HOLDING THEM ACCOUNTABLE:
PARALLELS BETWEEN THE BEHAVIOR OF THE TOBACCO AND CARBON INDUSTRIES

Sam Miller
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Introduction. In late 1998, attorneys general in forty seven U.S. states reached their "master agreement" with the tobacco industry. The purpose of the deal was to exempt producers of cigarettes and other poisonous, carcinogenic tobacco products from future criminal and civil liability for the massive harm to public health their products have caused, and the deliberate campaigns of false advertising (and other forms of propaganda they funded) to hide the health effects of tobacco use. In exchange for excusing tobacco producers from the legal consequences of their crimes and torts, they agreed to pay a *minimum* of about $200 billion in damages to the states in the settlement. The tobacco industry agreed to continue making these payments on an annual basis until the *end of time* (Estes, 2014). The purpose of this paper is to draw parallels between the behavior of the tobacco and carbon industries, and demonstrate that companies involved in the extraction, refinement, marketing, and sale of fossil fuels have engaged in precisely the same type of deceptive, corrupt behavior that landed the tobacco companies in such legal jeopardy. After that I will compare the harms caused by the two industries. My motivation for this exercise is the hope that one day, as the effects of Anthropogenic Global Warming (AGW) progress to the point that even the poorly-informed (and deliberately *misinformed*) general population of the United States recognizes the reality of the situation, the executive officers and owners of the carbon industry will be held to account both criminally and civilly for the massive harm they are causing, and the well-funded efforts they are making to confuse the public about the scientific facts.

Before I continue, I should say something about my background so that the reader can know that I understand atmospheric science, including climate change. I have been a specialist in meteorology, a branch of atmospheric science, since 1982. I began as a United States Air Force weather observer at Loring AFB, in Limestone, Maine. After attending the weather forecaster technical college in 1984, I served as a weather forecaster at Travis AFB, California; Plattsburgh AFB, New York; and Incirlik Air Base, in Adana, Turkiye. I left the USAF in 1989 (after nearly 11 years on active duty), and attended the University of New Hampshire, while working (for most of that time) as a full-time, contract weather observer at the Pease ANGB, in Portsmouth, New Hampshire, and (part of that time) as a research scientist in two of UNH's research laboratories. In 1996 I graduated from UNH with a B.Sc. in physics and a minor in applied mathematics. I continued on to UNH's graduate school and completed an M.Sc. in oceanography in 1999. In 2003 I completed my Ph.D. in earth sciences (focusing on New Hampshire's

coastal meteorology), and took a two-year position as a weather forecaster with the U.S. National Weather Service in Anchorage, Alaska. Since 2005 I have been a professor of meteorology. I teach courses in introductory weather and climate, basic meteorological analysis, atmospheric thermodynamics, meteorological instruments and observations, weather forecasting practicum, satellite meteorology, and radar meteorology. I have published papers on the sea breeze of New Hampshire's coast and the sea breeze globally, have co-authored papers on the use of radar wind profilers in New Hampshire's Seacoast region, and on the Foehn winds of northwestern Iran, and have a forthcoming book on applied thermodynamics for meteorologists. (My book will be available from Cambridge University Press in June, 2015.) I have also made it a personal interest to keep informed about the science of AGW, and have given several lectures on the subject at Plymouth State University, Harvard University, and many other venues around the region.

The applicable statute in the tobacco case. According to Keisler, *et al.* (2004), the tobacco industry was being investigated for offenses under the Racketeer Influenced and Corrupt Organizations (RICO) Act, 18 U.S.C. § 1961-1968, for engaging in and executing – and *continuing* to engage in and execute – "a massive 50-year scheme to defraud the public, including consumers of cigarettes, in violation of RICO." The United States prosecutors further stated that "Defendants' past and ongoing conduct indicates a reasonable likelihood of future violations."

Parallels between the tobacco and carbon industries – background facts and behavior. In the following paragraphs, I will include quotes from Keisler, *et al.* (2004), citing some background and the specific criminal/tort activities of the major companies of the tobacco industry. Each of these quotes will be followed by a discussion of analogous information about the carbon industry.

1. According to Keisler, *et al.* (2004), "By the middle of the twentieth century, physicians and public health officials in the United States had widely noted an alarming increase in numbers of cases of lung cancer. Virtually unknown as a cause of death in 1900, by 1935 there were an estimated 4,000 deaths annually. A decade later, the annual death toll from lung cancer had nearly tripled. The meteoric rise in lung cancers followed the dramatic increase in cigarette consumption that had begun early in the twentieth century." Keisler, *et al.* (2004) further state that "[b]y late 1953, there had been at least five published epidemiologic investigations, as well others identifying and examining carcinogenic components in tobacco smoke and their effects. The researchers conducting these studies had come to a categorical understanding of the link between smoking and lung cancer."

The science of AGW is equally well, perhaps even more strongly established, than the scientific link between consuming tobacco and resulting disease. As far as I'm able to determine, the Swiss

physicist and chemist Svante Arrhenius was the first scientist to note the possibility that the artificial addition of carbon dioxide gas to Earth's atmosphere would result in "global warming." He published his hypothesis toward the end of the 19th Century. The basic premise behind it is that incoming (Solar, mostly visible) and outgoing (Terrestrial, mostly infra-red) electromagnetic radiation has been in a quasi-stable balance since the beginning of the Holocene, about 11,000 years before present. This balance results in the world's current "equilibrium temperature" of about 15 °Celsius (59 ° Fahrenheit). By directly adding carbon dioxide (and other greenhouse gases; GHGs going forward) to the atmosphere, or by degrading those natural mechanisms that *remove* GHGs from the atmosphere, outgoing radiation is delayed, and a portion of it is reabsorbed by the Earth system, resulting in a higher equilibrium temperature. A very small imbalance is required to result in a slow but inexorable increase in temperature. (The current imbalance is on the order of one quarter of a Watt per square meter, out of a total in the neighborhood of 700 Watts per square meter.) There is considerably more to it than this, as Earth's climate system is an extremely complex *chaotic* system, with an unknown number of internal *positive* (amplifying) and *negative* (dampening) feedbacks. It is also forced by a number of naturally-varying astronomical cycles (involving the shape of Earth's orbit around the Sun, where the winter occurs in the orbital path, the tilt of its axis, and others) originally documented by Serbian scientist and engineer Milutin Milanković at the beginning of the 20th Century. These natural astronomical variations are known to be the primary forcing behind the ice-age/interglacial-period cycles of the last three million years (the current warm period – the Holocene – is one such interglacial), and are now named in honor of this man. Hansen (2009) is a good source for some of this early historical information.

James Hansen began his scientific career as a graduate student studying the climate of Venus, working under the guidance of James Van Allen, the discoverer of Earth's radiation belts. Hansen quickly recognized that Venus had suffered a "runaway greenhouse," resulting in surface temperatures on that planet in excess of 900 °F. A runaway greenhouse is one in which warming the planet by a small amount triggers a positive feedback, which amplifies the effect, resulting in additional warming. The process feeds on itself until some new equilibrium is achieved. Hansen's next realization was that, by adding GHGs to Earth's atmosphere through industrial and agricultural activities, we were, in effect, running an uncontrolled global experiment that might result in a runaway greenhouse on this planet as well (Hansen, 2009). From 1981 through 2013, he was the Director of NASA's Goddard Institute for Space Studies, in New York City, and he used that position to further his studies of Earth's climate. (For more about Goddard, please see http://www.giss.nasa.gov/.) In 1988, Dr. Hansen testified before the United States Congress, explaining his concerns about AGW on this planet. After this testimony, knowledge about artificially-induced climate change was well-established in the public record.

Following Hansen's 1988 testimony, the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations' World Meteorological Organization, and has since issued several

reports on the state of the science of climate change. Its first report was issued in 1990, the second report in 1995, the third in 2001 (following a special request by U.S. President George W. Bush), the fourth in 2007, and its most recent report, the Fifth Assessment, was released in parts, with the last part officially published in 2014. (For more about the IPCC, please see http://www.ipcc.ch/.) Each of these reports consists of a digest of many peered-reviewed papers, written by atmospheric scientists and other specialists in areas related to climate, with summaries provided for use by executive decision makers and the general public. Several thousand professional scientists from around the world were involved in each publication. I won't go into the details of the increasingly dire predictions in each of these reports – these are, by now, common knowledge – and have been reported extensively in the mainstream media. Several other professional scientific organizations have also published papers on AGW, including the National Oceanic and Atmospheric Administration, the National Aeronautics and Space Administration, the U.S. Environmental Protection Agency, and the U.S. Department of Defense. In other words, this information is well understood, and has now been widely available in the public realm for *decades*. ***Carbon industry representatives cannot legitimately claim to be unaware of the science***. (For an example of an excellent public, plain-language archive of scientific information about climate change, please see: http://news.bbc.co.uk/2/hi/science/nature/portal/climate_change/default.stm.)

2. Keisler, *et al.* (2004) then explain that "[w]ithin the individual Cigarette Company Defendants, high-ranking corporate employees and lawyers, as well as outside lawyers representing the companies, acknowledged that if they conducted research internally that confirmed that cigarettes cause disease and are addictive, such research, if disclosed, would jeopardize their unified public relations and legal positions, would threaten industry profits, and would expose not just individual companies, but the entire industry, to legal liability and product regulation. Of course, the Cigarette Company Defendants did, in fact, acknowledge internally that cigarettes caused lung cancer and other diseases*: they recognized the legitimacy of the scientific consensus, and the limited amount of internal research that their scientists did perform was wholly consistent with the results of mainstream scientific study* [emphasis added]." Further, "Defendants' internal documents acknowledge that their public denial that smoking cigarettes causes disease both was contrary to the overwhelming medical and scientific consensus – established through extensive epidemiological and other scientific investigation by the early 1950s – and was intended to convince smokers and potential smokers that there remained genuine scientific 'controversy' about whether smoking caused disease."

As explained in a 2009 New York Times article, internal documents from inside the carbon industry (filed as part of a 2007 lawsuit), indicate that they engaged in precisely the same behavior. The environmental and left-wing press had been drawing this parallel for more than ten years before the Times article of 2009, but it took a story about it in a prestigious mainstream media organization like the

Times to gain the attention of the wider population. Even as the "Global Climate Coalition," organized and paid for by major corporations involved in the carbon industry, carried on a public relations and lobbying campaign to cast doubt on the connection between GHGs and climate change, scientists directly employed by that industry itself were explaining to corporate leaders that "science backing the role of greenhouse gases in global warming could not be refuted" (Revkin, 2009). As early as 1995, these scientists were telling their employers that "[t]he scientific basis for the Greenhouse Effect and the potential impact of human emissions of greenhouse gases such as CO_2 on climate is well established and cannot be denied" (Revkin, 2009). Yet, the *public* stance by the very same corporations, as represented by the Global Climate Coalition, and provided in writing to members of congress and the media, was that "scientists differ," and "[t]he role of greenhouse gases in climate change is not well understood" (Revkin, 2009). Throughout the decade of the 90s, funded by money from coal, oil, and the automotive industry (which also provided lawyers), the Global Climate Coalition also "conducted a multimillion-dollar advertising campaign [aimed at the general public] challenging the merits of an international agreement" to regulate greenhouse gas emissions (Revkin, 2009). The goal of the lobbying and advertising campaigns was to put pressure on elected officials and prevent international agreements on limiting carbon emissions from the burning of fossil fuels. Copies of the internal records, as well as the "backgrounder" provided by the Global Climate Coalition to lobbyists and journalists (rejecting the evidence indicating human activities were already warming the climate), can be found at the New York Times documents archive: http://documents.nytimes.com/global-climate-coalition-aiam-climate-change-primer#p=1

Revkin (2009) points out the parallel between the behavior of the tobacco and carbon industries, stating that "[s]ome environmentalists have compared the tactic to that once used by tobacco companies, which for decades insisted that the science linking cigarette smoking to lung cancer was uncertain. By questioning the science on global warming…groups like the Global Climate Coalition were able to sow enough doubt to blunt public concern about a consequential issue and delay government action." This, of course, was the point of the campaign: Delay action as long as possible, so that corporate profits, executive bonuses, and stockholder dividends could continue (and even increase) unabated, while minimizing the inevitable expense of mitigation and adaptation that the industry would be forced to absorb should action to curb emissions become mandated by law. Among the environmentalists mentioned by Revkin (2009) is George Monbiot, who states that, because of journalism industry norms of maintaining "neutrality" (also called "Fair and Balanced," which implies telling two sides to every story, regardless of the scientific validity of either side), the carbon industry's public relations representatives "didn't have to win the argument to succeed…only to cause as much confusion as possible" to delay action into the indefinite future (Revkin, 2009).

The Global Climate Coalition ceased operations in 2002, but other front organizations have taken up the cause of professional denialism. These include the National Association of Manufacturers

(representing the auto industry), and the United States Chamber of Commerce. Their activities to publicly deny the science in order to delay meaningful action as long as possible continue to this day. Unfortunately, these propaganda efforts have been so successful that fewer Americans now believe in the reality of AGW than did in 1989 – and this has occurred even as the visible effects of AGW have grown more severe (Saad, 2013).

3. Keisler, *et al.* (2004) describes the reaction of the tobacco industry to the scientific findings about smoking and health. "In response to this growing body of evidence that smoking caused lung cancer, Defendants and their agents … developed and implemented a unified strategy that sought to reassure the public that there was no evidence that smoking causes disease. At the end of 1953, the chief executives of the five major cigarette manufacturers in the United States at the time – Philip Morris, R.J. Reynolds, Brown & Williamson, Lorillard, and American – met at the Plaza Hotel in New York City with representatives of the public relations firm Hill & Knowlton and agreed to jointly conduct a long term public relations campaign to counter the growing evidence linking smoking as a cause of serious diseases." Efforts to deny the effects of second-hand smoke were later added to the campaign. "The meeting spawned an association-in-fact enterprise…to execute a fraudulent scheme in furtherance of their overriding common objective – to preserve and enhance the tobacco industry's profits by maximizing the numbers of smokers and number of cigarettes smoked and to avoid adverse liability judgments and adverse publicity. The fraudulent scheme would continue for the next five decades" (Keisler, *et al.,* 2004). In summary, the point of these meetings was to develop a campaign that would refute the scientific consensus on the health hazards of smoking, for the purpose of continued sales and profits. This, and the carbon industry parallel, have already been discussed to some degree above. What has *not* been mentioned so far is the creation of well-funded, fake "research institutes," whose sole purpose was (and is) to produce and publicize junk science that would lend credence to the *public* positions of the tobacco and carbon industries.

As a result of the Plaza Hotel meetings, the tobacco companies "launched their long term public relations campaign by issuing the 'Frank Statement to Cigarette Smokers,' a full page announcement published in 448 newspapers across the United States. The Frank Statement included two representations that would lie at the heart of Defendants' fraudulent scheme – first, that there was insufficient scientific and medical evidence that smoking was a cause of any disease; and second, that *the industry would jointly sponsor and disclose the results of 'independent' research designed to uncover the health effects of smoking through the new industry-funded Tobacco Industry Research Committee* [emphasis added] ('TIRC'), later renamed the Council for Tobacco Research ('CTR'). At the same time [the] Defendants … established a sophisticated public relations apparatus…based on the 'cover' of conducting research – to deny the harms of smoking and to reassure the public. Once they had organized and set in motion the essential strategy of

generating 'controversy' surrounding the scientific findings linking smoking to disease, Defendants stuck to this approach, without wavering, for the next half-century" (Keisler, *et al.*, 2004).

Keisler, *et al.* (2004) explain that "the Tobacco Institute actively designed and wrote issue statements, advertisements, pamphlets, and testimony that advanced Defendants' jointly formulated positions on smoking and health issues, including denying that smoking cigarettes was addictive and caused diseases, and supporting the false claim that the link between smoking cigarettes (and exposure to secondhand smoke) and adverse health effects remained a legitimate 'open question.'" This is another parallel with the public stance of the carbon industry and its front organizations, who have repeatedly characterized the science of AGW as "unsettled," under the diversionary (and irrelevant) truism that "climate has always changed and always will "(Koonin, 2014). Keisler, *et al.* (2004) continue that "[i]n this way, the functions (public relations and research) of [TIRC and CTR] were integrally related; both were fully committed to Defendants' goals of denying and discrediting the substantial scientific evidence of smoking's harms and convincing the public (especially smokers and potential smokers) that smoking was not harmful to health."

The carbon industry has used an identical approach, consisting of two major components. The first is to employ well-recognized scientists already working in fields related to climate science, and pay them to speak out against the scientific consensus on climate change (as expressed in the various reports from the Intergovernmental Panel on Climate Change). One such scientist is Richard Lindzen, an atmospheric scientist with the Massachusetts Institute of Technology, who is a specialist in upper atmospheric dynamics (among other subjects, none of them directly related to climate change). Lindzen conducts a busy schedule of speaking engagements questioning the IPCC consensus reports, including one in 2006 at Plymouth State University. (I had dinner with him the evening after his talk.) Lindzen refers to the IPCC consensus reports as "alarmist."

The second component of the carbon industry's "scientific" strategy is to fund institutes that directly employ scientists, authors, and speakers. One such organization is The Heartland Institute, which has published books decrying AGW as "climatism" (which they define as a form of "alarmism"), sponsored annual conferences that bring together professional deniers from the United States, Canada, and Europe (the 2014 conference was held in Las Vegas – I received an invitation), and carried out advertising campaigns (such as billboards) that deliver the same message to the wider public. One of their books is called "The Mad, Mad, Mad World of Climatism" (Goreham, 2012). In the fall of 2012, everyone in Plymouth State University's Department of Atmospheric Science and Chemistry received a mailing from Heartland, offering them a free copy of Gorham's book. I received this postcard, and promptly threw it away. (I'm not interested in reading propaganda.) Nonetheless, about a month later, I received my free copy of the text, as did everyone else in the department. I've since learned that the same sequence of events occurred as several other atmospheric science, meteorology, climate, and earth

sciences departments around the country. This is obviously a very expensive undertaking, indicating the generous availability of funds. Offers of *free* books from publishers are a pretty rare event. Receiving a free copy of the book *after ignoring* such an offer is even rarer. The listed price of the book (on amazon.com) is about $61. If you multiply this by the number of people the book was given to, for free, you begin to understand the amount of money behind the project.

Fischer (2013) refers to the money funding these climate denial think tanks as "dark money." Fischer's article discusses a study conducted by Drexel University environmental sociologist Robert Brulle, who found that "[t]he largest, most-consistent money fueling the climate denial movement [is from] a number of well-funded conservative foundations" (Fischer, 2013). This funding came from 140 different foundations, who have used the tax-exempt status of the "non-profit" think tanks to disguise their identities. Brulle found that more than $550 million had been funneled to nearly 100 climate change denial organizations between 2003 and 2010 (Fischer, 2013). This has occurred as the "traceable money" (not hidden behind tax-exempt donor laws) has diminished. But, by carefully combining several databases, including information publicly available from the U.S. Internal Revenue Service, Brulle was able to learn that "[f]rom 2003 to 2007, Koch Affiliated Foundations and the ExxonMobil Foundation were 'heavily involved' in funding climate change denial efforts. But Exxon hasn't made a publically traceable contribution since 2008, and Koch's efforts [have] dramatically declined" (Fischer, 2013).

ExxonMobil Corporation is the world's largest oil company, and spent more than $30 billion in 2010 alone on oil exploration (ExxonMobil perspectives, 2011), so it obviously has a vested interest in maintaining an unregulated emissions market. Koch Industries is another multi-faceted, multinational corporation, with oil exploration, pipeline, and refining divisions. It is also one of the key promoters of the controversial Keystone-XL pipeline, which, if built, would transport "tar sands oil" from Alberta, Canada, to a refinery in Galveston, Texas. Tar sands extraction results in a very high level of carbon emissions – much higher than conventional petroleum – because of the amount of heavy machinery involved in mining the raw materials, and the amount of energy required to convert the raw "tar" (a very thick form of petroleum) derived from the bituminous sands to a form transportable via pipeline. James Hansen, the NASA scientist, has stated that, should the pipeline be built, the resulting carbon emissions would be so great that it would be "game over for the climate" (Hansen, 2012). It's obvious that, like ExxonMobil, Koch Industries also has a powerful economic interest in preventing (or at least delaying) any effective political action on greenhouse gas emissions.

The damage done. According the Centers for Disease Control, more than 480,000 deaths annually result from smoking (including second-hand smoke), which accounts for about one in every five deaths in the United States. The proximal causes of death include lung cancer, other forms of cancer (*e.g.* esophageal), heart disease, emphysema, diabetes, and many others. CDC classifies smoking as the leading cause of

preventable deaths in the country (CDC, 2014). To escape future criminal and civil liability for their culpability on causing these deaths, and for engaging in a 50-year campaign of lying about it to continue entrapping more people in tobacco addiction, the tobacco industry paid more $200 billion and agreed to stop engaging in criminal behavior (a promise that has not been entirely kept).

To complete the comparison of the tobacco and carbon industries, I include the following information about the current and predicted effects of anthropogenic climate change. What I hope to show by the following discourse is that the current and expected damage to Earth's environment, and human civilization, including its monetary economy, dwarfs by *several orders of magnitude* the damage caused by smoking. These paragraphs grew out of a conversation between myself and my friend Roy Morrison, who is an independent energy consultant. Roy asked the questions. I wrote the answers. In some cases I provide references for facts cited. In others I rely on my own expertise about the physics of Earth's atmosphere.

How could the weather change in the coming years if we continue on the current path? If we assume that human activity nudges the global climate system toward warmer temperatures without triggering any catastrophic shifts toward some other stable mode (such as a global ice age, similar to the Younger Dryas Event, or a global hot-house, similar to the Paleocene-Eocene Thermal Maximum, or PETM), then more heat will mean more evaporation and, therefore, more water vapor in the atmosphere. Since water vapor is a powerful greenhouse gas, this causes the warming to accelerate. The recondensation of all that vapor into liquid water also releases latent heat, which is the power source for tropical storms. More warming means more powerful hurricanes.

But it's much more complicated than that. Since the polar regions are heating up more quickly than the equatorial region, the *Polar Jet Stream,* which is driven by the temperature difference between the equator and the poles, will get weaker. The jet stream and the Polar Front, which is the boundary between polar and tropical airmasses near the surface of the Earth, are the driving force behind midlatitude storms, such as the big winter storms common in New England. Weakening the jet stream and the Polar Front could result in weaker winter storms, at least as we understand them.

Another consequence of warmer temperatures in the current climate is an extension northward and intensification of something called the *Subtropical Ridge*. This is an area of semi-permanent high pressure near 30 degrees north (and south) latitude, and is part of the Earth's large-scale atmospheric circulation. Warming up the atmosphere causes the Subtropical Ridge to get stronger and move farther away from the equator. That's been shown to be occurring. The center of the Subtropical Ridge has moved northward by about 250 miles from its previous position already.

Combine this with the weakening of the Polar Jet Stream and the Polar Front, and a possible consequence of climate change is that *convection* (smaller-scale vertical currents) becomes a more

dominant process. Thunderstorms, tornadoes, and showery precipitation would become more common during the traditionally cold times of year, when historically large-scale weather systems produced steady precipitation and flat clouds (call stratiform clouds).

What are the predictions for climate change by the year 2050 – 2070? If we continue on the current path of increasing carbon dioxide concentrations in the atmosphere, we'll probably see by 2050-2070 a global temperature increase in the neighborhood of 5 degrees Fahrenheit (3 degrees Celsius) (IRIN, 2012). This exceeds the 2-degree Celsius increase considered to be maximally tolerable, resulting in a sea-level rise ranging between 9 inches to two feet. Such a temperature rise will be disastrous for biodiversity. We are likely to lose 40-50% of the world's plant and animal species. This loss of biodiversity is discussed in a report by Nicholas Stern, who has worked for the British government and the World Bank (Guardian, 2006). Note that Nicholas Stern's report also predicts that climate change could result in the creation of more than 200 million environmental refugees.

The climate models indicate that there will be entirely new climate for five billion people, more than half the people on Earth. Climate in today's major breadbaskets will shift. Lester Brown's WorldWatch Institute (see www.worldwatch.org) reports that, for every one degree of warming beyond some critical point, there's a 10 percent *decrease* in plant productivity, so the food crops that we try to grow in the current breadbasket regions will see significant decreases in yield. It will be hotter and dryer for the most part, with more frequent extreme heat waves and droughts, and more frequent extreme precipitation events. Once unleashed, changes of this magnitude are both long lasting and probably irreversible by human actions on any time-scale that matters to us. Carbon dioxide, the greenhouse gas that's driving this change, has a residence time in the atmosphere of thousands of years. So any changes we initiate are likely to stay in place for a very long time.

What are the predictions for climate change in 2100? This is grim if we keep polluting. A recent paper by some Australian researchers indicates that we can expect by 2100 CE about 4 degrees C of warming (around 7 degree F), with a resulting sea level rise of two or three meters (about 6-10 feet) (Guardian, 2013). This will inundate the coastal environment. Winter storms whipping up waves will easily top existing seawalls. Most of the world's major cities are on the coast or nearby. Places like Miami and Washington and New York will be under water, or severely threatened on a regular basis.

What will be the effects on the world's grain producing regions? Cereal grains are based on four or five wild grasses, such as wheat, rice, and maize (corn). The major food producing areas of U.S., China, and Russia (in the zone between 40 and 50 degrees north latitude), where we cultivate the domesticated forms of these grasses, are increasingly susceptible to drought. These droughts, which have become more

common in the last decade, are caused by the northward movement and intensification of the Subtropical Ridge (noted above), and another form of persistent high pressure ridge called an *Omega Block*. These high pressure ridges create stable, hot and dry weather conditions. Precipitation that *does* occur often occurs in extreme events, which can create flooding and severe soil erosion (which is already a problem in the American Midwest). In 2012 and 2013, the expansion and intensification of the Subtropical Ridge brought heat and drought to western and central U.S., and to the Ukraine and Kazakhstan, and along with an Omega Block over south central Asia, brought epic floods to Pakistan.

There is already only a small amount of reserve wheat. The United Nations Food and Agricultural Organization indicated that the 2012 global reserve food supply was just 75 days, the lowest since 1974 (Lacey, 2012). And in six out of the last 11 years the world consumed more than it produced. So we're creating a situation of growing food insecurity. Climate change makes this even more insecure, because of the way it impacts food production.

Political systems, like climate systems, are non-linear. Climate-related food shortages can quickly lead to political instability, such as we saw in Egypt. The Arab spring uprisings were preceded by drought in North Africa that sharply increased the price of wheat.

What is the likely scenario *if* we keep pouring billions of tons of carbon dioxide into the atmosphere? Several dynamics of the climate system are linked together and reinforce one another. Pushing just one of these dynamics in the wrong direction is bad. Push several of them in the wrong direction, and the future of our civilization is under grave threat. Here's an example of an unhappy chain of events we could be setting into motion by failing to reduce the amount of carbon dioxide we add to the atmosphere.

First, the warming polar regions see melting ice that will inexorably raise sea-levels and threaten much of the global population that lives near the coast with floods, not just from normal weather events, but from great storms crashing over sea walls and dikes. We can conservatively project an average sea level increase of six feet by 2100 CE if we do not change our ways. And this is not a worst case scenario. A six foot increase in mean sea level will not just flood island nations and low lying areas such as Florida and Bangladesh but threaten coastal areas globally. Hurricane Sandy, a supercharged hybrid tropical-midlatitude storm that did something upward of 70 billion dollars in damage, was a small taste of things to come if we continue on this path.

Second, warming doesn't just melt ice, it also melts permafrost and methane hydrates (under the Arctic Ocean seafloor) formed by rotting ancient vegetation, potentially freeing huge amounts of methane. This is a positive feedback that will dramatically enhance climate change. Third, melting ice also decreases the Earth's albedo. Ice reflects a lot of sunlight, but bare ground and open ocean are heat sinks. This will further accelerate melting of permafrost and methane hydrates, resulting in more temperature increase. This is another positive feedback.

Fourth, the warming atmosphere intensifies and shifts the global Subtropical Ridge poleward, toward the population and food production centers particularly of the Northern Hemisphere. This is a drought mechanism that creates calm, hot, dry conditions, and is responsible for the great deserts like the Sahara and the Gobi at 30 degrees north latitude, as well as the Australian desert in the southern hemisphere. Climate change causes it to intensify and shift poleward into the temperate zone, and threaten some of the world's grain producing regions in the middle latitudes of the United States, Russia, Ukraine, and China. The Subtropical Ridge is already 250 miles farther north than in the last century. And drought conditions are already threatening to become the new normal in the U.S. from Texas to the Dakotas. Australians have already *defined* this as their new normal.

Fifth, warming in the polar regions, as we've seen this winter, can weaken the isolation of the Polar Vortex (which, like the Subtropical Ridge, is part of the Earth's large-scale, general circulation), and allow intense cold outbreaks to sweep southward in some places, while temperature increases greatly in others, as it did in Europe and Russia during the winter of 2013-2014. In other words, the extreme cold outbreaks we saw in January of 2014 are entirely consistent with "global warming." The consistency with global warming becomes even clearer when you look at the temperature on a global scale, and not just on a continental scale.

Sixth, adding huge amounts of fresh water melt from melting glaciers in Greenland to the high-latitude Atlantic ocean could weaken or shut down the global ocean conveyor belt, where cold and dense salty ocean water sinks and is replaced by warmer lighter ocean water from the Gulf Stream. For the past 11,000 years, this circulation has resulted in much warmer temperatures in high-latitude Europe. If this shuts down, the entire world could be cast into an artificially-induced rerun of the Younger Dryas Event – a mini ice-age. This would shut off food production in the middle latitudes just as effectively as a super heat wave and drought. With the world food reserves already down to 2 ½ months, any interruption of food production is *another* disaster in the making. The U.S. Department of Defense published a white paper on this possibility in 2004 (NASA, 2004), because of its grave implications for national security, and called it a "low-probability, high-consequence event."

That last scenario is looking less likely. It turns out that the amount of meltwater being added to the North Atlantic is at least an order of magnitude too small to trigger shutdown of the conveyor belt. Some recent measurements by the Jet Propulsion Laboratory, using radar altimetry from a satellite, indicate a lot of short-term fluctuations in the flow of the conveyor belt, but no long-term slowdowns (Black, 2010). So it seems that some kind of a thermal maximum scenario, like the PETM, is more likely than a rerun of the Younger Dryas Event.

In conclusion. The costs of uncontrolled climate change are incalculable. A runaway greenhouse as I've described above, fueled by unchecked emissions of GHGs, would result in severe damage (perhaps fatal)

to the world economy, massive species and ecosystem losses, human misery on a scale unseen in written history, the possible collapse of our civilization as we've understood it for the last several thousand years, and perhaps, the extinction or near-extinction of our species. I can say these things without exaggeration, and I am not alone in doing so. James Lovelock, one of the co-founders of the Gaia Hypothesis, wrote in his 2007 book *The Revenge of Gaia* that he expected the human race to be reduced to a few million individuals, huddled around the northern extremes of the continents surrounding the Arctic Ocean, by the year 2100 CE (Lovelock, 2007). His assertions are well supported by other scientists working in many other fields.

Just as the tobacco industry was eventually forced to pay billions in damages to atone for its 50-year crime spree, involving the sale of a product known to kill its user when correctly used – and a massive campaign of lies to prevent or delay actions to rein it in, it is my hope that the carbon industry will one day be called to account. The damage caused by the inevitable byproduct of burning fossil fuels affects not only the users, but everyone else on the planet as well. In this way, it is something like second-hand smoke, in that one doesn't have to directly consume the poisonous material to be poisoned by it. Big Carbon has conducted a sustained campaign of climate change denial, including hiring willing scientists ready to cash in on their reputations, and creating a complex of "think tanks" to spread misinformation, disguised as "scientific skepticism." The effect of this successful effort has been to delay *for decades* legally-enforceable, effective action to control carbon emissions. With each passing year, carbon emissions continue to increase, making the actions needed to avoid catastrophic climate change more and more extreme and expensive. When the bill comes due to pay for adaptation and mitigation, I know who should pay it.

References:

Black, R., 2010: Gulf Stream 'is not slowing down,' *BBC News*. [Accessed on-line 15 September 2014: http://news.bbc.co.uk/2/hi/8589512.stm]

Centers for Disease Control, 2014: Tobacco-related mortality. [Accessed on-line 16 November 2014: http://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/]

Estes, J., 2014: How the tobacco deal went bad, *New York Times*. [Accessed on-line 15 November 2014: http://www.nytimes.com/2014/10/07/opinion/how-the-big-tobacco-deal-went-bad.html?_r=0]
Fischer, D., 2013: "Dark money" funds climate change denial effort, *Scientific American*. [Accessed on-line 13 October 2014: http://www.scientificamerican.com/article/dark-money-funds-climate-change-denial-effort/]

ExxonMobil perspectives, 2011: Gas prices and industry earnings – a few things to think about the next time you fill up. [Accessed on-line 16 November 2014: http://www.exxonmobilperspectives.com/2011/04/27/gas-prices-and-industry-earnings-a-few-things-to-think-about/]

Goreham, S., 2012: The Mad, Mad, Mad World of Climatism, Atlas Books, 312 pgs. This book is available from amazon.com.

Guardian, 2006: Stern report – the key points, *The Guardian*. [Accessed on-line 15 September 2014: http://www.theguardian.com/politics/2006/oct/30/economy.uk]

Guardian, 2013: Planet likely to warm by 4C by 2100, scientists warn, *The Guardian*. [Accessed on-line 15 September 2014: http://www.theguardian.com/environment/2013/dec/31/planet-will-warm-4c-2100-climate]

Hansen, J., 2009: Storms of my grandchildren, Bloomsbury Press USA, 304 pgs.

Hansen, J., 2012: Game over for the climate, *New York Times*. [Accessed on-line 10 November 2014: http://www.nytimes.com/2012/05/10/opinion/game-over-for-the-climate.html]

IRIN, 2012: Climate change – a three-degree warmer world by 2050? United Nations Office for the Coordination of Humanitarian Affairs. [Accessed on-line 01 October 2014: http://www.irinnews.org/report/95182/climate-change-a-three-degree-warmer-world-by-2050]

Keisler, P. , Eubanks, S., Brody, S., Brooker, R., Marine, F., Clark, C., Gluck, M., Henry, D., Kinner, R., Burrell, M., Crane-Hirsch, D., Crocker, E., Gette, J., Goldfarb, A., Greif, M., Hahn, C., Kelley, S., Klein, P, Klontz, D., Kurtin, N., Laeser, J., Madison, S., McCabe, B., McMahon, L., Moltzen, M, Mosesso, S., Nelson, J., Schwartz, J., Schwind, G., Sealls, K., Spiegel, B., Steinberg, A., Strichartz, I., Taylor, J., Williams, R., and Wong, B., 2004: Executive Summary – United States Final Proposed Finding of Fact (Redacted), United States v. Philip Morris, United States District Court – District of Columbia. [Accessed on-line 01 November 2014: http://www.library.ucsf.edu/sites/all/files/ucsf_assets/uspm2.pdf]

Koonin, S., 2014: Climate science is not settled, *Wall Street Journal*. [Accessed on-line 5 November 2014: http://online.wsj.com/articles/climate-science-is-not-settled-1411143565]

Lacey, S., 2012: October 15 news – world grain reserves 'at a very low level leaving no room' for extreme weather, warns UN, *Climate Progress*. [Accessed on-line 15 September 2014: http://thinkprogress.org/climate/2012/10/15/1010821/october-15-news-world-grain-reserves-at-a-very-low-level-leaving-no-room-for-extreme-weather-warns-un/]

Lovelock, J., 2007: The revenge of Gaia – Earth's climate crisis and the fate of humanity, Basic Books, 208 pgs.

National Aeronautics and Space Administration (NASA), 2004: A chilling possibility. [Accessed on-line 15 September 2014: http://science1.nasa.gov/science-news/science-at-nasa/2004/05mar_arctic/]

Revkin, A., 2009: Industry ignored its scientists on climate, *New York Times*. [Accessed on-line 20 October 2014: http://www.nytimes.com/2009/04/24/science/earth/24deny.html?pagewanted=all&_r=0]

Saad, L., 2013: American's concerned about global warming on the rise, *Gallup*. [Accessed on-line 16 November 2014: http://www.gallup.com/poll/161645/americans-concerns-global-warming-rise.aspx]