Anti-Science and Anti-Environment are not Just Political Stances

By William Ross McCluney, B. A., M. S., Ph.D., Principal Research Scientist, Florida Solar Energy Center, retired. Research Physicist, SunPine Consulting, Cape Canaveral, Florida rm@sunpine.us

12 November 2015

Using anti-science arguments to bolster anti-environmental policy and legislation may seem legitimate to some politicians and the few voters to which they appeal. But they can lead to adverse results, further degrading the future prospects of our children and grand-children.

To understand this requires some elementary knowledge about how the Earth works and how our modern civilization obtains the water, food, energy, and mineral resources needed to sustain that civilization. A basic understanding of science and how it works is also needed, but seems to be absent in much of the discussion of this subject.

I here offer a relatively brief introductory background section on the historical beginnings, a summary of how science works, a short guide to how the Earth works, and a summary of the scientific understanding of the environmental crisis. This is followed by sections on Adverse Effects of Climate Change and Adverse Effects of Ecosystem Disruption Other Than Global Warming. These are provided to make clear the severity of the human-induced environmental problems happening now and expected to worsen in the next several decades. I've also added sections titled Inconvenient Truths Can Lead To Intentional Ignorance, Getting The Message, and Conclusions.

"Getting the Message" describes a variety of very positive trends in the financial sector, hopefully to be repeated in the political sector, toward reversing the currently accelerating global warming, bringing it back to a more sustainable and environmentally acceptable level. "Inconvenient Truths" describes the natural human responses to bad news or such news that threatens previously held beliefs. I believe that the mainstream media have not done a decent job explaining all these important components of the crisis and why I and a few of our leaders believe this issue to be the most serious one facing not only the U.S. electorate but all of humanity, greater even than the very serious threats of terrorism. One reason is that the environmental threat has the potential to extinct — or at least seriously degrade — the species *homo sapiens*. It is therefore a truly existential threat.

Background Information

Historical beginnings. The Earth itself is a nearly perfect sphere of ancient star material that coalesced with our solar system, formed some 4.5 billion years ago. This means that everything we eat, drink, touch, hold, and play with is made of star stuff, the elements and molecules produced, seemingly out of nothing, when our universe was formed by what appears to have been a nearly inexplicable "big bang" 13.8 billion years ago.

Most of the energy we use comes to us from our sun, either in the form of complex molecules formed in the earth about 360 to 286 million years ago (now being brought up as coal, oil, and natural gas) or directly in the form of solar rays impinging on our planet daily, keeping it warm, and powering our weather. Fresh water evaporates from the salty ocean and the sun-driven wind transports it to places where it falls as rain to wash our buildings, streets, and sidewalks and to fill our rivers, streams, reservoirs and underground aquifers. Some of our aquifers contain fresh water deposited from tens of thousands to a million years ago that is not continually replenished so has a finite size that can be depleted. (In 2013 large freshwater aquifers were discovered under continental shelves off Australia, China, North America and South Africa. They contain an estimated half a million cubic kilometers of "low salinity" water that could be economically processed into potable water.) Other aquifers, usually shallower, are refilled by rainwater seeping down through permeable layers beneath the surface.

We don't live only off of the energy in ancient deposits of dead and decayed plant and animal life converted to coal, oil, and natural gas — the fossil fuels. We need also the solar energy contained in the wind, the weather-elevated water running from high land areas down through hydro-electric generators, and that solar energy captured and stored in enumerable living organisms all over the world. These plants and animals are part of a global living system, called the ecosystem, which is composed of smaller regional component ecosystems. These ecosystems, all of them, are imbedded in the two fluids that dominate our planet: the atmosphere filled with gases, water vapor, and clouds, plus the oceans filled with salt water and largely connected with each other. The rotation of the Earth on its axis, the impingement of solar radiation onto more than half the rotating globe, and the gravitational pulls of the Earth itself and the Moon produce a lot of motion in both fluids, some global in scope.

This means that what happens to, or in, the fluid here does not always remain here, but has impacts of many kinds at other locations around the world. It also means that there is a huge amount of energy flowing in the solar radiation falling on the Earth and the winds and ocean currents circling the globe. These energy flows are renewable, in the sense that they are renewed or sustained by the flow of solar energy into the Earth's systems, so humanity can and is extracting some of the energy in these streams. We can extract much more of it, enough to replace the fossil fuels we currently use for energy production.

How science works. Scientists study the universe, our solar system, this world, and all its functioning systems. The way it works is that they make observations, ideally measuring as many aspects (subsystems) of them as possible, and then form theories which can be thought of as tentative explanations for what they have observed, describing how they think the observed subsystem works. Then they test their theories with experiments and report the results by writing them down. Once the printing press was invented, they could more easily share these observations with other scientists and people in the regions where they lived. As technology progressed, so did the means of communication. So the explanations provided by scientists could be read by many others, discussed, debated, and then tested by other scientists. These tests could sometimes disprove the theory proposed by the first scientist, in which case that line of thinking was usually abandoned (at least until some other scientist with better knowledge later could re-examine a discarded theory, rehabilitate it with new data and propose an improved version). Sometimes an initial theory or explanation was supported by the measurements of other scientists and often it was improved by them. Perhaps they noticed minor flaws in the original experiments and repaired them using the results of their new measurements, making it possible to better refine the earlier explanation.

This process has been going on now for at least a thousand years. (An interesting description of early science was written by William Harris. Harris mentions Ibn al-Haytham, who lived in present-day Iraq between 965 and 1039 A.D., as possibly the first known scientist.) Over time, many theories have been confirmed very precisely as true from many repeated measurements with increasing precision and accuracy as better instruments and procedures are used. At some point, the precision and accuracy become so high that the theory is confirmed and is accepted universally as true, so it is given the title of being a "law" of science. It is called a law of nature because it is no longer an opinion of scientists. Laws of nature are unlike the laws of humans because they are considered to be universal truths everywhere on Earth. As we explore space, these laws are extended to the whole solar system and beyond.

As the precision of the measurement becomes incredibly greater, or as we try to apply our laws of nature to dimensions much larger than our solar system, indeed our galaxy, or for systems much smaller than the molecules or atoms we can observe, occasionally we find that some of our "laws" don't appear to work for systems as large as a galaxy or as small as an electron, and are forced to re-examine them and in the light of new observations and measurements at the larger or smaller scales. In some cases, it is the speed of moving objects that becomes too great for our laws of mechanics discovered and quantified by Isaac Newton, to work. Albert Einstein modified and extended Newton's laws of motion so that they would work for very high speeds. As the speeds put into the equations of Einstein's Special Law of Relativity, are reduced, the formulas also reduce to the simpler, more familiar ones devised by Newton.

The result for 2015 is that the most important aspects of the physical, chemical, and biological systems we observe on Earth are well known by scientists and are clearly codified by well-established laws described clearly in the best textbooks and backed up by a large body of scientific research results. These are archived in published research journals available to anyone interested in obtaining them (easily through the internet) and then reading them.

Biological systems are in some ways more difficult to fully understand than purely physical ones, because they are in some ways more complex. Ecological systems contain varieties of biological species that interact very intimately with their physical, chemical, and geological surroundings and components. Fortunately, science has studied these systems for a long enough time and using very advanced measurement techniques to understand quite well how they work in general and have learned (and are still learning more) about what these ecosystems need in order to thrive. This means, the mix of water and water-borne nutrients, atmospheric gases (both in the air and dissolved in water), minerals in the soil, and the proper mix of prey and predators to sustain the plants and animals making up the ecosystem are generally well known for most species we use and depend on.

How the earth works. In addition to current measurements, scientists have access to knowledge about how physical and ecological systems have responded to major changes over Earth's pre-human history ― changes in solar radiation, temperature, oceanic salinity, the turbidity of the atmosphere (transparency to solar radiation), and historical variations in the constituent gases in the atmosphere and the contents of fresh and sea water over time. This information comes from direct historical measurements stored in research libraries and databases as well as trapped in the rings of old living trees, in fossilized plants, trees, and animals, in ancient sedimentary layers, geological structures, and giant thick glaciers on land. Modern radiological and other dating techniques can be used to determine the time in which a given layer was trapped and stored for our later discovery. There is a huge international repository of glacial ice cores going back many thousands of years maintained by the U.S. government in Boulder Colorado.

From this research comes an understanding that the modern industrial enterprise supplying humanity with food, clothing, shelter, communication systems, transportation systems, improved health systems, advanced educational systems, and a remarkable entertainment industry depends entirely upon a combination of the extraction of minerals and other nonliving resources from the Earth's interior and an increasing utilization of the living plant and animal biomass taken from the wild and cultivated in plant and animal production industries. These living resources themselves depend completely on other resources originating in the Earth.

Some of these resources are renewable, in the sense that they are replenished naturally by biological activity powered by sunlight and using saline water or fresh water distilled by the sun and spread by the wind ― thus available to power the human systems requiring them. If the rate of use, however, exceeds the rate of replenishment, their renewability declines toward depletion.

Other resources are finite in quantity, not naturally replenished by nature, so are not renewable in the same sense. They can be recycled, however, meaning reconditioned and returned to the input stream at the end of their productive lives, thereby putting off the time when the need for such resources exceeds even the partially recycled supply. For example, once an ancient, nonrenewable fossil water deposit has been pumped out, that source of water will be gone, no longer available for use.

This explains why the Earth's mineral resources, water cycles, food and energy pathways ― indeed the whole living ecosystem ― form the life-support system for humanity. We live on this Earth, as it hurtles through space, spinning on its axis, in its orbit around our Sun, and are completely dependent on the global ecosystem, our life-support system.

If we damage, disrupt, contaminate, or destroy significant portions of that system, human life on Earth will become increasingly degraded, possibly extinct.

The recent jump in the average temperature of the planet since 1900 is, almost totally, a direct result of the injection of a variety of gases into the atmosphere which alter the balance between the solar radiation coming through the atmosphere to warm the Earth's surface and the long-wavelength infrared radiation of heat away from the planet into outer space. The gases most responsible for this, called the *global warming gases*, are carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), and a variety of Fluorinated gases like hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride. These gases in our atmosphere act like the glass in a greenhouse, which is why they are also called the *greenhouse gases*. The glass of a greehouse is transparent to solar radiation, so warms the interior of the structure. The warmed surfaces inside a greenhouse emit long-wavelength infrared radiation that is largely blocked by the glass, so the heat is trapped inside, making the greenhouse glass analogous to the greenhouse gases in our atmosphere, which accomplish a similar trapping of heat below the atmosphere. If the concentration of greenhouse gases in the atmosphere becomes too low, the Earth cools. If their concentration increases the earth warms. (Particulates in the atmosphere, called aerosols, usually larger than the molecules of air in which they are imbedded, can reflect some of the incident solar radiation back into space. When their concentration is high for a period of time, as has happened following very large and prolonged volcanic eruptions, the Earth cools.)

Our current average global temperature is the result of an eons-old balance between the incoming solar heat that is not reflected back into space and the outgoing radiated infrared heat.

On the other hand, if the atmosphere experiences an increase in its content of the greenhouse gases, then the earth will warm up on average. Both heating and cooling processes have happened many times in Earth's ancient history and, for example, tropical forests have even grown near the north pole, the origin of some petroleum deposits known to exist below the Arctic Ocean and the seas and bays surrounding that ocean.

The current global warming is leading directly to changes adverse to human civilization, the beginnings of which are starting to be felt directly ― in property damage, losses of life, degraded human health, and substantial increases in the costs to mitigate this damage. Several of the ill effects of global warming are listed and summarized in the next section.

Scientific understanding of the environmental crisis. The result of all the research on Earth's life-support system is a general scientific consensus that the extremely rapid jump in world population following the development of modern technology and the discovery and rapid extraction and burning of oil and other fossil fuels in the late 19th and the entire 20th century have placed significant stresses on the global ecosystem, damaging important components of that ecosystem.

It has changed other components, causing the annual extinction of species at a rate much greater than new species are being created, for example, even threatening future human existence. These stresses have produced the death of sea corals in many locations. The dumping of human wastes into the ocean is turning our seas into sewers, causing ecological damage, especially to economically valuable seafood resources. We are fishing some valuable marine species to the brink of extinction. Human growth and development is converting wild areas (containing natural vegetation that captures and "sequesters" carbon dioxide from the atmosphere while releasing life-giving oxygen) into commercial, residential, and industrial cities crowded with people, asphalt, concrete, and steel, contributing more global warming gases to the atmosphere and accelerating global warming.

Vast agricultural monoculture areas (industrial farming) spread chemical fertilizers and pesticides that disrupt natural ecosystems in contact with them. There is a growing decline in bee populations worldwide, for example, that threatens the pollination services they provide to both natural and industrial plant growth. Through increasing agricultural and human demands for fresh water, we are draining our rivers, concentrating pollutants in them, and producing water shortages downstream. If this were not enough, we are seeing pandemics like AIDS, Ebola, and antibiotic-resistant bacterial strains, and the pervasiveness of industrial toxins in our food and air.

Christopher Ketcham put it this way in a recent CounterPunch.org article:

> I've found conversation with my biologist sources to be terribly dispiriting. The conversation goes like this: *Homo sapiens* are out of control, a bacteria boiling in the petri dish; the more of us, demanding more resources, means less space for every other life form; the solution is less of us, consuming fewer resources, but that isn't happening. It can't happen. Our economic system, industrial consumer capitalism, requires constant growth, more people buying more things. "I will go so far as to say [that] capitalism itself may be dependent on a growing population," writes billionaire capitalist blogger Bill Gross, Forbes magazine's Bond King. "Our modern era of capitalism over the past several centuries has never known a period of time in which population declined or grew less than 1% a year." Growth for growth's sake, what Edward Abbey called the ideology of the cancer cell.

Adverse Effects of Climate Change

In spite of all the adverse and varied impacts on our ecosystems produced by industrial civilization, global warming remains the largest, most damaging, most pervasive, and most intractable problem of all. It has many effects. Here is a partial list, some from the *National Geographic*:

Several climate change effects are already happening.

- Ice is melting worldwide, especially at the Earth's poles. This includes mountain glaciers, ice sheets covering West Antarctica and Greenland, and Arctic sea ice. The latter places great stress on polar bears, which use connected ice sheets to hunt their prey.
- Researcher Bill Fraser has tracked the decline of the Adélie penguins on Antarctica, where their numbers have fallen from 32,000 breeding pairs to 11,000 in 30 years.
- Sea level rise became faster over the last century and some islands and low coastal areas are already experiencing frequent flooding from the sea.
- Some butterflies, foxes, and alpine plants have moved farther north or to higher elevations and cooler areas. Others are unable to move and go extinct.
- Precipitation (rain and snowfall) has increased across the globe, on average.
- Spruce bark beetles have boomed in Alaska thanks to 20 years of warm summers. The insects have chewed up 4 million acres of spruce trees.
- Some hurricanes, tornadoes, and other storms seem to have increased in frequency and severity in the last few years.
- Increased carbon dioxide in the atmosphere is absorbed by the oceans to produce carbonic acid, an invisible but highly destructive substance that's rapidly changing the chemistry of the earth's waters and disrupting underwater ecosystems in a process called ocean acidification. Reduced levels of the mineral aragonite (crucial to the formation of shells in marine species) are a side effect of ocean acidification that can harm the health of shellfish like oysters and, in extreme cases, cause their populations to plummet. This has already had a negative impact on the fishing industry, especially on the west coast of the United States.

Other effects could happen later this century, if warming continues.

- Hurricanes and other storms are likely to become stronger and more frequent.
- Species that depend on one another may become out of sync. For example, plants could bloom earlier than their pollinating insects become active.
- Both floods and droughts will become more common and more intense. Rainfall in Ethiopia, where droughts are already common, could decline by 10 percent over the next 50 years. California in the U.S. experienced particularly bad droughts in 2014 and 2015, followed by flooding and mud slides when rains returned. This is expected to worsen and continue, extending to other areas around the world.
- Less fresh water will be available. If the Quelccaya ice cap in Peru continues to melt at its current rate, it will be gone by 2100, leaving thousands of people who rely on it for drinking water, crop irrigation, and electricity without sources for these essentials.
- Some serious diseases will spread, such as malaria carried by mosquitoes, many reaching pandemic proportions.
- Ecosystems will change, in many cases adversely for humans.

These are but a few examples of the consequences of global warming.

Melting of glaciers is of special concern. These are large areas of thick ice on land (above sea level), whose water runs into the ocean and raises its level. Some of these glacial areas produce needed freshwater runoff in the warming Spring season. This water is essential to the growth of crops in large areas supplied by such water. As the glaciers recede, less water is supplied and crop yields drop. According to the *National Geographic*, if all the glaciers on Earth melted, the sea level worldwide would rise by 216 feet, flooding huge areas of human settlement around the globe. We can hope it won't happen, but even a fourth of this sea level rise will be catastrophic.

Adverse Effects of Ecosystem Disruption Other than Global Warming

Though inadvertent climate change — mainly global warming — is the most urgent and dramatic result of the recent increase in global warming gases placed into the atmosphere by the burning of fossil fuels, by deforestation and burning of large areas of rain forests, and by the melting of permafrost (leading to the addition of significant quantities of methane to the global atmosphere), it is not the only one.

The greatly increased number of humans on the planet, coupled with a technological magnification of their adverse impacts, and greater affluence of a large portion of that population (which generally enhances per capita impact) has caused rapid increases in adverse changes in many additional components of the global life-support system.

Wikipedia divides the impacts into consequences from human overpopulation, intensive farming, land use, nanotechnology, and nuclear materials.

Some of the adverse environmental effects of human presence (other than from global warming) described by Wikipedia are listed below.

Habitat destruction • Invasive species • Air quality • Endocrine disruptors • Lead poisoning Nature deficit disorder • Sick Building Syndrome • Environmental impact of hydraulic fracturing • Soil erosion • Soil contamination • Soil salination • Agricultural runoff • Algal bloom • Fish kill • Groundwater contamination • Marine debris • Marine pollution • Mercury in fish • Microplastics • Nutrient pollution • Thermal pollution • Urban runoff • Wastewater pollution • Overexploitation of natural resources • Overdrafting of groundwater • Blast fishing • Bottom trawling • Cyanide fishing • Ghost nets • Illegal, unreported and unregulated fishing • Overfishing • Shark finning • Whaling • Deforestation • Acid mine drainage • Mountaintop removal mining • Slurry impoundment pollution • Water scarcity • Toxic pollution from Beryllium • Bioaccumulation • Chlorofluorocarbons Cyanide • DDT • Herbicides • Hydrocarbons • Perchlorate • Pesticides • Persistent organic pollutants • PBBs • PBDEs • Toxic heavy metals • PCB • Dioxin • Polycyclic aromatic hydrocarbons • Radioactive contamination • Volatile organic compounds • Litter • Waste disposal incidents • Marine debris • Medical waste Incineration

In many ways humanity is systematically (though unintentionally) taking apart or badly damaging its own life-support system.

Clearly there are rules in many countries governing the intentional, unintentional, and proper disposal of many of the chemicals and other pollutants listed above, but these rules may or may not be obeyed everywhere, causing these substances to pose serious threats to the health and safety of both humans and other plants and animals inhabiting the biosphere. Some of the items in the above list have direct adverse effects on the proper functioning of components of the global ecosystem (or the whole thing) important to humans and other species on which humans depend. In other words, in many ways humanity is systematically (though unintentionally) taking apart or badly damaging its own life-support system.

Inconvenient Truths Can Lead to Intentional Ignorance

It is very difficult for a youngster growing up in the world today—especially those in well-functioning households and receiving reasonably good educations—to reach an age at which they have to confront a very disturbing proposition. That proposition is this:

> For the last couple of centuries, the human species has been caught up in a system for the production of goods and services, coupled with a complex set of governing systems and bodies—which, at first, seems to be wildly successful, leading to a degree of affluence the world has never known before—but which, as a side-effect, seems to be destroying the very life-support system needed for our relative prosperity to continue.

A natural response to encountering this proposition for the first time is to deny that it is true. If some of the people one asks about this sorry state of affairs derides the question as being preposterous on its very face while others say that our scientists are telling us that it is true, who would the person believe? The deniers, those stating that the proposition is not worthy of further consideration?

That might be the easiest option to take. It means the youngster can feel safe and secure in the belief that things are going ok and that they can look forward to a rewarding and secure future, without having to worry about some Armageddon scenario or having to participate in a crash course of strong action to prevent it.

On the other hand, they might not be so persuaded. Hopefully they will try gathering more information on both sides of the two opposing answers. As time passes, one would hope that they will encounter in the news, from their teachers, from their parents, and/or from their friends and acquaintances, plus recurrent evidence, that the massive changes predicted are beginning to happen nearly everywhere.

Hopefully, they will use the skills for asking questions hopefully they learned in school. They might also start to believe that the adverse consequences already happening are becoming systemic rather than just transient and short-term variations in weather and other disasters the world has seen for a long time.

Looking at the political world in the U.S. today (and in a few other places abroad), we can see a disturbing trend amongst a fraction of our political leaders, who can be assumed to have benefitted from decent public, private, and university educations. Many of these politicians are taking positions which are decidedly anti-science and against government efforts to regulate, educate, and perform research on most aspects of the growing global environmental crisis. They try to eliminate the U.S. Environmental Protection Agency, the U. S. Department of Education, and much of the government-funded research on critical environmental topics.

For example, U.S. presidential candidate Marco Rubio, a Senator from South Florida, in 2014 said this on ABC News: "I do not believe that human activity is causing these dramatic changes to our climate the way these scientists are portraying it and I do not believe that the laws that they propose we pass will do anything about it. Except it will destroy our economy." On 22 June 2015, the Palm Beach Post quoted Rubio as saying: "I do believe it's in the common good to protect our environment. But I also believe it's in the common good to protect our economy. There are people all over this planet and in this country who have emerged from poverty in large respect because of the availability of affordable energy. It creates industries. It makes the cost of living lower. And we have to take that into account as well."

A June 23 Huffington Post article on Rubio's statement, said this: "Other politicians have argued that 'affordable energy' -- by which they generally mean fossil-fuel energy -- is necessary to the economy." So it is clear that Sen. Rubio is saying that switching from fossil fuels to energy efficiency and renewable energy efficiency will destroy the economy and that the economy cannot benefit from the switch.

Other U.S. politicians deny the human contribution to global warming more vociferously, and as Rubio has, seek to deflect the conversation with claims that actions to stop global warming will produce economic hardships, ignoring the many positive economic benefits that can result from reducing reliance on fossil fuels and replacing them with stronger energy conservation and a major transition to renewable energy sources.

These positive benefits of switching away from fossil fuels include increased employment in the U.S. through making and installing large renewable energy farms and installing renewable energy systems on the roofs of and in the neighborhoods of commercial and residential buildings. Such actions are accelerating around the globe now. Wind turbine and solar panel sales are skyrocketing — thanks in part to major increases in production of this equipment in both China and the U.S. plus large individual solar and wind farms and substantial distributed rooftop solar arrays.

Evidence is growing that switching away from fossil fuels can be a boone to jobs growth and can stimulate economic activity. A recent book by Lester Brown titled *The Great Transition: Shifting from Fossil Fuels to Solar and Wind Energy* details the revolutionary and growing global transition from fossil fuels to energy efficiency and renewable energy that is transforming the energy industry. Indeed, the President of the United States, Barack Obama, has made the enhancement of this transition a major goal of his last year in office.

In his 6 November 2015 statement on the cancellation of the XL pipeline to transport Canadian tar sands petroleum across the U.S. to the Texas coast, the President offered these remarks:

"…the United States will continue to rely on oil and gas as we transition — as we must transition — to a clean energy economy." "Since I took office, we've doubled the distance our cars will go on a gallon of gas by 2025; tripled the power we generate from the wind; multiplied the power we generate from the sun 20 times over. Our biggest and most successful businesses are going all-in on clean energy. And thanks in part to the investments we've made, there are already parts of America where clean power from the wind or the sun is finally cheaper than dirtier, conventional power."

"Today, we're continuing to lead by example. Because ultimately, if we're going to prevent large parts of this Earth from becoming not only inhospitable but uninhabitable in our lifetimes, we're going to have to keep some fossil fuels in the ground rather than burn them and release more dangerous pollution into the sky."

-President Barack Obama, Nov. 6, 2015

"Today, the United States of America is leading on climate change with our investments in clean energy and energy efficiency. America is leading on climate change with new rules on power plants that will protect our air so that our kids can breathe. America is leading on climate change by working with other big emitters like China to encourage and announce new commitments to reduce harmful greenhouse gas emissions. In part because of that American leadership, more than 150 nations representing nearly 90 percent of global emissions have put forward plans to cut pollution." "America is now a global leader when it comes to taking serious action to fight climate change. And frankly, approving this project would have undercut that global leadership. And that's the biggest risk we face — not acting."

"Today, we're continuing to lead by example. Because ultimately, if we're going to prevent large parts of this Earth from becoming not only inhospitable but uninhabitable in our lifetimes, we're going to have to keep some fossil fuels in the ground rather than burn them and release more dangerous pollution into the sky."

The president was correct in pointing out that there is already a strong transition from fossil fuels (FF) to energy efficiency (EE) and renewable energy (RE) accelerating around the world. And yet, some of his opponents argue against these measures, in apparent denial of the reality of climate change.

These politicians, presumably well educated and knowledgeable about how science works and what it is telling us about the serious environmental threats, still deny global warming and promote expanded production of fossil fuels for combustion, thereby promoting the introduction of global warming gases into the atmosphere at increased rates. One can only conclude that they have taken the option of ignoring the facts, wishing they were otherwise, and denying their scientific basis. I call this *intentional ignorance*, based almost completely on the inconvenient truths about global warming summarized above. Taking this approach is tantamount to admitting incompetency for service in a position of governmental responsibility.

Getting the Message

The scientific consensus is this: If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, the evidence strongly suggests that CO_2 will need to be stabilized to at most 350 ppm. The current value recently passed 400 ppm on its way upward to even higher values in a few years. Fortunately, the world is beginning to see early signs of what the future beyond 400 ppm will look like: More frequent and more intense hurricanes, tornadoes, droughts, flooding and mudslides, reduced fresh water for crop irrigation and other uses, and very high costs incurred from dealing with the aftermaths of these events.

A combination of the scientific evidence and the very real costs produced by investments in industries whose operations are putting the most global warming gases into the atmosphere is sending a strong message to the investment community worldwide. Some political candidates and sitting political leaders continue to deny these realities, so fail to enact and support legislation and other efforts to switch away from the combustion of fossil fuels, replacing them with energy efficiency and renewable energy sources.

In spite of this denial of reality by certain political figures, Paula DiPerna reports in a recent issue of *Environment: Science and Policy for Sustainable Development* that nearly everyone else is getting the message, that "doubt of the science is merely political theater and insurance companies are warning that they may not be able to underwrite the costs of increasing extreme weather events that flood cities and knock out power." She describes a "… new momentum in the investment field worldwide, among mainstream investors who have, at last, begun to align their capital decisions with environmental imperatives more than ever before. What was once boutique is becoming generalized, with a quiet revolution taking place among investors and the financial services sector overall—a glimmer of hope that may trigger the needed pivotal shift in capital flow."

Citing DiPerna's article, ScienceDaily wrote on 5 November 2015 that the new push among mainstream investors to take climate change issues into account stems from a strong "reckoning with the fact that both the risks and costs of extreme weather events will continue to rise, with significant implications for economic stability. As more environmental information is accumulated, and the more climate change becomes irrefutable, the more relevant environmental reality becomes to economic well-being."

This trend is certainly bolstered by striking statements coming from the insurance industry. DiPerna writes that:

> According to Richard Merbaum, executive vice-president of Willis Group Holdings, a major global risk advisor, insurance and reinsurance broker, speaking at a spring 2015 seminar co-hosted by CDP and McGraw Hill Financial on new and emerging trends in environmental investing and sustainable finance, "In most cases, exposure to extreme

> natural catastrophes (the 1:100 year events) cannot today be fully covered by insurance." Merbaum added, "Most companies have not adopted the modeling approaches of the insurance industry to fully assess their exposure to such events and to enhance their resilience to them." Of the relationship between insurance risk and the financial services sector, he said, "The financial sector does not take adequate account of natural disaster risk. Investors do not factor it into their valuations and creditors do not systematically assess natural hazard risks against their loan books, and this includes real estate markets which largely ignore extreme event risk, regardless of the location."

To this wake-up call from the insurance industry can be added a focusing-of-the-mind effect stemming from the coming COP-21 meeting, the 21st Conference of the Parties to the climate change convention in Paris, 7 December 2015, a result of which, DiPerna writes, is that "nations and emitters are scrambling to keep up with the trajectory of emissions increase to try to hold inevitable temperature rise to two degrees Celsius by 2030. This is the current best estimate of when it will be too late to even think of managing impacts of the climate change that will by then have been unleashed by accumulating greenhouse gases in the atmosphere."

To these pressures on mainly institutional investors can be added the desires of clients of investment firms for more of their dollars to go into energy efficiency and renewable energy technology.

Additional motivation for investments in EE and RE comes from two sources.

First are the very visible consequences of the prolonged drought in California the past few years, mainly the extreme wildfires that have ravaged the state and the mudslides and floods resulting from the return of Fall rainfalls, all generating huge costs. This is coupled with the human and financial costs of hurricanes Sandy ($75 billion), Katrina ($134 billion), and the Midwest and Eastern droughts of 1988 ($71 billion) and 1980 ($55 billion).

Second, and perhaps the most important of all, are the dramatic drops in the prices of solar electric (PV) cells, other solar energy systems, and large wind turbines. These technologies have the added advantages that they can be installed much more quickly than conventional fossil fuel powered electric plants. If this were not enough, the costs of the electricity supplied by the fossil-fuel based electric grid are rising just as the costs of EE and RE are dropping.

When the Florida Solar Energy Center was founded in 1976 and I started work there, the great hope in the solar community was that the price of PV would drop to the magic value of 50¢ per peak Watt of electrical output, making the technology more competitive. At the time that price was an exhorbitant $76 per peak Watt ($76/W_p). It seemed hopeless back then that the industry would ever be able to reach the miracle low price of 50¢/W_p, but it actually passed that milestone back in 2013 and is now at an amazing 30¢/W_p!

Such declining prices for renewable energy have fueled a dramatic rise of investments in giant solar and wind farms in sunny places around the world. The desire for lower energy costs has also driven similar investments in efficient buildings, efficient transportation, and efficient electrical appliances of all kinds. Energy codes for new buildings have been steadily getting stricter, with builders and manufacturers responding with new technologies and electronic controls to make buildings operate more efficiently. More and more businesses and residences are putting solar electric panels on their rooftops, in effect, competing with the mostly fossil-fueled electric utility grids.

Some of this was stimulated by government regulations as well as government financial and other incentives of different kinds, but a growing fraction results from the normal marketplace forces mentioned previously, plus fears of investors in poorly performing investments in fossil fuel-based enterprises. What makes good financial sense generally makes good economic sense. It's both a carrot and stick incentive process. Fears of the adverse economic consequences of horrible storms, droughts, floods, and pandemic diseases are coupled with rising costs of insurance to send this important message: We better deal with global warming now, before the costs become exorbitant and before the damage to our life-support system becomes unmanageable.

If the evidence of science is not enough to force action on the climate front, the financial markets are beginning to show strong signs of doing so, and nature itself is weighing in rather heavily. The flooding of Bangkok, Thailand, in 2011 cost $3 billion in local losses alone, excluding damages and reconstruction. The flooding of Lower Manhattan after Hurricane Sandy in 2012, cost about $50 billion. The fires and floods of 2015 are likely to cost even more, once the talley is completed. Such events represent significant economic risks, including the risk of insolvency, throughout the economy, including to investors, and all the more if climate change spurs such events to occur more frequently.

Conclusion

You can dislike your government, hate any government, fear one-world government, push public policy based on a few isolated scientist errors or seemingly reverse trends, and subscribe to all the conspiracy theories you want, but the Earth itself is demonstrating every year that the climate is changing in ways we humans don't like and scientists are showing clearly how general human action is accelerating the trend, even causing most of the adverse changes we have been and are seeing every year.

In conclusion, it is just not acceptable, even politically, to continue denying the science of global warming. Instead of clinging to this fallacy, science-denying politicians should instead work hard to improve elementary through high school education about basic science itself, the scientific process, and provide a lot more curriculum on how the Earth works. This needs to include the following linked topics:

- Solar heat flows, into and out of the biosphere
- Influence of the internal heat from the Earth's core
- Fluid flows, both liquid and air ― locally and globally
- The history of the Earth, the development of life, the emergence of the human
- The history of human interaction with the earth and its evolving ecosystems
- The history and roles of solar energy, wood energy, and fossil fuel energy in human affairs, both positive and negative, including the distinction between burning coal and petroleum resources and using them for durable products, keeping in mind the finite nature of fossil resources and certain minerals also needed for our technological society to thrive
- The origin, current status, and future prospects for climate change, including what will happen if we continue adding global warming gases to the atmosphere and what can happen and on what schedule if we reduce such additions

The more we know, the more will we be able to protect ourselves and the futures of our progeny. It's the right thing to do and thereby has a strongly moral underpinning. Our political leaders seem to be caught in a dance that is failing properly to inform either the public or each other about the factual realities facing humanity at this critical point in Earth's history. I hope the information contained herein can help reverse that trend.