, Sr., “Under natural field conditions, elevated CO2 not only increased susceptibility of soybean to herbivory by the invasive species Japanese beetle, but also enhanced the performance of these beetles.” The findings are specific to these particular species of soybean and beetle, so they are not necessarily indicative of results in other species. However, the results do suggest that similar mechanisms may be affected in different species and present another argument for the role of CO2 in global change. Soybeans are an important agricultural crop in many different economies; therefore, the results of this study show an important correlation between atmospheric CO2 levels and economic effects. —American Society of Plant Biologists press release, 6 July. (M.P.M.) A NEW LOOK AT URBAN SOIL The soil beneath urbanites’ feet might not be as sterile as expected and is so varied in composition that there is no single “urban soil,” according to a new study in Baltimore, MD. The research team, composed of scientists from the USDA Forest Service and the University of Maryland, Baltimore County, set out to observe how land use and cover impact soils. Researchers EXTracted soil samples from 122 sites across the city of Baltimore and analyzed the differences in the properties of the soil samples. The samples revealed high chemical variability, but less variation among physical characteristics. “In general, levels of essential nutrients in Baltimore’s soils were adequate for plant growth, but in some cases calcium levels were excessive, making those soils more alkaline,” says lead author and U.S. Forest Service researcher Richard Pouyat. “The high calcium levels are probably related to the presence in urban environments of calcium-rich structural materials such as concrete.” Among their findings, the researchers came across variations in soil pH levels when observing the samples. Soil in residential areas differed from areas more commercial in nature. The team did not find a correlation between land use and larger concentrations of heavy metals. Rocks on the surface of the soil indicated that trace metals tended to occur naturally, rather than as the result of commercial industries. “This was surprising, since in an old industrial city like Baltimore, large volumes were disturbed, added, or removed over time and have been exposed to various contaminants,” says Pouyat. While the results of the study are particular to Baltimore, Pouyat says, “Since some of the properties measured are related to human activities that typically occur in urban landscapes, comparable studies in other cities should show similar results.” —Soil Science Society of America press release, 20 June. (M.E.P.)

**Dead Soybeans destroy U.S crop production**

**Nikkita, 5** – Patel, Wildlife Trust, empowers local conservation scientists worldwide to protect nature and safeguard ecosystem and human health, “Hurricanes and Emerging Plant Diseases,” <http://www.wildlifetrust.org/news/2005/0801_hurricane.htm>

The second leading cause of plant disease emergence, with 25%, is severe weather conditions, which includes hurricanes, heavy rains and strong winds. Unlike the previous factor, weather is not something that is controllable. Furthermore, global warming is likely to bring changing patterns of climate variability, including EXTreme meteorological events. However, with increased surveillance and control measures, these diseases can be detected before EXTensive damage has occurred. The ranges of several plant diseases have been steadily expanding northward, following the trajectories of most hurricanes. Citrus canker has spread throughout Florida, facilitated by hurricanes and strong rain-driven storms. In 1994, it was thought that citrus canker had been eradicated in the US; however in 1995, it was found near Miami International airport. Since then, various hurricanes, including hurricanes Charley, Frances and Jeanne, have propelled this bacterial disease to 22 counties in Florida. Citrus canker weakens the tree and reduces the number of fruits produced. In attempt to control this disease, almost two million trees have been destroyed, yielding a loss of over US $200 million. Another disease threatening the food security of the US is soybean rust. This fungal disease causes soybean leaves to drop early, which reduces soybean yield. Soybean rust is thought to have moved from Brazil or Venezuela into North America for the first time in the fall of 2004 with Hurricane Ivan. Fortunately, this was the end of the harvest season, so damage was minimal. Yet, this disease has been steadily increasing in geographic distribution. Soybeans account for 16% of all U.S. crop production. Hurricane Dennis in June 2005, threatened to spread rust further north into the Midwestern states.Recent hurricanes have impacted other plants including peanuts, tomatoes, peppers and cucumbers with bacterial, fungal and viral diseases. With the inevitable yearly hurricane season, the best protection is surveillance. Any suspected plant diseases should be reported to the local plant health authorities.

**Global war**

**Ikerd, 8** – John E. Ikerd, Professor Emeritus Agricultural Economics University of Missouri, 2008, “Crisis and Opportunity: sustainability in American agriculture”, p.254-5

Economists argue that it doesn’t matter where our food is produced. If producing it elsewhere in the world will be cheaper, we will all be better off without agriculture in the United States, so they say. But how long will it before an “Organization of Food-Exporting Countries” is formed to restrict world food supplies, causing our food prices to skyrocket—as we have seen OPEC do with our energy prices in the past. Even more importantly, we have only a few days’ supply of food in the “food pipeline” at any point in time. The disruption of global food supplies, even for a short period of time, could have devastating consequences for millions of people. Perhaps we could keep our food imports flowing, through our military might, if economic coercion fails. But what will be the real costs? How many more terrorist attacks might we expect as a result of our global food policy? How many small wars will we feel compelled to fight? How many people will be killed to support a global food system? The higher the real costs of globalization may be paid in human blood.

**AT: Rice**

**CO2 destroys rice production**

**Perry, 12** (Ann is a researcher for the United States Department of Agriculture. “Rice Production Hindered by Carbon Dioxide Levels.” <http://westernfarmpress.com/rice/rice-production-hindered-carbon-dioxide-levels>) H. Kenner

New research at the U.S. Department of Agriculture confirms that rising levels of atmospheric carbon dioxide facilitate the flow of genes from wild or weedy rice plants to domesticated rice varieties. **As a result, domesticated plants could take on undesirable weedy characteristics that may interfere with future rice production.** This is the first study to demonstrate that the effects of increasing atmospheric carbon dioxide concentrations include not only an influence on gene flow between closely related domesticated and wild plant genotypes, but that this gene flow is not the same in both directions. The investigation was conducted by researchers at the Agricultural Research Service (ARS), which is USDA's chief intramural scientific research agency. "We know that global climate change will require some farmers to revise production strategies in response to shifting weather patterns and crop demands," said ARS Administrator Edward B. Knipling. "These new findings will help plant breeders design and interpret studies on how changes in climate may affect crop response." ARS plant physiologist Lew Ziskaled the investigation. Collaborators included David Gealy, Martha Tomecek, Aaron Jackson, and Howard Black. Ziska and Tomecek work at the ARS Crop Systems and Global Change Laboratory in Beltsville, Md., and the other scientists work at the ARS Dale Bumpers National Rice Research Center in Stuttgart, Ark. Weedy wild rice, often called red rice, is the same species as domesticated rice and is very difficult to control in production settings. The team conducted a two-year combination growth chamber and field study to document how atmospheric carbon dioxide concentrations affect growth in weedy and domesticated rice and to observe the exchange of genetic material between the two plant types. Twenty-four-hour carbon dioxide concentrations in the chambers were set at 300, 400 and 600 parts per million (ppm). These concentrations approximated the atmospheric carbon dioxide values present during the end of the 19th century, the current value, and values projected for the end of the 21st century, respectively. When grown in carbon dioxide concentrations of 400 ppm and 600 ppm, both types of rice put out more tillers and flowers and grew taller, compared to plants grown at carbon dioxide concentrations of 300 ppm. However, these changes in height, which scientists believe are an important factor in pollen sharing and therefore impact gene flow, were more pronounced in the wild rice. The number of flowers produced by the wild rice grown in 600 ppm carbon dioxide was doubled compared to rice grown at 300 ppm, a significantly larger increase than the flowering increase in the domesticated rice. At the greatest concentration of carbon dioxide, wild rice also produced flowers an average of eight days earlier, a shift that apparently enhanced the likelihood of pollen transfer between the two rice types.   The researchers then conducted a genetic analysis of the hybrid seed offspring of the two rice varieties. The results of these tests indicated domesticated rice transferred only a small amount of genetic material to its weedy relative, even at the greatest concentration of carbon dioxide. But the weedy plants transferred a relatively greater amount of genetic material to their domesticated relatives, which differed from 0.22 percent at carbon dioxide concentrations of 300 ppm to 0.71 percent at carbon dioxide concentrations of 600 ppm. The transfer of wild genetic material to the domesticated rice line resulted in the production of seed with significant weedy characteristics that would be undesirable in domesticated rice production.

**Specifically, seal level rise hurts rice production**

Chen and McCarl et al., 12 **–** Regents Professor and Distinguished Professor of Agricultural Economics at Texas A&M University. Received B.S. in Business Statistics at the University of Colorado and Ph.D. in Management Science from Pennsylvania State University. Chi-Chung Chen heads the National Taiwan University Department of Agricultural Economics Master of the United States Texas A & M University Department of Agricultural Economics, Dr.MR

 (Chi-Chung and Bruce. 4-12, “Climate change, sea level rise and rice: global market implications” < [http://www.springerlink.com.proxy.lib.umich.edu/content/2rt713v778g1j492/fulltEXT.pdf](http://www.springerlink.com.proxy.lib.umich.edu/content/2rt713v778g1j492/fulltext.pdf)>)

Sea level rise would affect coastal areas in a variety of ways, including flooding, potential loss of life, damage to property, coastal erosion, changes in surface and ground water quality, decreased agricultural and aquaculture production through land inundation, and damages to transportation infrastructure. Darwin and Tol (2001) estimated the direct economic damage of sea level rise but did not focus much on agricultural implications. However, a literature review did not reveal studies that focused on sea level rise implications for global food markets in general or rice in particular. Agriculture and the global food market are vulnerable. Figure 1 displays the percentages of agricultural lands that would be inundated under various levels of sea level rise in Southeast Asia, East Asia, South Asia, and the Southeast U.S (Dasgupta et al. 2009). Significant rice acreage occurs in these areas thus sea level rise constitutes a threat to rice. This is of concern since rice is a major staple crop for half of the world’s population.

 **AT: Rice Internal Link**

**Rice is resilient – won’t affect the international market**

**The Economist ‘11**

(The Economist, 11/12/11, “Asia’s rice bowls: How serious will the impact of the Thai floods be on Asian tables?” http://www.economist.com/node/21538099) DHirsch

But the nature of the rice market means that the consequences may not be as severe. Rice is a resilient crop, and the floods may not do as much damage as some fear. Although rice is a staple for half the world’s population, international trade is small compared with the 451m tonnes that will pop out of the ground in the 2010-11 growing season. Only about 7% of the total crop hits global markets, compared with 20% or so for wheat.

Politics and tastes mean that rice is mainly consumed where it is grown. Rice is such a vital foodstuff in Asia—some 90% is grown and eaten there—that policies aim at self-sufficiency. Domestic markets are usually heavily regulated and protected. It is one of the most politicised of commodities, according to Concepción Calpe of the Food and Agriculture Organisation. Moreover rice comes in many varieties: long-grain, short-grain, sticky, fluffy and so on. Consumers want their customary sort, not an unfamiliar rice from far afield.

**Rice isn’t key to Asian economies – its been declining for years**

**Timmer ‘10**

(Peter, Thomas D. Cabot Professor of Development Studies, emeritus, Harvard University and Adjunct Professor, Crawford School of Economics and Government, Australian National University, 10/2010. “FOOD SECURITY IN ASIA AND THE CHANGING ROLE OF RICE”, http://asiafoundation.org/resources/pdfs/OccasionalPaperNo4FoodSecurityFinal.pdf) DHirsch

Finally, Section 9 provides the “bottom line” to our question: how has the role of rice changed? At a world level, rice accounted for just over one half of one percent of GDP in 1961. Over the next half century, the share of rice in GDP for the entire world fell to just 0.174% of GDP. In terms of overall economic output on a global scale, rice is a very small factor.

In Asia, rice is far more important, although its share in national economies is not as large as many observers think. Even in 1961, rice accounted for just 6.8% of GDP in East Asia, 8.4% in South Asia, and 14.5% in Southeast Asia. Naturally, because of the structural transformation and the declining role of agriculture in successfully growing economies, and the agricultural transformation, where farmers diversify out of low-valued rice production, the share of rice in Asian economies (share of GDP) has declined very rapidly. In 2007, it was just 1.0% in East Asia, 2.7% in South Asia, and 3.8% in Southeast Asia. So, even in Asia, rice is less important economically than livestock, construction, transportation, or even banking. Total employment in the rice economy may still rival these other sectors, but that is because the economic returns to working in the rice sector are so low—a failure of the structural transformation to absorb rural workers fast enough.

**AT: Cassava**

**Elevated CO2 dramatically decreases the size of the cassava crop and makes it poisonous**

**Glaser, 10** – research scientist at the U.S. Environmental Protection Agency’s National Risk Management Research Laboratory, where he leads the Biotechnology Research Program (John A., “Climate geoengineering”, Clean Technologies and Environmental Policy, 20 March 2010, [http://www.springerlink.com/content/p317m25216u288g6/)//BI](http://www.springerlink.com/content/p317m25216u288g6/%29//BI)

The increasing ambient CO2 concentration in air has been regarded as a potential benefit to plant life. A recent report of the effects of higher CO2 concentrations (360, 510, 710 ppm) on a selection of nutritive crops showed significantly reduced development of cassava tubers after 9 months of growth. At the 710 ppm concentration, an 80% reduction in food yield was observed for the comparison of plants grown under ambient and 710 ppm CO2 concentrations. The plants growing in the higher CO2 concentrations grew taller, slightly more woody, more stems and smaller leaves. Cassava is an important staple crop as the third largest carbohydrate source in the tropics. The cassava plants were found to be poisonous. The staple crops generally produce cyanogenic glycosides to deter consumption by grazing animals. The cassava plant grown under high CO2 conditions was found to produce three times the cyanide of a plant grown under ambient CO2. In the high-CO2 test plants, the cyanogenic glycoside content in the leaves significantly increased. Since some African human populations consume leaves as a protein supplement, this finding is significant to human health in developing countries. In other studies, C3 plants like rice, wheat, or cassava absorb CO2 to form three carbon molecules when exposed to higher CO2 concentrations, show deficits in calcium, magnesium, phosphorous, and protein by 15%. This study has received some criticism for the experiment design of the reported study. This has prompted the authors to answer the questions by a redesigned study which is expected to reaffirm the reported observations.

## Indicts/Prodicts

**Studies Indict**

**Their studies are wrong – on the complex ecological scale increased CO2 hurts plant growth**

**Schwartz 02** Mark Schwartz, writer for Stanford University’s Stanford Report, and referencing a multi-year study and its results done by Stanford biologists, December 11 2002, “High carbon dioxide levels can retard plant growth, study reveals” http://news.stanford.edu/news/2002/december11/jasperplots-124.html

The prevailing view among scientists is that global climate change may prove beneficial to many farmers and foresters -- at least in the short term. The logic is straightforward: Plants need atmospheric carbon dioxide to produce food, and by emitting more carbon dioxide into the air, our cars and factories create new sources of plant nutrition that will cause some crops and trees to grow bigger and faster. But an unprecedented three-year experiment conducted at Stanford University is raising questions about that long-held assumption. Writing in the journal *Science*, researchers concluded that elevated atmospheric carbon dioxide actually reduces plant growth when combined with other likely consequences of climate change -- namely, higher temperatures, increased precipitation or increased nitrogen deposits in the soil. The results of the study may prompt researchers and policymakers to rethink one of the standard arguments against taking action to prevent global warming: that natural ecosystems will minimize the problem of fossil fuel emissions by transferring large amounts of carbon in the atmosphere to plants and soils. "Perhaps we won't get as much help with the carbon problem as we thought we could, and we will need to put more emphasis on both managing vegetation and reducing emissions," said Harold A. Mooney, the Paul S. Achilles Professor of Environmental Biology at Stanford and co-author of the Dec. 6 *Science* study. He noted that the Stanford study is the first ecosystem-scale experiment to apply four climate change factors across several generations of plants. "To understand complex ecological systems, the traditional approach of isolating one factor and looking at that response, then EXTrapolating to the whole system, is often not correct," Mooney said. "On an ecosystem scale, many interacting factors may be involved."

**Idsos Indict**

**The Idsos are biased and are funded by oil companies.**

**Harkinson 9** – (Josh Reporter for Mother Jones, who specializes in the occupy movements, economy, and politics Mother Jonesis a nonprofit news organization that specializes in investigative, political, and social justice reporting. We currently have two main "platforms": an award-winning bimonthly national magazine (circulation 240,000), and a website featuring new, original reporting 24-7. No. 8: Center for the Study of Carbon Dioxide and Global Change (A.K.A. The Idso Family)

<http://www.motherjones.com/environment/2009/12/dirty-dozen-climate-change-denial-11-idso-family%20%20> )

The Idso clan is the von Trapp family of climate change denial. In 1980, paterfamilias Sherwood Idso, a self-described "bio-climatologist," published a [paper](http://www.sciencemag.org/cgi/content/abstract/207/4438/1462) in **Science** concluding that doubling the world's carbon dioxide concentration wouldn't change the planet's temperature all that much. In years that followed, Idso and his colleagues at Arizona State University's Office of Climatology received more than [$1 million in research funding from oil, coal, and utility interests](http://geoplan.asu.edu/files/balling.pdf). In 1990, he coauthored a paper funded by a coal mining company, titled "Greenhouse Cooling."In 1998, Idso's son Craig founded the Center for the Study of Carbon Dioxide and Global Change and began publishing **CO2****Science**, an online digest of climate change skepticism. He subsequently earned his PhD in geography from ASU under the tutelage of climate skeptic [Robert Balling](http://motherjones.com/politics/2005/05/put-tiger-your-think-tank), then the director of its climatology program. In the early 2000s, Idso was director of environmental science at Peabody Energy, the world's largest privately owned coal company. After Peabody laid him off, he began aggressively fundraising for the center, whose budget increased from just north of $30,000 in 2004 to more than $1 million last year. Since 2006, the center has mounted a spirited defense of carbon dioxide using everything from ancient tree-ring data to elementary-school science experiments. "[S]cience tells us that putting more CO2 in the air would actually be good for the planet," its website says. "Therefore, in invoking the precautionary principle one last time, our advice to policy makers who may be tempted to embrace Kyoto-type programs is simply this: **Don't mess with success!**"Like his dad, Craig Idso has become a preeminent "scientific" climate change naysayer. In lieu of his father, who refuses to travel in airplanes, in June the younger Idso jetted off to the [Heartland Institute](http://motherjones.com/environment/2009/12/dirty-dozen-climate-change-denial-06-heartland-institute)'s climate change conference. There he released "Climate Change Reconsidered," a 20-page report that suggested that Intergovernmental Panel on Climate Change scientists had tweaked their findings in hopes of being invited to conferences involving "hotel accommodations at exotic locations." More recently, the Idsos have marketed the report as a timely expose of "Climategate Culture."In 1998, Keith Idso, vice president of the Center for the Study of Carbon Dioxide and a school teacher, did an experiment with his fifth-grade science class. The lesson, which demonstrates that plants need CO2 to thrive, has been taught in other classrooms across Arizona. Sherwood Idso has praised his son's experiment for showing that cutting carbon emissions would reduce "the future benefits we could have in terms of agricultural productivity." In 1999, the speaker of the Arizona House of Representatives appointed Keith Idso to serve on the state's Advisory Council on Environmental Education. Sherwood Idso says the coal and oil interests that have supported the Center for the Study of Carbon Dioxide have been backing off. Fundraising is "so poor that I'm not earning anything," he says. "Everything has to go to my son [Craig] to help him maintain himself and the five kids that he has now, and so we're just scraping by." But the center's 2008 tax filing shows that it entered 2009 with $445,000 in cash on hand. Last year, it paid Sherwood Idso $50,000, Craig Idso $79,000, and Craig Idso's wife, M. Anne Idso, $52,000. The center also made a $58,000 "scientific research" grant to a group called CO2 Science. Tax records reveal that CO2 Science's $75,000 budget that year mostly went toward paying Craig Idso a $45,000 salary, bringing his and his wife's total take from the family business to $182,000.

**All three of the Idsos are biased and are affiliated with Fuel Associations**

**UCS 5 –** (The Union of Concerned Scientists report, Smoke, Mirrors & Hot Air: How ExxonMobil Uses Big Tobacco's Tactics to "Manufacture Uncertainty" on Climate Change,details how ExxonMobil has adopted the tobacco industry's disinformation tactics, as well as some of the same organizations and personnel, to cloud the scientific understanding of climate change and delay action on the issue. According to the report, ExxonMobil has funneled nearly $16 million between 1998 and 2005 to a network of 43 advocacy organizations that seek to confuse the public on global warming science,Global Warming Skeptic Organizations<http://www.ucsusa.org/global_warming/science_and_impacts/global_warming_contrarians/global-warming-skeptic.html>)

The Center claims to "disseminate factual reports and sound commentary on new developments in the world-wide scientific quest to determine the climactic and biological consequences of the ongoing rise in the air's CO2 content." The Center is led by two brothers, Craig and Keith Idso. Their father, Sherwood Idso, is affiliated with the Greening Earth Society; the Center also shares a board member (Sylvan Wittwer) with GES. Both Idso brothers have been on the Western Fuels payroll at one time or another.

**Spin**: Increased levels of CO2 will help plants, and that's good.

**Funding:** The Center is extremely secretive of its funding sources, stating that it is their policy not to divulge it funders. There is evidence for a strong connection to the Greening Earth Society (ergo Western Fuels Association).

**Lindzen Indict**

**Lindzen is a right-wing hack, and his findings have no true evidence**

**Romm 10 –** (Joe, a Fellow at American Progress and is the editor of Climate Progress, which New York Times columnist Tom Friedman called "the indispensable blog" and Time magazine named one of the 25 “Best Blogs of 2010.″ In 2009, Rolling Stone put Romm #88 on its list of 100 “people who are reinventing America.” Time named him a “Hero of the Environment″ and “The Web’s most influential climate-change blogger.” Romm was acting assistant secretary of energy for energy efficiency and renewable energy in 1997, where he oversaw $1 billion in R&D, demonstration, and deployment of low-carbon technology. He is a Senior Fellow at American Progress and holds a Ph.D. in physics from MIT, [Lindzen debunked again: New scientific study finds his paper downplaying dangers of human-caused warming is “seriously in error”](http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/)

<http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/>)

Richard Lindzen routinely accuses scientists, even his close friends, of scientific

misfeasance, based on no evidence whatsoever (see [Kerry Emanuel asserts Lindzen charge is “pure fabrication”](http://climateprogress.org/2010/05/16/lindzen-emanuel-boston-globe-beth-daley-worst-global-warming-article-ever/)).

So it’s no surprise that in written testimony for a congressional hearing on the state of climate science that comes on the one-year anniversary of the [hacking of climate scientist emails](http://wonkroom.thinkprogress.org/2009/11/20/climategate/), Dr. Lindzen of MIT accuses his colleages of academic corruption.  Brad Johnson [has the low lights](http://wonkroom.thinkprogress.org/2010/11/17/lindzen-climategate-cheat/).

Lindzen, a [right-wing ideologue](http://www.sourcewatch.org/index.php?title=Richard_S._Lindzen) who has also argued on behalf of corporations that cigarettes are safe and CFCs don’t hurt the ozone layer, was [asked to testify](http://wonkroom.thinkprogress.org/2010/11/16/judith-curry-zombies/) by the Republican minority, dominated by global warming deniers.

Lindzen cites “climategate” as proof of “[overt cheating](http://democrats.science.house.gov/Media/file/Commdocs/hearings/2010/Energy/17nov/Lindzen_Testimony.pdf)” and claims “so-called climate science” is actually “science in the service of politics.” Although he concedes that manmade global warming is “trivially true,” Lindzen essentially argues that as long as you ignore the data that indicates CO2-driven global warming, you can’t find CO2-driven global warming.

Other lowlights of Lindzen’s [testimony](http://democrats.science.house.gov/Media/file/Commdocs/hearings/2010/Energy/17nov/Lindzen_Testimony.pdf):

- Argues that the deceased Steven Schneider, one of the most influential climate researchers up to the time of his death this year, was not an “active contributor” to climate science

- Calls the global surface temperature anomaly an “obscure statistical quantity.”

- Claims “so-called climate science” is actually “science in the service of politics.”

- Says climate science “has become a quasi-religious issue.”

- Says “climategate” is one of several “instances of overt cheating.”

- “I am quite willing to state that unprecedented climate catastrophes are not on the horizon.”

Of course, Lindzen’s testimony somehow manages to ignore the crushing weight of scientific research finding dramatic, unprecedented changes in the natural world in all realms, including (for just one example) the freak Russian heat wave and associated Asian monsoon which killed over 60,000 people this summer during the hottest year on record.

Lindzen’s own work carries all the hallmarks of the crimes he plants on the rest of his colleagues “” [science designed to get pre-determined results](http://climateprogress.org/2010/01/11/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/) driven by [political ideology](http://climateprogress.org/2010/05/16/lindzen-emanuel-boston-globe-beth-daley-worst-global-warming-article-ever/).

**Lindzen’s findings are flawed and his ideas should be rejected**

**Romm 10 –** (Joe, a Fellow at American Progress and is the editor of Climate Progress, which New York Times columnist Tom Friedman called "the indispensable blog" and Time magazine named one of the 25 “Best Blogs of 2010.″ In 2009, Rolling Stone put Romm #88 on its list of 100 “people who are reinventing America.” Time named him a “Hero of the Environment″ and “The Web’s most influential climate-change blogger.” Romm was acting assistant secretary of energy for energy efficiency and renewable energy in 1997, where he oversaw $1 billion in R&D, demonstration, and deployment of low-carbon technology. He is a Senior Fellow at American Progress and holds a Ph.D. in physics from MIT,[Lindzen debunked again: New scientific study finds his paper downplaying dangers of human-caused warming is “seriously in error”](http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/)

<http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/> )

Trenberth: The flaws in Lindzen-Choi paper “have all the appearance of the authors having contrived to get the answer they got.”

Consistently being wrong and consistently producing one-sided analyses that are quickly debunked in the literature should lead scientific journals and the entire scientific community (and possibly the media) to start ignoring your work.

But when you are one of the last remaining “serious” professional scientists spreading global warming disinformation who retains a (nano)ounce of credibility because you are associated with a major university — M.I.T. — and your name is Richard Lindzen, apparently you can just keep publishing and repeating the same crap over and over and over again.

It’s not just that Lindzen’s popular disinformation tracts have been widely debunked — see[RealClimate here](http://www.realclimate.org/index.php/archives/2007/04/lindzen-in-newsweek/).  Or that his one remaining big idea — that clouds are negative feedback — has been refuted in the literature [see [Science: "Clouds Appear to Be Big, Bad Player in Global Warming,"an amplifying feedback (sorry Lindzen and fellow deniers)](http://climateprogress.org/2009/07/24/science-deniers-lindzen-clouds-amplifying-positive-feedback-not-negative/)].   That idea of course meant ignored the myriad observations that climate impacts are occurring faster, not slower, than the models had predicted, and that therefore the multiple strong amplifying feedbacks are overwhelming whatever few week negative feedbacks occur in the climate system — see[Study: Water-vapor feedback is “strong and positive,” so we face “warming of several degrees Celsius”](http://climateprogress.org/2008/10/26/study-water-vapor-feedback-is-strong-and-positive-so-we-face-warming-of-several-degrees-celsius/) (and below).

At the Heartland conference of climate-change disinformers last year, Lindzen went from disinformation to defamation as he smeared the reputation of one of the greatest living climate scientists, Wallace Broecker (see “[Shame on Richard Lindzen, MIT’s uber-hypocritical anti-scientific scientist](http://climateprogress.org/2009/03/09/richard-lindzen-heartland-denier/)“).

But still his shoddy work manages to make it through the peer review process of a few journals, and the antiscience crowd eat it up and regurgitates it over the blogosphere like a toddler with H1N1.  His latest nonsense is about to be thoroughly eviscerated in the literature, and RealClimate his multiple posts on how flawed Lindzen’s analysis was and how the peer review process failed.  You should start with “[Lindzen and Choi Unraveled](http://www.realclimate.org/index.php/archives/2010/01/lindzen-and-choi-unraveled/)” by climate scientists John Fasullo, Kevin Trenberth and Chris O’Dell:

**Lidzen’s findings are not reliable his LC09 paper proves**

**Romm 10 –** (Joe, a Fellow at American Progress and is the editor of Climate Progress, which New York Times columnist Tom Friedman called "the indispensable blog" and Time magazine named one of the 25 “Best Blogs of 2010.″ In 2009, Rolling Stone put Romm #88 on its list of 100 “people who are reinventing America.” Time named him a “Hero of the Environment″ and “The Web’s most influential climate-change blogger.” Romm was acting assistant secretary of energy for energy efficiency and renewable energy in 1997, where he oversaw $1 billion in R&D, demonstration, and deployment of low-carbon technology. He is a Senior Fellow at American Progress and holds a Ph.D. in physics from MIT.[Lindzen debunked again: New scientific study finds his paper downplaying dangers of human-caused warming is “seriously in error”](http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/) <http://thinkprogress.org/climate/2010/01/11/205326/science-lindzen-debunked-again-positive-negative-feedbacks-clouds-tropics/> )

A recent paper by [Lindzen and Choi](http://www.drroyspencer.com/Lindzen-and-Choi-GRL-2009.pdf) in GRL (2009) (LC09) purported to demonstrate that climate had a strong negative feedback and that climate models are quite wrong in their relationships between changes in surface temperature and corresponding changes in outgoing radiation escaping to space. This publication has been subject to a considerable amount of hype, [for instance](http://www.examiner.com/examiner/x-7715-Portland-Civil-Rights-Examiner~y2009m8d18-Carbon-Dioxide-irrelevant-in-climate-debate-says-MIT-Scientist) apparently “[LC09] has absolutely, convincingly, and irrefutably proven the theory of Anthropogenic Global Warming to be completely false.” and “we now know that the effect of CO2 on temperature is small, we know why it is small, and we know that it is having very little effect on the climate”. Not surprisingly, LC09 has also been highly publicized in [various](http://scienceandpublicpolicy.org/images/stories/papers/originals/response_to_us_engerysec.pdf) [contrarian](http://www.rightsidenews.com/200910297053/energy-and-environment/senate-testimony-of-secretary-chu-refuted.html)[circles](http://www.youtube.com/watch?v=8bLUEMWicyo&feature=related).

Our initial reading of their article had us independently asking, how we could have missed such explicit evidence of the cloud feedback as shown in LC09? Why would such a significant finding have gone undiscovered when these feedbacks are widely studied and recognised as central to the projections of climate change? We discovered these common concerns at a meeting last year and then teamed up to address these questions.

With the hype surrounding the manuscript, one would think that the article provides a sound, rock solid basis for a reduced climate sensitivity. However, our examination of the study’s methods demonstrates that this is not the case. In an article in press ([Trenberth et al. 2010](http://www.agu.org/journals/pip/gl/2009GL042314-pip.pdf) (sub. requ.), hereafter TFOW), we show that LC09 is gravely flawed and its results are wrong on multiple fronts. These are the major issues we found:

The LC09 results are not robust….

LC09 misinterpret air-sea interactions in the tropics….

More robust methods show no discrepancies between models and observations….

LC09 have compared observations to models prescribed with incomplete forcings….

LC09 incorrectly compute the climate sensitivity.

The paper itself is behind a firewall, but finds:

Atmospheric model results are explored and found to be consistent with observations.  From 1985 to 1999 the largest perturbation in TOA [top-of-atmosphere] radiative fluxes was from the eruption of Mount Pinatubo and clearly models which do not include that forcing will not simulate the effects. Consequently, regressions of radiation with SSTs in the tropics may have nothing to say about climate sensitivity….

As shown here, the approach taken by LC09 is flawed, and its results are seriously in error.  The LC09 choice of dates has distorted their results and underscores the defective nature of their
analysis….

I’m shocked, shocked that Lindzen did shoddy, one-sided analysis and was wrong about feedbacks and sensitivity.

But, seriously, how could such crap make it into a serious journal?  Gavin Schmidt [prints](http://www.realclimate.org/index.php/archives/2010/01/lc-grl-comments-on-peer-review-and-peer-reviewed-comments/) a long explanation from O’Dell:

Given the large number of comments on the peer-review process in general and in the LC09 case in particular, it is probably worthwhile to give a bit more backstory to our Trenberth et al. paper. On my first reading of LC09, I was quite amazed and thought if the results were true, it would be incredible (and, in fact, a good thing!) and hence warranted independent checking. Very simple attempts to reproduce the LC09 numbers simply didn’t work out and revealed some flaws in their process. To find out more, I contacted Dr. Takmeng Wong at NASA Langley, a member of the CERES and ERBE science teams (and major player in the ERBE data set) and found out to my surprise that no one on these teams was a reviewer of LC09. Dr. Wong was doing his own verification of LC09 and so we decided to team up.

After some further checking, I came across a paper very similar to LC09 but written 3 years earlier – Forster & Gregory (2006) , hereafter FG06. FG06, however, came to essentially opposite conclusions from LC09, namely that the data implied an overall positive feedback to the earth’s climate system, though the results were somewhat uncertain for various reasons as described in the paper (they attempted a proper error analysis). The big question of course was, how is it that LC09 did not even bother to reference FG06, let alone explain the major differences in their results? Maybe Lindzen & Choi didn’t know about the existence of FG06, but certainly at least one reviewer should have. And if they also didn’t, well then, a very poor choice of reviewers was made.

This became clear when Dr. Wong presented a [joint analysis](http://science.larc.nasa.gov/ceres/STM/2009-11/index.html) he & I made at the CERES science team meeting held in Fort Collins, Colorado in November. At this meeting, Drs. Trenberth and Fasullo approached us and said they had done much the same thing as we had, and had already submitted a paper to GRL, specifically a comment paper on LC09. This comment was rejected out of hand by GRL, with essentially no reason given. With some more inquiry, it was discovered that:

1. The reviews of LC09 were “extremely favorable”
2. GRL doesn’t like comments and is thinking of doing away with them altogether.
3. GRL wouldn’t accept comments on LC09 (and certainly not multiple comments), and instead it was recommended that the four of us submit a stand-alone paper rather than a comment on LC09.

We all felt strongly that we simply wanted to publish a comment directly on LC09, but gave in to GRL and submitted a stand-alone paper. This is why, for instance, LC09 is not directly referenced in our paper abstract. The implication of statement (1) above is that LC09 basically skated through the peer-review process unchanged, and the selected reviewers had no problems with the paper. This, and for GRL to summarily reject all comments on LC09 appears extremely sketchy.

In my opinion, there is a case to be made on the peer-review process being flawed, at least for certain papers. Many commenters say the system isn’t perfect, but it in general works. I would counter that it certainly could be better. For AGU journals, authors are invited to give a list of proposed reviewers for their paper. When the editor is lazy or tight on time or whatever, they may just use the suggested reviewers, whether or not those reviewers are appropriate for the paper in question. Also, when a comment on a paper is submitted, the comment goes to the editor that accepted the original paper – a clear conflict of interest.

So yes, the system may work most of the time, but LC09 is a clear example that it doesn’t work all of the time. I’m not saying LC09 should have been rejected or wasn’t ultimately worthy of publication, but reviewers should have required major modifications before it was accepted for publication.

It is typical for the few bad papers that make it through peer-review to fail to reference the multiple analyses in the literature that prove the opposite position.  The question is why journals allow that.

Shouldn’t the fact that it had Lindzen’s name on it wrung alarm bells that called for extra scrutiny.  Few people have been as consistently wrong as he has.

UPDATE:  I see climate scientist Tom Wigley commented on Gavin’s first post [here](http://www.realclimate.org/index.php/archives/2010/01/first-published-response-to-lindzen-and-choi/#comment-153754):

You say “LC09 was not a nonsense paper – that is, it didn’t have completely obvious flaws that should have been caught by peer review “. I beg to differ.

It is a priori obvious that one cannot determine the climate sensitivity from an incomplete energy balance over the tropics. LC09 ignores the fluxes of heat into and/or out of the region via the atmosphere, and the flux of heat into the ocean. As Trenberth et al. point out, these are large terms, and they simply cannot be ignored. This is a glaringly obvious error that any competent reviewer should have picked up. It undermines the whole analysis and makes it worthless. In my view, the other issues raised by Trenberth et al. are important, but secondary to this fundamental problem.

DotEarth’s [Revkin](http://dotearth.blogs.nytimes.com/2010/01/08/a-rebuttal-to-a-cool-climate-paper/?src=twt&twt=dotearth) interviewed Trenberth, who has some choice quotes:

In a telephone interview today, Dr. Trenberth told me that the flaws in the Lindzen-Choi paper “have all the appearance of the authors having contrived to get the answer they got.”

… I asked Dr. Trenberth to run the numbers on how much the difference in analysis amounts to in terms of warming from a doubling of the carbon dioxide concentration that long prevailed before the industrial revolution. He said that, if done correctly, the Lindzen-Choi analysis would have produced a 1.5 degree Fahrenheit warming instead of the 0.9 degree warming the paper initially contained. But rectifying an additional flaw “” the paper’s selection of sea temperatures in a way that did not appear to be objective “” produces a warming of 4.1 degrees, a level at the heart of what most climate simulations and other studies project. That did not include issues related to the original paper restricting its analysis to the tropics, he added.

**Lindzen’s research is supported by oil companies**

**Zill 7**

(Oriana productions director at the Center for Investigative Reporting (CIR), is an investigative journalist and documentary filmmaker with twelve years of experience on programs for network, public and cable television. She has produced award-winning documentaries and news stories for PBSFrontline World, PBSFrontline, PBSNow with Bill Moyers, ABC NewsNightline, National Geographic Channel'sScience Times, and The Travel Channel. She was senior producer for CIR on investigative documentaries forABC News: Peter Jennings Reportingand forCNN Presents. The Doubters of Global Warming <http://www.pbs.org/wgbh/pages/frontline/hotpolitics/reports/skeptics.html>)

Area of Expertise: A meteorologist, Lindzen is a member of the National Academy of Sciences. His published works include papers on monsoons, how heat and water move around the world, the ice ages and the effects of seasonal changes on the atmosphere. Lindzen worked on -- and was vocally critical of -- the Second Assessment of Climate Change by the UN Intergovernmental Panel on Climate Change, released in 1995; that same year he also signed the Leipzig Declaration. He has frequently aired his skepticism in testimony before Congress.

Affiliations & Funding: Dr. Lindzen has claimed in [Newsweek](http://www.msnbc.msn.com/id/17997788/site/newsweek/) and elsewhere that his funding comes exclusively from government sources, but he does not seem to include speaking fees and other personal compensation in this statement. Ross Gelbspan, who did some of the first reporting on climate skeptics' links to industry, [wrote](http://dieoff.org/page82.htm) in Harper's Magazine in 1995: "[Lindzen] charges oil and coal interests $2,500 a day for his consulting services; his 1991 trip to testify before a Senate committee was paid for by Western Fuels, and a speech he wrote, entitled 'Global Warming: the Origin and Nature of Alleged Scientific Consensus,' was underwritten by OPEC."

Dr. Lindzen is a member of the Advisory Council of the Annapolis Center for Science Based Public Policy, which has received large amounts of funding from ExxonMobil and smaller amounts from Daimler Chrysler, according to a review Exxon's own financial documents and 990s from Daimler Chrysler's Foundation. Lindzen is a also been a contributor to the [Cato Institute](http://www.cato.org/), which has taken $90,000 from Exxon since 1998, according to the website Exxonsecrets.org and a review Exxon financial documents. He is also a contributor for the George C. Marshall Institute.

Recent viewpoints: On January 31, 2007, Lindzen appeared on [Larry King Live](http://transcripts.cnn.com/TRANSCRIPTS/0701/31/lkl.01.html) and said, regarding fear of global warming, "I think it's mainly just like little kids locking themselves in dark closets to see how much they can scare each other and themselves." Weeks later, he told the [San Diego Union-Tribune,](http://www.signonsandiego.com/uniontrib/20070214/news_1b14sempra.html) "To say that climate change will be catastrophic hides a cascade of value-laden assumptions that do not emerge from empirical science." Dr. Lindzen also appeared in the March 8, 2007 film [The Great Global Warming Swindle](http://www.channel4.com/science/microsites/G/great_global_warming_swindle/index.html), which aired on British television.

 **AT: WSJ Article**

**Non-warming skeptics grossly misrepresent their claims**

**Hamburg 12** (Steven Hamburg is EDF’s public voice for its commitment to science-based advocacy and is responsible for the scientific integrity of EDF’s positions and programs. His training and research specialty is ecosystem ecology, with a focus on forests. “ A Flawed Global Warming Analysis in the Wall Street Journal.” <http://blogs.edf.org/climate411/2012/01/30/a-flawed-global-warming-analysis-in-the-wall-street-journal/>) H.Kenner

Many of the specific claims in the Journal piece also have already been definitively laid to rest. As the Union of Concerned Scientists has pointed out: the authors claim there has been a "lack of warming" for 10 years…. [yet] 2011 was the 35th year in a row in which global temperatures were above the historical average and 2010 and 2005 were the warmest years on record. Moreover, **every decade since the 1950s has been warmer than the last.** **The authors recycle an out-of-contEXT quotation from Kevin Trenberth, distinguished senior scientist at the National Center for Atmospheric Research, to imply that he harbors doubts about warming.** As Trenberth has said publicly:I was not questioning the link between anthropogenic greenhouse gas emissions and warming, or even suggesting that recent temperatures are unusual in the contEXT of short-term natural variability. The authors misuse his words in service of what they call an “inconvenient fact” that is no fact at all. They ignore the multiple streams of scholarship that rebut their claims and point to rising global temperatures caused in large part by anthropogenic emissions.In truth, climate skeptics may be finding it harder to cling to their doubts. Last year, for example, scientists at the University of California, Berkeley – in a study partially funded by climate skeptics – found that technical issues that skeptics claim skew global warming figures had no meaningful effect on them.

As the Guardian reported: The Berkeley Earth project compiled more than a billion temperature records dating back to the 1800s from 15 sources around the world and found that the average global land temperature has risen by around 1C since the mid-1950s. This figure agrees with the estimate arrived at by major groups that maintain official records on the world's climate, including Nasa's Goddard Institute for Space Studies in New York, the US National Oceanic and Atmospheric Administration (Noaa), and the Met Office's Hadley Centre, with the University of East Anglia, in the UK. “My hope is that this will win over those people who are properly skeptical,” Richard Muller, a physicist and head of the project, said.

**AT: IPCC Bad**

**Even if the IPCC isn’t perfect it still is the best resource and its main theories have been proven correct.**

**Sherwood 11 –** (Steve, Co-Director, Climate Change Research Centre at [University of New South Wales](http://theconversation.edu.au/institutions/university-of-new-south-wales) Study how the various processes in the atmosphere conspire to establish climate, how these processes might be expected to control the way climate changes, and how the atmosphere will ultimately interact with the oceans and other components of Earth, ad a research group that applies basic physics to complex problems by a combination of simple theoretical ideas and hypotheses and directed analyses of observations. Depending on requirements we use simple or advanced statistical techniques, bridging the gaps between these (where needed) by using state-of-the-art climate models as research tools. One practical goal of the work is to figure out how these models might be improved, as they are ultimately necessary for regional predictions of weather and climate. A more academic goal is just to unlock the secrets of our atmosphere. Professor, Climate Change Research Centre, University of New South Wales. Trust us, we’re climate scientists: the case for the IPCC <http://theconversation.edu.au/trust-us-were-climate-scientists-the-case-for-the-ipcc-806>)

News stories in 2010 hyped an error concerning Himalayan glaciers found on page 493 of the 2007 impacts volume. There are probably more such errors buried in the main text, much of which is reviewed by only a few experts, but none has been reported in the important summaries, which receive far more scrutiny. Nor have any errors been found in the volume of the report dealing with the basic science. Another embarrassment came when the so-called “[Climategate](http://www.guardian.co.uk/environment/2010/jul/07/climate-emails-question-answer)” emails seemed to show collusion among a few authors to exclude certain papers. While these authors were hardly alone in doubting the validity of the papers in question, the papers were still ultimately included in the report, which if anything shows the report to be inclusive. An InterAcademy Council Review of the body in 2010 suggested improvements, and criticised the impacts volume in particular, but did not find fundamental problems with the IPCC. It’s hard to imagine a report free of any such glitches, but these have fuelled calls by conservative politicians in the US for an end to the IPCC. Are the assessment reports alarmist, or too weak? Instances can be found to support either view. Conclusions can be weakened by the need to accommodate contrary views whether well-founded or not: for example, the 2007 report judged the 20th-century rise in CO2 only 90% likely to be human-caused, when the full brunt of evidence leaves no rational doubt of this. And 11th-hour negotiations have on some occasions turned clear predictions of harm into meaninglessly vague ones. On the other hand, many of the IPCC’s claims on current or future climate impacts rest on weak foundations or emphasise the worst possibilities. To some extent this reflects the literature itself, the great difficulty in pinning down impacts rigorously, and perhaps, a feeling that we really should be looking at the worst possibilities. It is (to use the IPCC’s uncertainty language) “highly likely” that the IPCC will continue to be criticised, mainly by those opposed to emissions reductions. Its reports will never be perfect. But they remain the ultimate compendia of climate knowledge, an unparalleled resource for scientists, students and punters alike, and are almost certainly the most thoroughly vetted scientific documents in history. This author would be very happy to hear of a better alternative.

**The IPCC is very reliable and goes through an extensive peer review process**

Sherwood 11 **–** (Steve, Co-Director, Climate Change Research Centre at [**University of New South Wales**](http://theconversation.edu.au/institutions/university-of-new-south-wales)Study how the various processes in the atmosphere conspire to establish climate, how these processes might be expected to control the way climate changes, and how the atmosphere will ultimately interact with the oceans and other components of Earth, ad a research group that applies basic physics to complex problems by a combination of simple theoretical ideas and hypotheses and directed analyses of observations. Depending on requirements we use simple or advanced statistical techniques, bridging the gaps between these (where needed) by using state-of-the-art climate models as research tools. One practical goal of the work is to figure out how these models might be improved, as they are ultimately necessary for regional predictions of weather and climate. A more academic goal is just to unlock the secrets of our atmosphere. Professor, Climate Change Research Centre, University of New South Wales. Trust us, we’re climate scientists: the case for the IPCC, <http://theconversation.edu.au/trust-us-were-climate-scientists-the-case-for-the-ipcc-806>**)**

“Why don’t scientists just get together and figure out what’s going on?” It’s a common question we hear about global warming. The answer is simple: “They have.” The largest effort to pull the relevant research together is the series of assessment reports commissioned by the Intergovernmental Panel on Climate Change (IPCC). The latest IPCC report on renewable energy was released yesterday, and will no doubt be open to much criticism. But will it be justified? Given the amount of talk that goes on about climate change, it is perhaps surprising that so few people are aware of the IPCC, and the ones that do know so little about it. The IPCC was set up by the UN in 1988 to assess the science for policy makers, releasing its first Assessment Report in 1990 and its fourth in 2007. Each successive report has articulated more confidently that humans are changing the climate by emitting greenhouse gases, and that our current trajectory will bring much greater warming. The warming predicted in 1990 has, so far, transpired on schedule. One thing many people don’t realise is that each report is actually in three volumes. The first tackles the basic science: how much the earth has warmed, how much of it we caused, and what climate change to expect in the future. The second concerns impacts and adaptation, for example impacts on crop yields or actions needed to protect coastal areas. The last is about mitigation: how much it would cost to deal with the problem (or not to), and how might various policy and technological approaches pan out. Each is written by a separate team of 200-plus authors and review editors chosen on the basis of their scientific accomplishments by an international nomination and evaluation process. They must serve on top of their “day jobs” as academics or other demanding positions. These reports are massive, resembling a set of telephone books (though with flashier covers). Their task is huge: to fairly and accurately assess all of the many thousands of peer-reviewed articles that have come out since the last report. These are from a wide range of relevant scientific and technological disciplines including atmospheric physics and chemistry, oceanography, geology and economics. Because it is an assessment, authors have leeway to express doubts about published work that is not deemed credible by the community. Each report goes through several iterations of peer review. The 2007 report attracted 90,000 review comments, each of which required an individual response. Preliminary drafts of the 2014 report have already been written but await two more years of revision and review. The final step includes negotiations between scientist authors and non-scientist government representatives on the text of the report summaries (the parts non-scientists usually read). Some authors have described these negotiations as harrowing, with a few governments driving hard to water down the findings. While climate contrarians often question the objectivity of the IPCC, the extensive review procedures leave little room for its conclusions to stray from those dominating the main scientific literature. Each new report gets a different batch of expert authors – by now more than two thousand individuals have contributed. Hardly a cabal of extremists, this is a hefty share of the world’s most qualified experts. Several well-known contrarians have been authors, but constitute a tiny fraction of qualified experts and have therefore been unable to steer the conclusions (nor do they quibble with most of the contents anyway). The range of reasonable views, discrepancies in published results, or lack of evidence on some issues are taken into account via the probabilistic language attached to report conclusions, although no claimed degree of uncertainty will ever satisfy everyone. Nothing is claimed with absolute certainty, especially projections of the future.

**CO2 Kills Forests**

Elevated levels of CO2 empirically proven to destroy forests

Sorey et al. 2007 Michael L. Sorey, Christopher D. Farrar, Terrance M. Gerlach, Kenneth A. McGee, William C. Evans, Elizabeth M. Colvard, David P. Hill, Roy A. Bailey, John D. Rogie, James W. Hendley II, and Peter H. Stauffer, government geologists who created this US geological fact sheet, “Invisible CO2 Gas Killing Trees at Mammoth Mountain, California” Last Modified July 9 2007 http://pubs.usgs.gov/fs/fs172-96/

Since 1980, scientists have monitored geologic unrest in Long Valley Caldera and at adjacent Mammoth Mountain, California. After a persistent swarm of earthquakes beneath Mammoth Mountain in 1989, geologists discovered that large volumes of carbon dioxide (CO2 ) gas were seeping from beneath this volcano. This gas is killing trees on the mountain and also can be a danger to people. The U.S. Geological Survey (USGS) continues to study the CO2 emissions to help protect the public from this invisible potential hazard. Mammoth Mountain is a young volcano on the southwest rim of Long Valley Caldera, a large volcanic depression in eastern California. The Long Valley area, well known for its superb skiing, hiking, and camping, has been volcanically active for about 4 million years. The most recent volcanic eruptions in the region occurred about 200 years ago, and earthquakes frequently shake the area. Because of this, the U.S. Geological Survey (USGS) operates an EXTensive network of instruments to monitor the continuing unrest in the Long Valley area.Numerous small earthquakes occurred beneath Mammoth Mountain from May to November 1989. Data collected from monitoring instruments during those months indicated that a small body of magma (molten rock) was rising through a fissure beneath the mountain. During the nEXT year, U.S. Forest Service rangers noticed areas of dead and dying trees on the mountain. After drought and insect infestations were eliminated as causes, a geologic explanation was suspected. USGS scientists then made measurements and discovered that the roots of the trees were being killed by exceptionally high concentrations of carbon dioxide (CO2) gas in the soil. Today, areas of dead and dying trees at Mammoth Mountain total more than 100 acres. The town of Mammoth Lakes, just east of this volcano, has not been affected.

#### Increasing levels of CO2 lead to dead zones in forests

Waldrop et al, 4/4 Mark Waldrop, Jack McFarland, Margaret Mangan, Bill Evans, Monica Haw, Sabrina Sevilgen, Rob Klinger, Laurel Triatik, Carli Morgan, Lisamarie Windham-Meyers, all US Geological Survey (USGS) personnel, April 4 2012 “Elevated CO2 in Forest and Soil Ecosystems (ECO2FASE)” http://carbon.wr.usgs.gov/eCO2fase.html

Overview and Objectives High concentrations of volcanic cold CO2 emanating from Mammoth Mountain by the Long Valley Caldera has resulted in several large zones of tree kill over the past two decades. The absence of plants among affected areas has negatively impacted microbial populations, resulting in decreased biomass and/or shift to unique assemblages better adapted to chronic energy stress. However, separating the direct impact of elevated CO2 from the effect of excluding vegetation (and associated C inputs) on soil microbial community structure is complicated. At the Horseshoe Lake tree kill, there is evidence that the effects of elevated CO2 have decreased enough in some areas to allow recolonization of plant-free zones by lodgepole pine. This study capitalizes on the resurgence of plant growth to examine how microbial communities restructure in response to the CO2 disturbance and how resilient they are to returning to pre-starvation levels with the reintroduction of plants. Our sampling sites span a gradient of CO2 ranging from aerobic, to microaerobic, to anaerobic zones completely devoid of plant life. Investigations along this gradient include measures of soil function (enzyme activities, respiration, decomposition) as well as analyses of the composition of broad soil functional groups (fungi, bacteria, and archaea), and specific microorganisms, (CO2-reductive acetogenic bacteria and methanogens), physiologically suited to microaerobic and anaerobic environments. In addition, we are conducting greenhouse trials to determine the influence of mycorrhizae on seedling survivorship and growth for possible future outplanting experiments in affected areas. Information gained from this study should enhance our understanding of the impact of large-scale disturbances on plant-microbial interactions and belowground processes in forested ecosystems, and prove insightful to industries concerned with the effects of accidental release of CO2 from geologic reservoirs. Results to date The size, composition, and presumably activity of microbial populations are negatively impacted by elevated soil CO2. Estimates of microbial biomass indicate that microbial populations, fungi in particular, decline precipitously in the absence of C inputs from plants.

Microbial community composition shifts with increasing CO2; however, these changes are most evident among high-CO2 soils, suggesting that direct effects of CO2 (low pO2, low pH) on microbial physiology may play a role in structuring communities at the center of the kill zone. Plant-associated fungal communities show little overlap between elevated and ambient CO2 environments; however, it is unclear if these differences are attributable to opportunism by ‘weedier’ mycobionts, plant-mediated controls over infection, or simply distance to mature vegetation.