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Review

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Abstract

Anthropogenic global climate change (AGC) is proceeding rapidly. The proximate cause is the greenhouse effect of carbon dioxide, methane and other greenhouse gases (GHG), which have rapidly accumulated in the atmosphere from burning fossil fuels and other human activities. Measurements of incoming and outgoing radiation have verified the warming imbalance. Effects manifest themselves in accelerating sea level rise and diminishment of the cryosphere. This has already created climatic refugees and water stress, and will destroy coastal infrastructure. It also impacts ecosystems and biodiversity in many ways. To avoid catastrophic effects, fossil fuel use must cease and carbon sinks must be protected and expanded. While voluminous scientific evidence supports the need for action, the U.S.A. has not acted. A survey of manifestos of geographically diverse conservative national parties in nine industrialized democracies (US, Canada, UK, Spain, Norway, Sweden, Germany, Australia, New Zealand; Båstrand 2015) shows that eight see this as an urgent problem to be solved; the exception being the U.S. Republican Party. I explore reasons for this anomaly.

Are Humans Changing Our Climate?

Major scientific societies certainly think that humans are changing the Earth's climate, e.g., the American Association for Advancement of Science (2013), which did a very thorough assessment of the problem that cited "overwhelming evidence" for AGC. Many other organizations, including the American Meteorological Society (2008), the American Geophysical Union (2012) and the Geological Society of London (2010) have affirmed their support for this position with similar statements. Many individual scientists have published their support for the idea, too, e.g., Flannery (2005), Doran and Zimmerman (2009) and Salinger (2005). Oreskes (2004) and Cook et al. (2013) surveyed publications on the subject and found a consensus that was especially strong among those doing climatology research.

Some excellent references on the subject include Hay (2016), a paleoclimatologist and geologist, and Houghton (2015), who has lead the Intergovernmental Panel on Climate Change (IPCC); both excellent summaries of our knowledge of this subject. There are many disciplines involved in this subject that also cover these issues. The latest IPCC findings (IPCC WG I 2013; IPCC WG II 2014a, 2014b; IPCC WG III 2014) offer a thorough explanation and evaluation of the physical basis of climate change, ongoing and possible future impacts and possible adaptation strategies. A good reference on atmospheric physics is Barry and Chorley (1998).

The Greenhouse Effect and Global Warming

Simply put, the atmosphere passes a considerable percentage of solar short wave (SW) radiation, which is absorbed by the Earth, and the planet then radiates the energy back into space as long wave (LW) radiation. Greenhouse gases (GHG) in the atmosphere, however, block some of the outgoing LW radiation, raising the Earth's temperature to reach equilibrium (Barry and Chorley 1998, Crowley and North 1991, Ledley et al. 1999, Leviticus et al. 2001, Ramanathan and Carmichael 2008, Ramanathan and Feng 2009, Raval and Ramanathan 1989). This effect is responsible for the Earth's temperature being higher than it would be if it had no atmosphere. CO_2 is a major GHG and atmospheric concentrations have paralleled global temperatures for at least 600 kyr (Houghton 2015, IPCC WG I 2013, Royer et al. 2004). In fact, CO_2 is the principal GHG, stabilizing Earth's climate (Lacis et al. 2010, Royer et al. 2004).

The Earth Radiation Budget Experiment (ERBE) and many other studies have measured the imbalance between SW and LW radiation leading to warming (Hansen et al. 2005, Huber and Knutti 2012, Ramanathan et al. 1989, Trenberth et al. 2009). Although uncertainties in measurements exist, there is no doubt more radiation comes in than leaves, creating ongoing warming of the planet. The global temperature records confirm this, showing a trend of increasing temperatures (with many excursions created by complexity of the system) since at least the late 19th century (NOAA 2016).

There is no doubt that CO_2, methane and other GHG concentrations have been rising since the industrial revolution began, that temperatures have also been rising and that much of the excess CO_2 comes from burning fossil fuels (Hay 2016, Houghton 2015, IPCC WG I 2013). The greenhouse effect has been understood since the 19th century and as early as the 1960s scientists understood that continued CO_2 buildup could have dire consequences (Weart 2015). Ignorant people have blamed volcanoes for the rise in atmospheric CO_2, but Gerlach (2011) has estimated that on an annual basis human sources emit 135 times as much CO_2 as volcanic activity. Solar activity does influence climate (Haigh 1996; e.g., the Little Ice Age, a period of low solar activity, Eddy 1976), but does not account for current global temperature trends (Duffy et al. 2009, Meehl et al. 2003, 2004).

Orbital variation governs the Earth's natural climate cycles of glacial periods interrupted by interglacials, the Milankovitch (1941) cycles (Hays et al. 1976, Weart 2015). At present we are in an interglacial period but we were transitioning into a glacial period as evidenced by over a thousand years of gradual cooling abruptly reversed by the industrial revolution increasing GHG concentrations (Kaufman et al. 2009). So our intervention has prevented a highly undesirable (from our point of view) glacial period. Our intervention, however, inadvertently creates a "hot house climate" that could damage human civilization as much or more than the glacial period we avoided. If we had the wisdom, we might have been able to prolong the present interglacial without melting the ice caps. The present orbital configuration creates cooling. If it were not for that, we would be warming even faster than we are now.

The year 2014 was the warmest since 1880 and 2015 was even warmer (NOAA 2016). Since little American effort has been made to eliminate emissions from fossil fuel utilization, in large part because of political and corporate obstruction (Bradley 2011; Mooney 2005, Oreskes and Conway 2010), it forces us to examine the evidence for climate change and the consequences of our inaction. Climate change is already underway and we have already begun to incur the consequences of our inaction, but much worse will occur in the future from the ongoing changes.

Table 1. Indicators of climate change due to human alteration of the atmosphere and the attendant environmental changes and the probability of changes greater than normal variability.

Indicator	**Probability**
Greenland ice loss	High
Antarctic ice loss	High
Loss of permanent Arctic sea ice	Very high
Loss of mountain glaciers	Very high
Decreasing snow cover	High
Ocean acidification	Certain
Longer fire season in U.S.	Very high
Animal migrations	Very high
Plant migrations	Very high
Changes in seasonal timing of plant and animal events (e.g., bud break, breeding, insect hatch)	Very high
Increased pest problems (e.g., bark beetles, invasive species)	Very high
Increased human conflict	Moderate
Refugees, esp. from low-lying islands	Certain
Drought, heat waves, floods	Moderate
Increased violent weather	?

Evidence Climate Change is Underway

Some of the most telling evidence for global warming comes from the cryosphere, sometimes called the air conditioner of the planet. The huge Greenland and Antarctic ice sheets hold a very large percentage of all the fresh water on Earth. The Greenland ice sheet loses more than 150 km^3/yr of ice (Dowdeswell 2006, Zwally et al. 2002), and the Antarctic ice sheet a similar amount (Velicogna 2009, Velicogna and Wahr 2006a, 2006b). Loss of the Greenland ice cap could raise sea levels by 7m and loss of the Antarctic ice more than 50m (Miller 2014). At present only the West Antarctic ice sheet is melting rapidly (Joughin et al. 2014), but the East Antarctic ice sheet may also be vulnerable (Cook et al. 2013a, Miller 2014). This, along with thermal expansion of the oceans as the planet warms, contributes to sea level rise. The loss of ice is accelerating, so it progresses nonlinearly (IPCC WG I 2013).

Scientists have consistently underestimated the rate of loss of Arctic sea ice (Johannessen et al. 1999, Levi 2000), which primarily affects the Greenland ice cap, and there is reason to believe that estimates of loss of ice from the ice caps may be greatly underestimated (Holland and Holland 2015). If that is the case, sea level rise in the near future could possibly be measured in meters, not centimeters. Sea level rise is an immediate threat along our coasts. Low lying cities such as Miami, Florida and Norfolk, Virginia are particularly vulnerable. Some neighborhoods in Norfolk flood every high tide (Kramer 2016).

Climate warming creates even greater climate warming through positive feedback. A good example of this is melting of Arctic ice that has a very high albedo, i.e., it reflects much of the sunlight falling on it back into space. Part of the enhanced melting occurs when the albedo is reduced by human atmospheric pollution, especially black carbon particulates emitted by power plants and diesel engines that fall on ice and snow, reduce the albedo, and increase melting of the snow and ice (Ramanathan and Carmichael 2008, Flanner 2009). Melting of high albedo ice and snow may expose much lower albedo water and tundra, which in turn increases absorption of solar radiation, leading to more warming and more melting.

In addition, various reservoirs of CO_2 storage may be destabilized, e.g., carbon stored in permafrost and frozen peat (Zimov et al. 2006) and methane hydrates on the seafloor, further accelerating global warming. The logical expectation would be that rising atmospheric CO_2 would lead to increased sequestration in terrestrial (e.g., forests) and marine sinks (e.g., coral reefs). This may not be the case, however, for example when increased CO_2 actually reduces carbon stored in soils (Heath et al. 2005). Other human actions, such as clearing of forests and destruction of coral reefs by pollution and warming water, also reduce the ability of sinks to respond to the overabundance of CO_2.

Of more immediate importance to humanity, most mountain glaciers are losing mass (Hall et al. 1992, Oerlemans 2005), and this exceeds past natural variability (Reichert and Bengtsson 2002). As an example, of an estimated mid-19th century 150 glaciers present in Glacier National Park, currently the park retains only 25, and they shrink every year (Pederson et al. 2004). This runoff from mountain glaciers changes seasonal distribution of water availability and it raises sea level, of course.

Additional evidence for climate change comes from minimum and maximum temperature trends. Minimum temperatures have increased more than maximum temperatures, reducing the diurnal range (Braganza et al. 2004, Easterling et al. 1997, Karl et al. 1993, Meehl et al. 2009). This is exactly what we would expect to happen if GHG are reducing LW radiation of energy into space.

Consequences

The IPCC (IPCC WG II 2014a, 2014b) and others (Hassol 2004, Strauss et al. 2016, Woodworth et al. 1992) have detailed the impacts of climate change. Sea level rise is already creating climate refugees as low lying islands experience flooding and salt water intrusion in their water supply. As an example close to home, some Florida mayors asked the Republican presidential candidates to address the issue of climate change (they refused) because the mayors recognize that Florida is extremely vulnerable to sea level rise. As ice cap melting accelerates, sea level rise is accelerating. If we do not stop the loss of glacial ice, and no one knows how to do that except by halting the rise of CO_2, eventually we will lose enormous amounts of coastal infrastructure. The cost of inaction has been quantified by Strauss et al. (2016). Coastal flooding will eventually displace millions, probably billions, of people (e.g., Rowley et al. 2007).

Rising atmospheric CO_2 levels create potentially disastrous changes in oceanic chemistry and ecosystems (Barnett et al. 2001, Caldiera and Wickett 2003, Feely et al. 2009). As CO_2 dissolves in sea water, it increases acidity and decreasing pH lowers the saturation state for carbonate minerals. This means that many marine species that form carbonate shells and skeletons, such as corals and foraminifera will be stressed or even destroyed (Zeebe et al. 2008). Such organisms form an important sink for CO_2 sequestration and their destruction or damage may be a positive feedback that increases atmospheric CO_2 levels.

The diminishing glacial runoff from mountain glaciers and snowpacks maintains streamflow and provides water for human and industrial consumption, irrigation and hydroelectricity in many regions, potentially affecting up to two billion people (Bradley et al. 2006, Hall et al. 1992, Mankin et al. 2015). Loss of the storage in mountain glaciers creates a strain on the societies that depend on them and may increase the number of climate refugees (Barnett et al. 2005). Recycling water might alleviate some of these stresses, but that requires technology and resources not universally available.

Heat waves have become a major factor in many places. A three-month European heat wave in 2003 caused at least 35,000 deaths (estimates go as high as 70,000) and a central Russian heat wave in 2010 may have caused 55,000 deaths (Houghton 2015). A famous 1995 heat wave caused hundreds of deaths in Chicago.

The place where heat waves will hit hardest, however, is in the tropics where heat stress is a daily occurrence.

A logical consequence of increased temperature is increased aridity in some places, e.g., the western US (Cook et al. 2004). Westerling et al. (2006) show that climate change in the western US has also resulted in longer fire seasons and more damaging wild fires.

Climate models have less reliability predicting specific regions that will be affected than global changes, but it is possible to make some reliable general predictions. The Hadley cells will expand and the jet streams and storm tracks will shift poleward (Yin 2005, Seidel and Randel 2007, Archer and Caldeira 2008). As the zones shift, the world's great desert areas will probably expand into subtropical areas.

As always, there will be winners and losers (Committee on Ecological Impacts of Climate Change 2008). Agriculture may become possible in areas that experience increased rainfall or warmth. For example, the Canadian prairies will have a longer growing season. Warmer winters at high latitudes may have some benefits such as reduced heating costs. On the other hand, native northern cultures often rely on sea ice for subsistence and build on permafrost, both disappearing as climate warms. The loss of Arctic coastal sea ice is creating accelerated shore erosion, requiring relocation of whole villages.

Regional climate will change, requiring adaptation of agriculture (Rosenzweig et al. 2000). Wise resource managers are already planning for the effects of climate change, regardless of what politicians say, e.g., Iverson et al. (1999). If rainfall decreases or fails to increase enough to compensate for increased evaporation, there must be increased reliance on irrigation. If surface water supply decreases, the deficit will have to be made up from groundwater or adoption of new water management techniques. Unfortunately, many aquifers are being depleted by withdrawals in excess of recharge in the face of diminishing surface water supplies, e.g., Borsa et al. (2014).

Climate remains an abstraction to many, but weather affects us all noticeably. Based on atmospheric physics, increased energy of a warmer Earth could easily make wilder, more energetic weather (Barry and Chorley 1998, Emanuel 2005, Knutson 1998, Webster 2005). For example, 2013 Typhoon Haiyan rendered more than two million people homeless and killed at least 6,000 in the Philippines and may have been the strongest cyclone to ever make landfall (Houghton 2015). Attributing extreme weather and other physical and biological anomalies to climate change (Rosenzweig et al. 2008), such as the "1,000-year" floods in South Carolina in 2015 (Wikipedia 2015) presents difficulties. The Committee on Extreme Weather Events and Climate Change (2016), however, reports rapid progress in the attribution of extreme weather events to climate change.

What is certain is that there will be great changes in ecosystems and a steep price to pay (Committee on Ecological Impacts of Climate Change 2008, Cowie 2007, Flannery 2005, King et al. 2006). There have been studies showing that the ranges of plants and animals will change, in some cases drastically (e.g., Field et al. 2006, Iverson et al. 1999, Matthews et al. 2004, Bradshaw and Holzapfel 2006). Animals are sometimes appearing in places they were unknown in the past (e.g., Field et al. 2006). Butterfly populations have shifted northward in response to climate warming and plants are showing phenological changes (such as breaking dormancy or flowering earlier than they have historically (e.g., Primack and Gallinat 2016). Plant ranges are changing dramatically, e.g., forests invading the southern edges of Arctic tundra.

Some of the worst consequences will be felt by plant and animal populations on isolated mountain peaks ("islands in the sky"). If bioclimatic zones shift too much vertically, such populations face certain extinction because they cannot migrate. Even many animal and plant populations that have apparently shifted easily in the past may be trapped by the human infrastructure (e.g., the interstate highway system) that impedes movement of land bound animals. Oceanic ecosystems are not immune to climate change either. Major changes associated with climate warming have occurred in the northern Bering Sea, for example (Grebmeier et al. 2006). Again, there will be winners and losers. The polar bear and many other species may become extinct, but history tells us that at least a few species will expand their populations and ranges.

At present we may be undergoing a mass extinction event (MacLeod 2013), and it does not help that the United States is the only major nation that has never participated in the Convention on Biological Diversity that has been signed by 193 other countries (Milius 2010). The current rapidity of climate change is a factor. Species that had 10,000 years to adjust to climate change in the past may have only 100 or ten years now. Humans can assist in the process of adaptation, but there is little indication of the will and certainly a lack of the necessary knowledge and resources to accomplish this task. The evidence is conflicting, but the combination of climate change and exploding human population that destroys habitat may lead to a mass extinction on the order of the one that occurred in the late Permian or at the K-T boundary (MacLeod 2013, Kolbert 2014). Avoiding current lesser extinctions has proven impossible (Bradshaw and Holzapfel 2006).

Of course, the damage to ecosystems will probably reduce the ability of the Earth to sustain life, reducing net productivity, at least temporarily. Humans will not escape the consequences of this ecological disaster because we depend on ecosystem services estimated to be at least equivalent in value to the world economy's gross domestic product (Costanza et al. 1997). Current difficulties with the pollinators like honey bees (e.g., colony collapse disorder) that are absolutely essential to much of our crop production may be a prelude to much greater difficulties in the future.

When consequences of climate change begin to impact our security, you would expect the government to take note. In fact, the military is well aware of the destabilizing effects of climate change, including conflict over resources made scarcer and large refugee populations created by, e.g., coastal inundation, continual crop failures and natural disasters (CNA Corporation 2007). The Military Advisory Board, composed of general officers from the armed forces, perceives serious threats to our national security and recommends action to minimize climate change and mitigate the effects that are certain to occur (CNA Corporation 2007). A synthesis of studies on climate and human conflict found broad agreement that "Deviations from normal precipitation and mild temperatures systematically increase the risk of conflict, often substantially" (Hsiang et al. 2013).

The effects of climate change may bear most heavily on the poorest, who live in poverty in places where governments may lack the resources and competence to deal with the problems, especially effects of climate change on health, e.g., the spread of pathogens and vectors to new areas (Patz et al. 2005). Typically, these impoverished societies contribute much less to global warming than the more developed countries, which raises a question of fundamental fairness (Huntingford and Gash 2005).

Mitigation and Adaptation

Mitigation reduces the effects of climate change, primarily by decreasing emissions of GHG and maintaining or improving sinks that sequester CO_2. (IPCC WG III 2014). The primary action to effectively mitigate climate change clearly must be the rapid elimination of fossil fuels, the only practical way to stop the rise of CO_2 in the atmosphere. There are many nonpolluting sources of energy available: nuclear (fission and fusion), hydropower, solar, wind, geothermal, wave, tidal and ocean thermal. Biofuels can be used for applications such as aviation that require high density fuel. All energy sources have potential drawbacks, e.g., solar and wind require some form of storage for periods when the sun doesn't shine or the wind does not blow, hydropower can be reduced by extended drought, etc. Clearly, considering the potential consequences of climate change, the future will challenge humanity in incredibly stressful ways (Ramanathan and Feng 2008).

Atmospheric CO_2 has recently increased past the 400 ppm concentration and there has long been a consensus that anything more than 350ppm is dangerous and even 350 ppm may be too much (IPCC WG I 2013). It would be highly desirable, therefore, to find a way of removing CO_2 from the atmosphere and there has been some work done (Kramer 2008, Orr 2009, Schrag 2009), but little has been accomplished, unfortunately.

The Committee on Geoengineering Climate (2015a) reported that currently the most practical approach uses vegetation, e.g., reducing deforestation and promoting afforestation to remove CO_2 from the atmosphere (Kintisch 2009). Artificial approaches need intensive research to determine their practicality and explore different approaches to the problem. The committee also briefly compared the carbon sequestration approach to albedo modification, i.e., ways of reflecting sunlight to cool the Earth in this report. The committee emphasized, however, that elimination of CO_2 emissions must remain the highest priority, since that will almost certainly be the most practical and cost effective way of limiting climate change.

The Committee on Geoengineering Climate (2015b) also considered albedo modification as the primary focus in another report. Reflecting some incoming sunlight to cool the Earth, perhaps by introducing aerosols into the stratosphere, imitating volcanic eruptions such as Tambora in 1815 (Harington 1992, Stothers 1984), would be one approach. The committee concluded that albedo modification has considerable potential benefits, but also poses great risks of unintended consequences and needs extensive research into multiple possible approaches before deployment can be considered. The potential for creating problems that may be a feature of geoengineering should be examined thoroughly before implementation (Levi 2008, Shepherd et al. 2007). The

Committee on Geoengineering Climate (2015b) reiterated the need for eliminating emissions as the best current approach to solving the overall problem of climate change and limiting the damage incurred.

It must be emphasized that both mitigation and adaptation are needed to cope with the problem of climate change. The changes would continue and increase in the future, even if we were able to stop increasing the amount of atmospheric CO_2 immediately because the Earth system exhibits inertia (Houghton 2015, IPCC WG I 2013). For example, the ice caps will continue to melt until some new equilibrium is reached, which means that sea levels will continue to rise for the foreseeable future. Adaptation, therefore, is absolutely necessary. Human societies must increase their resilience to the changes and disasters that climate change brings. Without mitigation, however, adaptation is a futile attempt to adjust to a constantly worsening situation. In the worst case scenario, where the ice caps and mountain glaciers melt almost completely (raising sea levels more than 60m), the planet will not support even the present, let alone the projected population, billions would die and much of the infrastructure that our civilization has built and many of the resources we depend on would simply vanish under water.

Reasons for Delayed Action?

The effects of climate change have the potential to disrupt human civilization to a great degree. Given that scientists have actually had a good appreciation of the consequences of experimenting with our atmosphere in this manner since at least the 1960s (Weart 2015), why has there been little action to avert the worst consequences? This is a particularly relevant question since the required changes could have been phased in over a lengthy period and would have been much less disruptive than they will be, even if effective. On the other hand, technology has advanced remarkably in the last decade or two, e.g., innovations in solar and wind power. It is by no means certain that such advances were possible four or five decades ago without dedicating very large research efforts in those areas. This was unlikely, given that policy makers saw no cause for efforts to solve the problem at that time, although much could have been done to enhance efficiency that would have benefited the economy, no matter what transpired.

Unfortunately, as any psychologist will tell you, human rationality is a sometimes and fragile thing. Most people believe what they want to believe without regard to established scientific facts (McNall 2011, Washington and Cook 2011), a perfect example being belief that the Earth is only a few thousand years old, supposedly based on the Christian Bible, instead of the actual well established age of the Earth being some 4.5 billion years.

Gifford (2011) and Hulme (2009) have explored the reasons that people resist the need for mitigation and adaptation to climate change. One of the broad categories Gifford (2011) found included limited cognition. Limited cognition includes ignorance, judgmental discounting, optimism bias and uncertainty. There are many dimensions of ignorance and even people who know the most about the problem may not know how to solve it on a personal or institutional level. Judgmental discounting "... refers to the undervaluing of distant or future risks" (Gifford 2011, p. 292). This undervaluing of the future certainly applies to societies that see an environmental problem that threatens future wellbeing but cannot summon the resolve to take action to solve it (Diamond 2005), as well as to individuals.

Ideologies can provide powerful motivations both for and against climate action. The reliance on suprahuman powers (e.g., God or "Nature") to save us, the blind belief that technology will solve all our problems or belief in the existing system's ability to meet the challenge are some of the ideological deterrents to action on climate change (Gifford 2011, Hulme 2009). It should be noted that ideology can also be a force for action on climate change, e.g., the "Creation Care" movement which holds that people have a duty to limit climate change and protect biodiversity because it is a gift from God.

Gifford (2011) and Hulme (2009) see many other impediments to individual and collective action. Among them are behavioral momentum ("we've always done it this way"), financial investments of individuals and institutions (e.g., pension and mutual funds) and corporations (e.g., the fossil fuel industry), mistrust of groups or institutions (e.g., scientists, government agencies) and perceived risks of required changes. One of the psychological barriers is denial, the adamant refusal to believe facts. Those people and institutions who refuse to admit that climate change poses a potential threat to the planet and its inhabitants are clearly in denial.

There is an ethical dimension to the refusal to acknowledge the threat that climate change poses. Some people apparently anticipate that their great grandchildren or great, great grandchildren will have to cope with the first effects of climate change, pushing the problem far into the future and absolving them of any responsibility for taking action now. This is judgmental discounting (Gifford 2011). Many find that attitude to be morally reprehensible, even if it were true that the effects of climate change lie far in the future. As we have seen, however, that is definitely not true because we are experiencing the effects of climate change now and the effects will worsen.

Another aspect of the problem is that most people assume effects will be gradual, giving us abundant time to respond. They have experienced few of them or did not recognize them and probably do not pay attention to the amazingly rapid changes in the Arctic or other places (Hassol 2004). The assumption of gradual change, however, is definitely not valid (Alley et al. 2003, Clement et al. 2001). The potential for abrupt changes for which we are ill-prepared cannot be disregarded because such events do occur in the paleoclimatic record (Committee on Understanding and Monitoring Abrupt Climate Change and Its Impacts 2013).

Many people assume that conversion to a low/no carbon economy would be ruinous to the economy. In fact, detailed plans have been made and estimate that an 80% reduction in carbon emissions could be achieved by 2050, using less than 1% of our GDP (Williams et al. 2014). Enhancing efficiency across the board in housing and transportation, however, would pay economic dividends, even if climate change were not a serious threat.

Climate Change Denial

Climate scientists have reached a consensus that humans are changing the climate (Cook et al. 2013b; Oreskes 2004) and most scientists think that the changes will have a net detrimental effect on the planet in general and especially humanity. In view of the fact that without swift and decisive action we face possibly catastrophic changes, why have we not taken action? One answer is that the fossil fuel industry has taken a page from the tobacco industry playbook and funded efforts to obfuscate the facts, confuse the public and influence politicians (Oreskes and Conway 2010, Shulman 2008).

President Obama has accepted the facts presented by science and attempted to act on them through executive orders and the Environmental Protection Agency (EPA). Yet the Republican Party (labeled as "The Party of 'No'" by some commentators because of continual obstruction of federal operations, going so far as to shut down the government and threatening to default on the national debt) has resolutely refused to act, and, in fact, almost uniformly denies that the problem exists (Bradley 2011). Is this a universal characteristic of conservative parties globally?

A survey of the manifestos (in the US it is called a "platform") of conservative parties from nine geographically diverse modern industrial democracies (US, Canada, UK, Germany, Spain, Norway, Sweden, Australia, New Zealand) found that eight of the nine stated that anthropogenic climate change was a serious problem and needed urgent action to solve it, although they differed in their preferred approaches to solutions (Båtstrand 2015). The US Republican Party stands out in its refusal to accept the scientific consensus. This would be of little concern if the US played only a minor role in the world economy or if the US were not the largest per capita emitter of CO_2. Like it or not, our actions lead the world on this issue. What can explain this complete denial of reality by a US political party while other conservative parties accept the scientific consensus?

US conservatives have a long history of disregarding science when they perceive it to be in conflict with "conservative values" such as unregulated capitalism and anti-government individualism, as detailed in Bradley (2011), Mooney (2005), Oreskes and Conway (2010), Shulman (2008) and Washington and Cook (2011). Republicans tend to dismiss science as a liberal activity to be disregarded in favor of their ideological approach to the world as Mann (2012), Mooney (2005) and Shulman (2008) have shown. Unfortunately, Republican ideology favors "magical thinking" that disregards facts and established science (Mooney 2005, Shulman 2008, Washington and Cook 2011), e.g., the rationale for invading Iraq in search of weapons of mass destruction after the UN inspectors certified that their continuing exhaustive inspections had found none and scientists found their arguments for invasion lacking in foundation. This is a perfect example of Republican ideology leading them to risk catastrophic results with little regard for reality. It is now acknowledged that the invasion occurred in search of weapons of mass destruction thought by most intelligence analysts to be nonexistent. What is almost equally unbelievable, the invasion occurred without a plan for the occupation, which resulted in a lengthy and costly insurgency. The ideologically-driven misadventure in Iraq has created turmoil and destabilized the entire region, culminating in the rise of the Islamic State (ISIS) while costing the US dearly in terms of lives and treasure (Stiglitz and Bilmes 2008), and our involvement is ongoing.

Republican rejection of science may, in part, stem from their close association with business. Corporate interests frequently come in conflict with science that shows some products or practices to be dangerous. The pursuit of corporate profit seems to be a powerful incentive to disregard safety (Michaels 2008, Mooney 2005, Oreskes and Conway 2010). A good example is the demonization of Rachel Carson by the business community that began immediately before the publication of her book *Silent Spring* (1962). Carson has since been vindicated (e.g., Graham 1970) and the vilification shown to be motivated by protecting profits from the sale of harmful chemicals, e.g., DDT.

The inability of humans to change climate has become a set Republican ideological belief in the face of the massive scientific evidence that has accumulated over more than a century (Hay 2016, Washington and Cook 2011). I speculate that these false beliefs have been so amplified by talk radio and Fox News that, even if Republican leaders recognized the problem of climate change, they probably would not dare to articulate the truth to their voters. In fact, Republican politicians routinely misrepresent the truth about scientific facts, apparently in the belief that their voter base does not know enough to detect falsehoods (Mooney and Kirshenbaum 2009), or does not care (McNall 2011; Mooney 2005). Unfortunately, when Democratic President Clinton was in office he did little to advance solutions to the climate problem, I suspect because he anticipated Republican obstructionism.

Another factor is that many of the Republican voters are fundamentalist Christians who already reject well established science, e.g., the fact of evolution and the antiquity of the universe. With that set of beliefs, one could argue that those voters would have a propensity to reject scientific facts that their leaders reject (Kaufman 2010, Mooney and Kirshenbaum 2009) or that they find inconvenient for some reason, without any regard for objective truth.

There are some ideas common to those who deny human responsibility for climate change that prevent them from addressing the issue, such as rejection of the scientific literature as a product of conspiracy, making other problems (e.g., economics) more important, blind belief in the efficacy of free markets to solve all problems, and the view that people who want to protect the natural environment oppose all progress (McNall 2011). These views result in constant attacks on the Environmental Protection Agency and the Endangered Species Act as well as rejection of any action to combat climate change.

Diamond (2005) looks at historical examples of societies that encountered environmental problems that threatened their survival. Some, (e.g., the Greenland Norse) failed to comprehend the problems or would not take appropriate action. The Norse died out, but the Inuit thrived in the same deteriorating climate. Analogous mistaken attitudes and beliefs may actually endanger the future of human civilization (Inman 2009, Jamieson 2014).

Summary

There can be no doubt that human actions have greatly increased GHG in the atmosphere and that those GHG are warming the planet. We are already seeing the changes from this warming that diminish ice and snow, raise sea level, acidify the oceans, destroy biodiversity, disrupt ecosystems, intensify extreme weather and many other deleterious effects. These changes will accelerate and intensify, resulting in more climate refugees and increased conflict. Even if the world took decisive action now to stop GHG increases, there will be cascading effects that will make this planet a much less pleasant place to live. The Republican Party of the US has obstructed meaningful action for a variety of reasons and bears much of the responsibility for the consequences of inaction.

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