Climate Change Texas:
The Worst-case Scenario is Happening Now

An Evaluation of Recent Academic Work on Ongoing and Regional Climate Change Impacts and the Latest Future Projections

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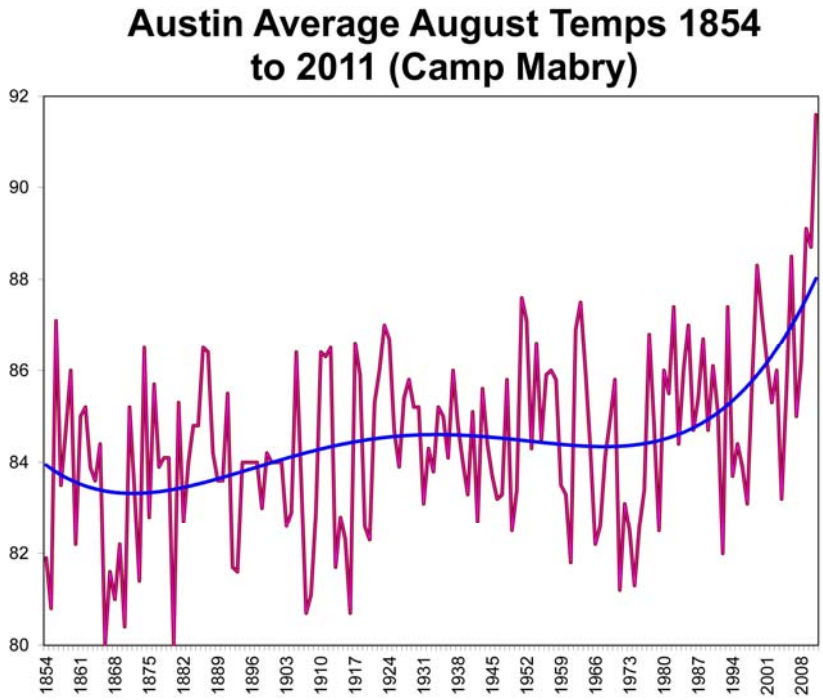
January 2012

[Caption: Austin, Texas, Late Summer 2011: This is not autumn in Central Texas. The fall leaf drop does not begin here until about mid-October and extends through the first of the year. This photo shows the tree kill in a suburban neighborhood in Southwest Austin (Scenic Brook Drive).

AUSTIN -- If this is not dangerous climate change, then this is exactly what dangerous climate change will be like in as little as a decade. What has been happening in Texas, with these unprecedented (in time frames that matter) droughts and wildfires, is exactly what the climate scientists have been warning us about for over 20 years. We have been building up to this point since about the turn of the century, and now ecosystems have tipped over the edge. Climate feedbacks have kicked in hard.

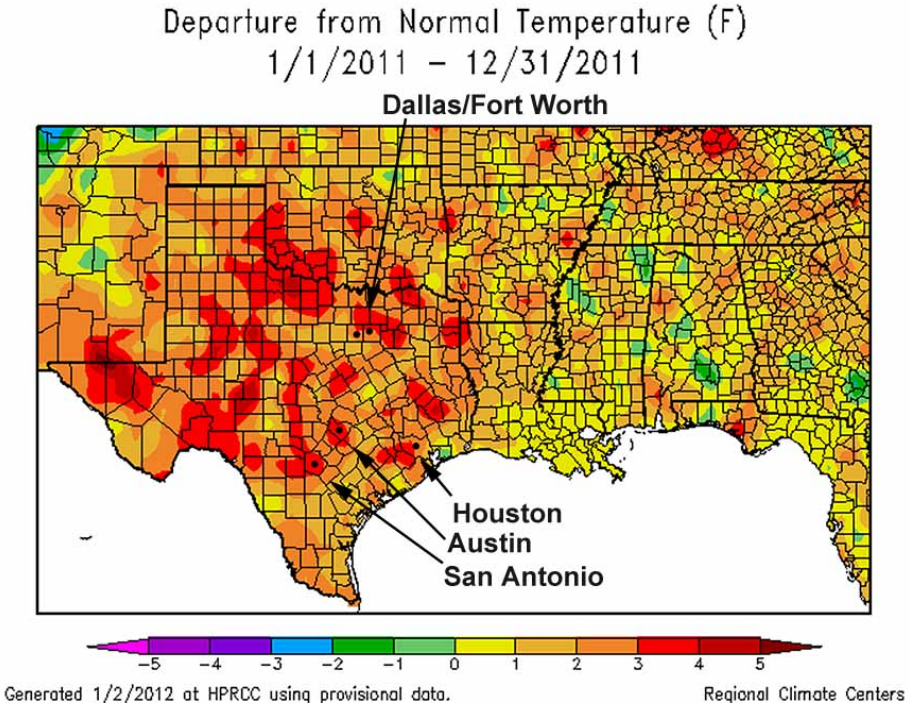
The Texas Forest Services tells us that a half billion trees have died. The first of this series of droughts in 2005/6 was just classified as extreme. The last two have been one category worse than extreme—the exceptional category. The last 12 months were drier than the worst 12 months of the great drought of the 1950s. This has been a $10 billion drought, with another $1 billion in damages from the fires.

Worse, it's hotter now. This summer was 5.4 degrees warmer than average. This may not seem like a lot, but think how sick you would be if you had a 104 degree temperature. The reason that increased heat makes such a big difference in a drought is that extra heat greatly increases evaporation. Four percent more water evaporates for every degree of temperature increase. With 5.4 degrees of warming above average, summertime evaporation in Austin was more than 22 percent greater than normal. In other words, the same drought is much worse if it is only a little hotter. In the same breath, even with normal rainfall, because of warmer temperatures, drought can persist because of much greater evaporation. The warmer temperatures are easy to see looking at the average August temperature for the period of record.



It is important to talk about the urban heat island effect here too. The chaos of information presented by our media today does little to shed light on the latest climate science. An evaluation of regional temperature departure from normal for 2011 shows the exceptional nature of this most recent in a string of droughts.

Urban heat island signatures are easily evaluated and constant correction is an integral part of climate work on global land/ocean temperatures. Corrections are made through the comparison of individually impacted weather stations and their normal neighboring rural weather stations. Published work on the heat island effect shows that even without correction, the heat island's influence on global temperatures is as yet inconsequential because of the relative size of the heat islands compared to the global surface.



The evaluations can also be visually confirmed looking at the temperature departure from normal for the region during the 2011 drought. Where the heat island effect looks to be dramatically visible in the Austin and San Antonio metropolitan areas, it is dramatically absent from the Houston and Dallas metro areas.

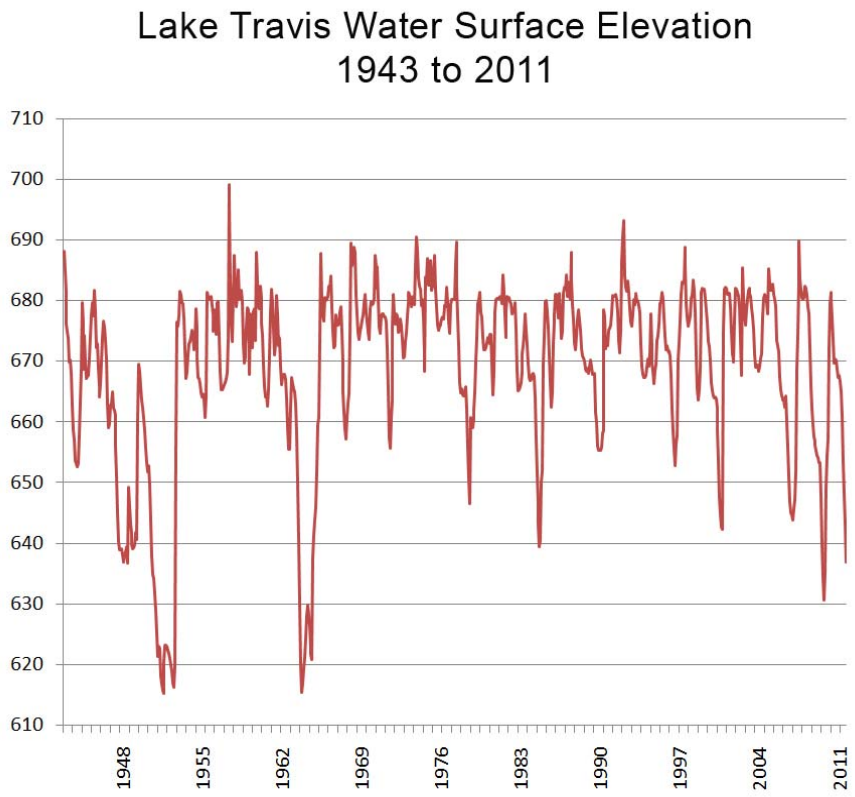
The total number of fires in Texas since November 2010 (through September 20, 2011) is 22,790, totaling 3,759,331 acres. This exceeds the previous record of 2.1 million acres, set in just 2005/6, by 80 percent. We almost doubled the last record, set just five years ago.

Thirty-three percent of U.S. wildland fires this year have been in Texas. This number is 61 percent greater (as of September 2011) than the 10-year national average for the entire United States. Six of the 10 largest wildfires in Texas history have occurred in 2011.

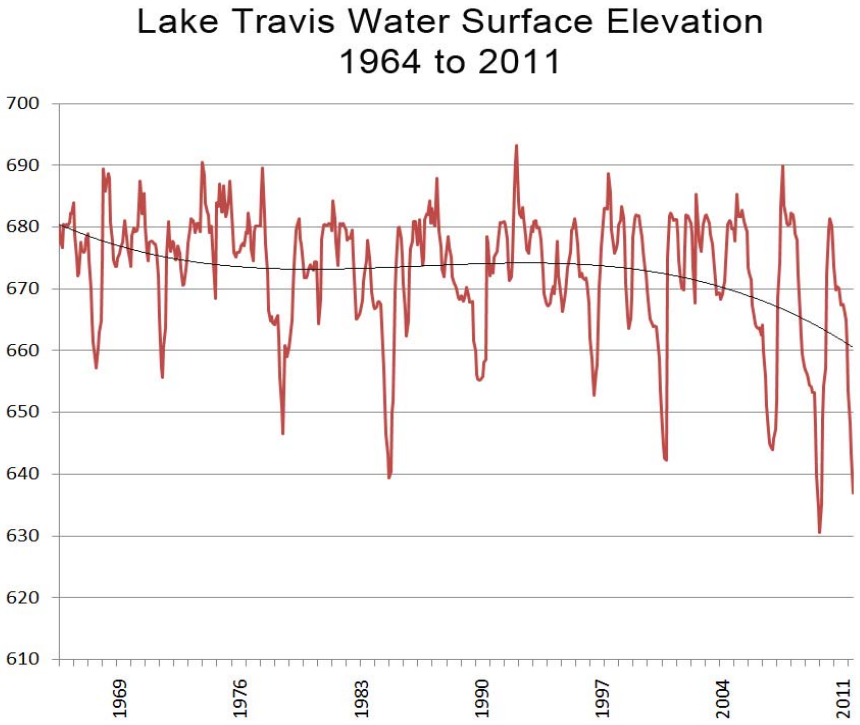
Sure, there have been bigger droughts and bigger fires in the early 1900s or the 1800s or the 1,300 hundreds or 3,000 year BC, but our complicated society did not evolve back then. We do not have the water to support our region today. This is why we have water use restriction in effect now, and last summer and every summer since the turn of the 21st century.

It cannot be emphasized more that this is exactly what our climate scientists have been warning us would happen for the last 20 or 30 years. Only their warnings were generations distant from actual impacts happening today. The impacts happening now are far ahead of the projected schedule. The reason is that the projected future climate changes have always been based on the middle of the road "Kyoto" suggested emissions behaviors.

Our society has not limited our emissions as was suggested by climate scientists to be a prudent way of avoiding dangerous climate change. What should have been a global emissions path reduction to a few percentage points less than the emissions made in 1990 has instead



Casual observation tells us that there have been two droughts (1951 and 1964) much larger than our recent drought. What is not shown in this graph is that LCRA discharged water to generate electricity until the mid 1960s. The amount of water needed for electrical generation is far greater than used for drinking and still much greater than what is used for irrigation downstream. Since the mid 1960s, LCRA only generates electricity when they are releasing irrigation water or excess stormwater. They no longer release water just to generate electricity.

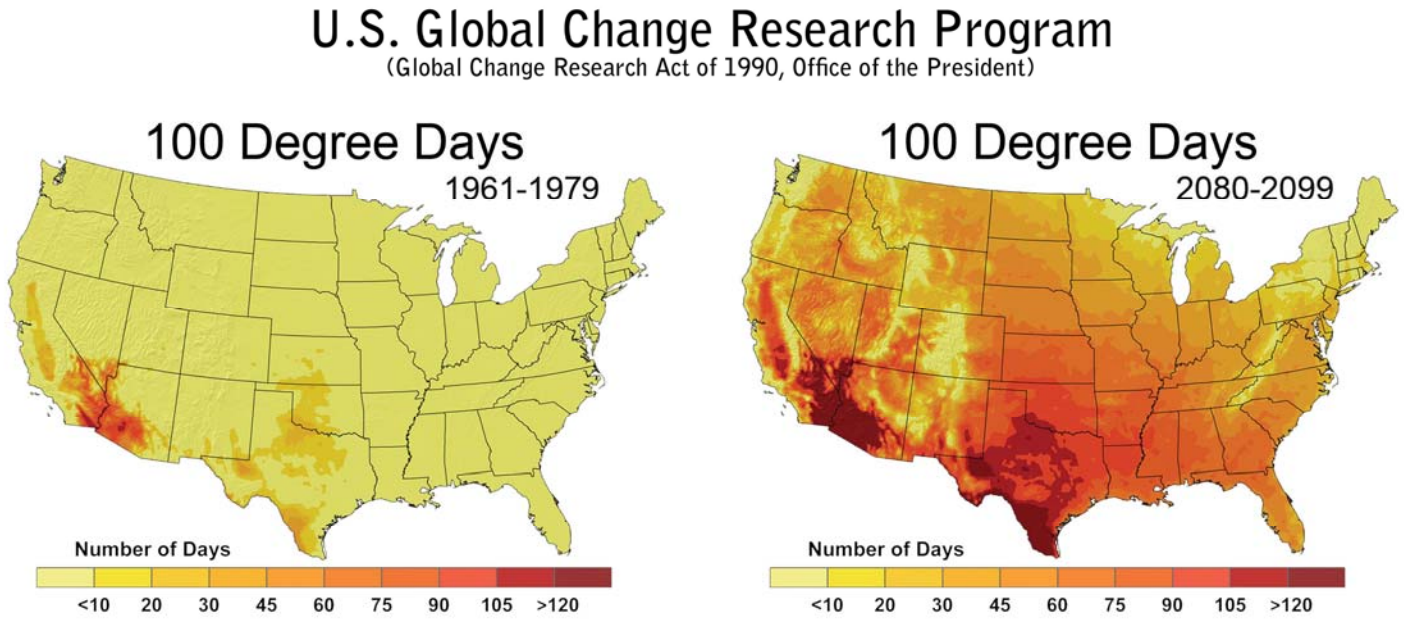


When we start comparing apples a little more closely to apples, leaving off the data where LCRA was releasing massive amounts of water for electricity generation, a trend does become apparent. The question is: "Is this trend a natural cycle or is it related to climate change?" The answer is unrelated to whether or not this trend is anything more than normal weather fluctuations. Statistically, we can not yet say. Morally? For over twenty years now, climate scientists have been telling us that things like this are going to happen in the future if we do not control our greenhouse gas emissions. We have yet to begin controlling our GHG emissions.

seen emissions grow to fifty percent greater than they were in 1990. Climate scientists warned us that if we did not significantly limit our emissions, our climate would change much faster, with much greater risks of even larger changes do to positive feedbacks that we were just beginning to understand.

Since the IPCCC stopped taking papers for the 2007 report in 2005, we have learned a lot about these feedbacks. We have also been able to document changes to our climate happening much faster than previously projected and these two things are, as suggested by our climate scientists for a generation or more, intimately related.

In June 2009, the U.S. Global Change Research Program (USGCRP), founded by Ronald Reagan, published a report that tells us that by 2080, Austin will see an average of 90 to 120 days of 100 degree weather every year—10 times more than today's average of 12 days per year.

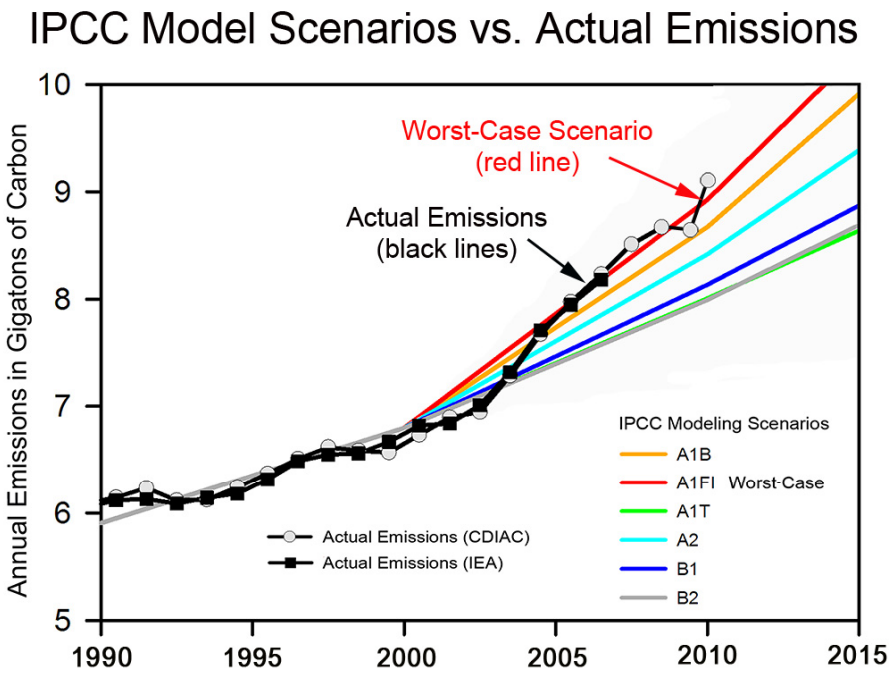


Based on middle of the road emissions scenarios, Texas will see summer temperatures as hot as or fifty percent more extreme as the Sonoran Desert Research station in Arizona today. USGCRP, Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

Look Closely at Arizona. The area of the map with 100 degree day data from the 1961-1979 data can be considered to be representative of the average for the 20th century. What the USGCRP tells us is that enormous areas of the North American continent will see the same climate that has seen the evolution of the Saguaro Cactus, in the Sonoran desert of south central Arizona or in many cases, a climate that is up to 50 percent more extreme than that of the Sonoran Desert today.

But the most mind-boggling part of this future projection is that it is based on the IPCC A1B scenario. This is one of the middle of the road emissions scenario families where our society makes a modest effort to reign in greenhouse gas emissions. It is loosely based on a path that could be represented by efforts with the Kyoto protocol where new efficient technologies are rapidly put into use and there is a balanced emphasis on all energy sources. For decades it has been considered to be the most likely scenario of actual emissions. But this thinking is enormously dated. We are currently smack-dab in the middle of the worst-case scenario considered by climate models. Even with the economic recession, global carbon emission in 2010 were double the recent average and as high as anything seen since the late 1970s/early 1980s.

Let me repeat one more time: The USGCRP projections are based on the middle of the road scenario. We are currently on the worst-case scenario path. This means that temperature change will be more to significantly more than we have been expecting for decades. And this is one of the main reasons why our climate has already changed so much, so rapidly and why future change will be even faster than projected. This middle of the road scenario is also considered in the next two examples of climate projections as well. It is very clear from discussions of these results by the principal investigators in their research papers that these results are conservative and the future is very likely to see changes that are greater than what are indicated.

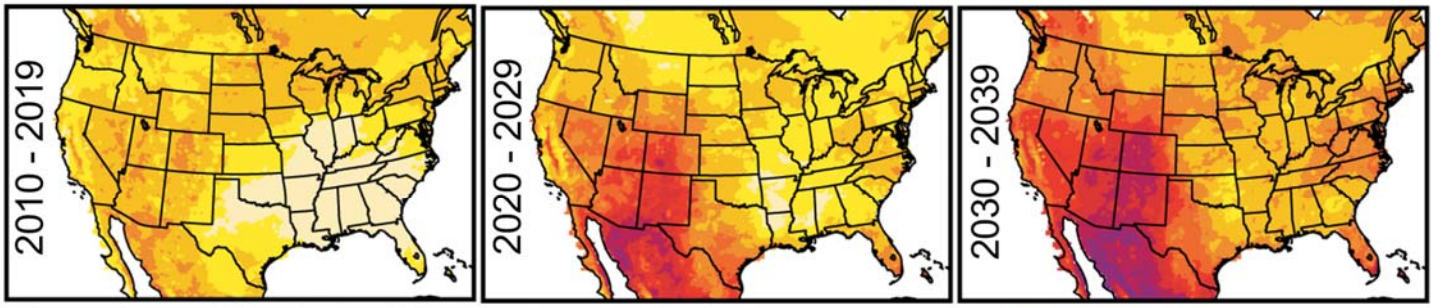


Observed global fossil-fuel and industrial CO2 emissions compared with averages of 6 scenario groups from the IPCC Special Report on Emissions Scenarios (colored lines). The Carbon Dioxide Information and Analysis Center (CDIAC) and the International Energy Agency provided the current observations of CO2 emissions. The latest update was obtained from www.globalcarbonproject.org.

Source: Synthesis Report, Climate Change, Global Risks, Challenges and Decisions, Climate Change Congress, International Alliance of Research Universities, University of Copenhagen, March 2009. Raupach and Canadell, Carbon and the Anthropocene, Current Opinion in Environmental Sustainability, August 2010. Updated 2008 to 2010: CDIAC 2009 = 8.627 Gtons C, CDIAC 2010 = 9.137 Gtons C.

A paper in *Geophysical Research Letters* in July 2010 by two researchers from Stanford and Purdue (Diffenbaugh and Ashfaq) tells us that climate conditions will continue to rapidly worsen in the interior of North America and especially the West. The worsening will be so rapid that in Central Texas the current decade of 2010 to 2019 will see two to three droughts as bad as or worse than the drought of the 1950s.

Beginning in just 8 years, in the decade 2020 to 2029, Central Texas will see four to five droughts as bad as or more extreme than the drought of the 1950s. The implications of these projections are staggering. And remember, these projections are based on the middle of the road scenario. It is quite likely that changes will be even greater than what these Stanford researchers suggest.



Research out of Stanford and Purdue shows that the hottest season from 1951 to 1999 will be repeated two to three times across much of the U.S. in just the next decade. (Diffenbaugh and Ashfaq 2010)

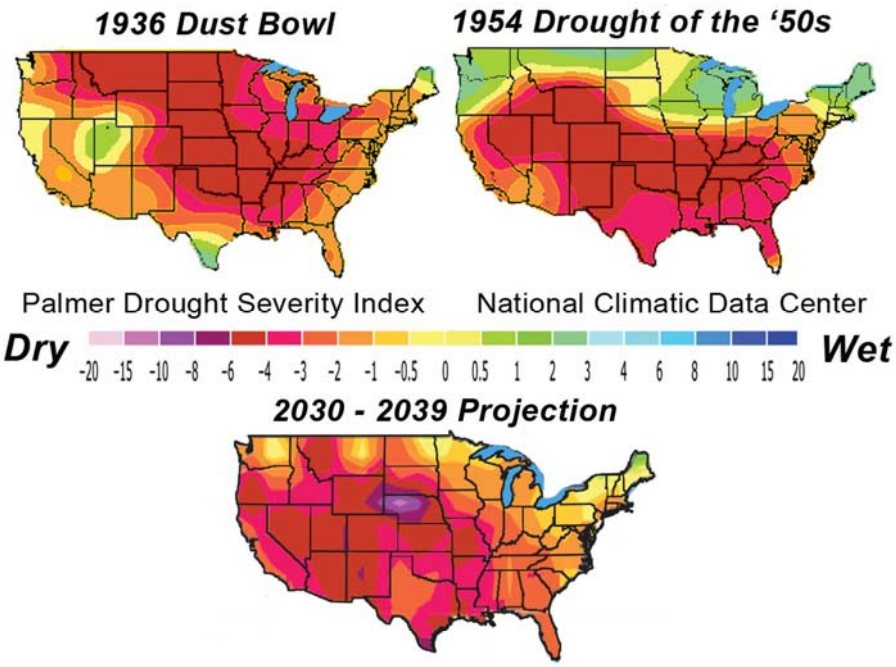
A report out of the National Climatic Data Center in February 2011 (Dia) tells us that beginning in just 19 years (2030) Dust Bowl conditions will be the average climate condition across much of the interior of the U.S. By 2060, much of the interior of the nation will be two to three times as bad as the Dust Bowl with some areas four to five times more extreme than the Dust Bowl.

The 20-year projection is sobering. What is depicted here is the average condition. Across much of the United States, the average drought condition will be similar to that of the Dust Bowl. It is very important to understand that these findings indicate the average condition. Some years will be worse, but on average, it will be as bad as the Dust Bow—continually—and in some areas four to five times as bad as the Dust Bowl. What is most important to remember about exceptionally extreme events such as these is that it is the most extreme events that do the most damage. Climate change increases the occurrence of these most catastrophic of events. As the temperature increases, the number of extreme events disproportionately increases too. What this means is that a little warming increases the number of extreme events a lot, not a little.

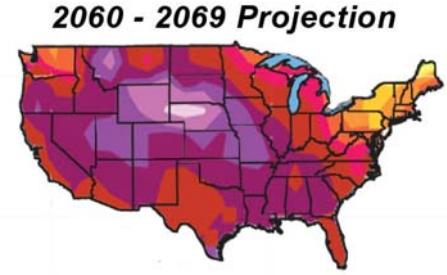
By mid-century however, we reach completely catastrophic levels of continuous drought several times more extreme than the Dust Bowl. Implication of this type of non-stop drought and adaptation strategies for these extreme conditions have simply not been contemplated in the literature. Significant work is underway to gain insight into these situations that seemed so improbably just a few years ago.

Again, I must insist on repeating that this research, like that from Stanford and the USGCRP, looks at the A1B scenario or a middle of the road climate emissions projection. In reality we are now on the worst-case path. Climate changes are almost certain to be more extreme than these studies have shown.

This is no longer business as usual. Water use restrictions will not meet this challenge alone. We must act now to convince our leaders that this is not just another in a long string of extraordinary weather events that we cannot yet blame on climate change. If we do not immediately change our habits and lifestyles, we will run out of water. Our forests are already dying because they have run out of water. The evidence supporting the relationship between this string of unprecedented droughts and climate change is overwhelming.



The results of 21 climate models using the IPCC A1B scenario and represented using the Palmer Drought Severity Index, as compared to the Dust Bowl and the Drought of the '50s. There is little difference between the two biggest droughts of the twentieth century and about the year 2035. Dust bowl-like conditions will not disappear however, but will worsen significantly. If immediate reductions in greenhouse gas emissions are made, Dr. Dai says conditions in 2060 - 2069 will be slightly less extreme than shown.



Reference: North American Drought, Paleo Perspective, National Climatic Data Center, Dia, Drought under global warming - a review, Wiley Interdisciplinary Reviews, Climate Change, p 45 through 65, January / February 2011.

A paper by Kevin Trenberth and colleagues from the National Center for Atmospheric Research, Scripps Institute and The Weather Underground has summarized 61 different findings concerning climate changes already occurring and dating back to 1998. An example of these findings includes the Moscow Heat Wave of 2010 where over 60,000 died. The findings show that this heat wave was 80 percent likely to have been caused by climate change.

A draft paper by James Hansen, Director of the NASA Goddard Institute for Space Studies (The main U.S. climate modeling agency) tells us that the Texas drought in 2011 is significantly similar to the Moscow heat wave (only we have a lot more air conditioning in Texas contributing to far fewer deaths.) The Hansen paper speaks to the issue that, because our climate has so significantly changed, all weather now must be considered to have been caused by climate change.

Many of us have heard by now that it was much drier during the droughts of the 1600s, 1700s and 1800s before reliable record keeping began in Texas. These droughts however, do not hold a candle to what scientists have discovered to be true "megadroughts." Two of them happened between the 900s and about 1350. These droughts saw rainfall drop to 25 percent of normal and they lasted for centuries—hundreds of years!

Water level changes of hundreds of feet in closed basin lakes of The Great Basin show that these droughts were widespread. Hundred-year old trees growing a hundred feet or more below the current water level attest to that. The climate also likely changed quite rapidly when rain did begin to fall again because many of these trees remain intact with their branches, submerged and semi-preserved in the cold waters. One tree in Jenny Lake at the foot of the Grand Tetons in Wyoming still has a raptor nest in it, now about a thousand years old.

There is also evidence that large portions of the Great Plains desertified during these droughts. This is one of those big things the climate scientists have been warning us about now for decades. During these desertification events, much of the Great Plains actually changed to a sea of shifting sand. This desertification was much larger than that at the turn of the 19th century that fostered the term "Great American Desert."

Sure, there have been bigger droughts and bigger fires in the early 1900s or the 1800s or the 1300 hundreds or 3,000 years BC, but our complicated society did not have 1.7 million people in the Austin/Round Rock Metropolitan Area then.

Projections of climate changes from a few decades ago have been shattered. Future projections are exceedingly stark, and these projections are based on the middle of the road scenario—far, far from where our emissions are today. Now the climate scientists are warning us of upcoming weather far more extreme than our civilization has ever experienced and that our society will have difficulty adapting.

We must prioritize our actions towards immediate action *and* adaptation strategies far more rigorous than anything yet contemplated. Climate scientists continue to warn us, and their warnings continue to worsen.

Our State Climatologists has attributed only a small portion of our 2011 event to climate change. I have amassed a very large amount of data over the years looking at this issue in Central Texas and specifically the validity of the previous heat wave of record in the mid 1920s. The culmination of this work can be seen in a three part series published on an investigative internet journal the Rag Blog. A summary of my reporting shows that the heat records of the mid 1920s are likely to be in error. This means that the 2011 heat wave was not an event that shattered the previous record by more than 30 percent. It means that the 2011 event likely obliterated the previous record event by over 100 percent. This of course means that our State Climatologists opinion of the science is significantly dated. These articles can be seen at:
http://theragblog.blogspot.com/2011/12/bruce-melton-welcome-to-climate-change.html

Even with the erroneous 1923 and 1925 heat records intact in the data, what we have just seen in Central Texas, in combination with the warnings we have been given for over two decades and the evidence showing the global trend of climate change is much faster than previously assumed; scientifically and morally there is no reason to doubt that climate change is not the cause.

The solutions however, will be nowhere near as expensive or "ruinous to our economies" as have been suggested by many voices reported by the media. The most recent academic evaluations of the solutions to the cleaning up climate change pollution have shown that costs will be exceedingly non-ruinous. Many non-academic sources are also claiming that this "new energy economy" that we are embarking upon will not only

be highly prosperous for humankind, but it will also be highly profitable for humankind as well. Historically, this kind of fundamental societal change is very well correlated with highly prosperous and highly profitable historic changes to our civilization. Much more on this topic is also included in the three part series mentioned above.

Bruce Melton is a professional engineer, environmental researcher, filmmaker, writer and front man for the band Climate Change. You can see his latest climate change outreach, films, writing and music at www.meltonengineering.com Bruce's new book, Climate Discovery Chronicles, detailing 41 recent discoveries in climate science with 100 color photos, was published in November and is available from Amazon or Barnes and Noble's website. It can also be ordered from any bookstore through Ingram Publishing. For more information go to:
http://www.meltonengineering.com/Climate%20Discovery%20Chronicles%20Book%20Series.html

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Welcome to Climate Change Texas: Part One

Bruce Melton PE

[Caption: Austin, Texas, Late Summer 2011: This is not autumn in central Texas. The fall leaf drop does not begin here until about mid-October and extends through the first of the year. This photo shows the Barton Creek Greenbelt, looking northwest from near where Loop 360 crosses through the Greenbelt. Forest die-off from the drought could approach 50 percent in this area.]

This three part series explores the current unprecedented string of droughts in Texas, the extraordinary fires of 2011 and their strong relationship with climate change. Bruce Melton is a professional engineer, environmental researcher, filmmaker and climate change outreach specialist based in Austin, Texas.

AUSTIN -- If this is not climate change, then this is exactly what climate change will be in as little as a decade. What has been happening in Texas, with these unprecedented (in time frames that matter) droughts and wildfires, is exactly what the climate scientists have been warning us about for over 20 years. We have been building up to this point since about the turn of the century, and now ecosystems have tipped over the edge. Climate feedbacks have kicked in hard.

The Texas Forest Services tells us that a half billion trees have died. Many more will die in the next five to 10 years from disease and insect infestation allowed by the damage that has already been done. The forest service also tells us that trees killed in the fires are not included in this count.

The first of this series of droughts in 2005/6 was just classified as extreme. The last two have been one category worse than extreme—the exceptional category. The last 12 months were drier than the worst 12

months of the great drought of the 1950s. This has been a $10 billion drought, with another $1 billion in damages from the fires.

Worse, it's hotter now. This summer was 5.4 degrees warmer than average. This may not seem like a lot, but think how sick you would be if you had a 104 degree temperature. The reason that increased heat makes such a big difference in a drought is that extra heat greatly increases evaporation. Four percent more water evaporates for every degree of temperature increase. With 5.4 degrees of warming above average, summertime evaporation in Austin was more than 22 percent greater than normal. In other words, the same drought is much worse if it is only a little hotter.

Trees started dying from the drought in 2005/6. The die-off became really bad in 2009 when broad swaths of the countryside west and east of Austin turned brown and failed to turn green again in the spring. Trees continued to redden and die in 2007 even with ample rain because of damage done during the drought. The little root hairs that soak up water on tree roots take a long time to grow back. The two previous droughts in rapid succession have left this region poorly prepared to face an epic drought like happened in 2011.

West of Fredricksburg for 100 miles to where the Central Texas forest meets the Trans-Pecos zone on the boarder of the Chihuahuan desert in West Texas, forest mortality is at its greatest. Fully half of the trees in that region are defoliated from drought. The fate of many of these trees is sealed, but there is hope that rain will return fast enough to make a difference for some.

The total number of fires in Texas since November 2010 (through September 20, 2011) is 22,790, totaling 3,759,331 acres. This exceeds the previous record of 2.1 million acres, set in just 2005/6, by 80 percent. We almost doubled the last record, set just five years ago.

Thirty-three percent of U.S. wildland fires this year have been in Texas. The number of Texas fires this year is 61 percent greater (so far) than the 10-year national average for the entire United States. Six of the 10 largest wildfires in Texas history have occurred in 2011.

Sure, there have been bigger droughts and bigger fires in the early 1900s or the 1800s or the 1,300 hundreds or 3,000 year BC, but our complicated society did not evolve back then. We do not have the water to support our region today. This is why we have water use restriction in effect now, and last summer and every summer since the turn of the 21st century.

Do those bigger droughts in the past matter? Not one bit unless one uses that knowledge to understand the droughts and other really serious impacts allowed by drought that will happen because of climate change right here, starting now. This is exactly what our climate scientists have been doing for these last 20 or 30 years as they have been warning us that these things would become the normal condition on a warmer planet.

In June 2009, the U.S. Global Change Research Program (USGCRP), founded by Ronald Reagan, published a report that tells us that by 2080, Austin will see an average of 90 to 120 days of 100 degree weather every year—10 times more than today's average of 12 days per year. And this evaluation was done based on one of the middle of the road scenario.

We are currently smack-dab in the middle of the worst-case scenario of the climate models. FYI: the Sonoran Desert Research Station in Arizona, the one with the giant Saguaro cactus, has an average of 87 days every year where the temperature tops 100 degrees.

A paper in Geophysical Research Letters in July 2010 (Diffenbaugh and Ashfaq) tells us that climate conditions will continue to rapidly worsen in the interior of North America and especially the West. The worsening will be so rapid that the decade 2020 to 2029 will include three to five droughts as bad as or worse than the worst drought that we have seen since 1951 (like what we just had).

A report out of the National Climatic Data Center in February 2011 (Dia) tells us that beginning in just 19 years (2030) Dust Bowl conditions will be the average climate condition across much of the interior of the U.S. By 2060, much of the interior of the nation will be two to three times as bad as the Dust Bowl with some areas four to five times more extreme than the Dust Bowl.

Our State Climatologist is projecting the second year of this current drought to be similar to or worse than what we have just experienced. With a growing La Nina (known for drought in the southwest U.S.) and Lake Travis at 38 percent of capacity right now, this is a real life example of dangerous climate change that the climate scientists have been telling us about

[This amazing scene was taken in late summer 2011 on US 290 in Southwest Austin. The mature trees are live oaks and Spanish oaks. The brush is elbow bush, agarita, immature live and Spanish oaks, sumac, Carolina buckthorn and others—all native. A drought of this magnitude, where forests mortality has been so high, has not happened in the historic record. It is hard to say how many of these trees will live because we have never seen this sort of thing happen before. Those trees that do survive will continue to have an enhanced risk of disease and infestation for decades because of the long time frames needed to recover from a drought of this magnitude. Ultimately, many of the survivors will die of complications.]

Lake Travis is our drinking water source. It was 100 percent full as recently as May 2010. Travis is at its third lowest level or as low as it has been in 47 years. The only reason that it is not the lowest level ever though, is that prior to 47 years ago Lake Travis was used extensively for hydropower generation. This has not been done since that time so all of that extra water stays in the lake.

What are we gonna do? Getting through the drought and fires is very important. This situation is extremely dangerous. Trim your trees, police your underbrush, move that firewood pile away from the house, get your valuables together in a "go-bag."

The threat of suburban and even urban firestorms, as demonstrated recently in Bastrop and accidentally predicted, to the weekend by our State Climatologist, is real and it is not likely to get better for another year. The future is here now. We must change the evolution of our society fast, before we run completely out of water. Prehistory tells us that these abrupt climate changes can be exceedingly violent.

This is no longer business as usual. Water use restrictions will not meet this challenge alone. We must act now to convince our leaders that this is not just another in a long string of extraordinary weather events that we cannot yet be blamed on climate change. If we do not immediately change our habits and lifestyles, we will run out of water. Our forests are already dying because they have run out of water. The evidence supporting the relationship between this string of unprecedented droughts and climate change is overwhelming. This is what I will report on in the next two parts of this discussion.

Now: if you have read this far, you deserve a break. The bigger picture is a little more comforting than what is happening in our region today. I just finished another book by Dr. Richard Alley, one of the pivotal climate scientists of our time. Professor Alley tells us in Earth, the Operators Manual, that fixing our climate will be no more difficult or costly than creating our society's wastewater collection and treatment infrastructure.

Cleaning up human waste took about 100 years and so will fixing our climate. It took about one percent of global gross domestic product (GDP) to install our toilets and sewer treatment plants and this is close enough to the latest economic analyses of dealing with climate change to make the comparison valid. One percent of global GDP is almost exactly the same amount of money as the U.S. spends on its military every year, not counting wars.

But please understand that our climate scientists have been warning us for more than 20 years that as we continue to delay we will see the costs and impacts grow larger faster.

You can see Melton's climate change outreach, films, writing and music at www.meltonengineering.com Bruce's new book, Climate Discovery Chronicles, detailing 41 recent discoveries in climate science with 100 color photos, was published in November and is available on line at Amazon and Barnes and Noble and can be ordered from your favorite bookstore in town. For more information go to: http://www.meltonengineering.com/Climate%20Discovery%20Chronicles%20Book%20Series.html

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Welcome to Climate Change: Part Two

Bruce Melton PE

[Caption: Downtown Austin seen from near the intersection of Loop 360 and US 290/71 West. This photo was taken in early September 2011. The brownish yellow and red leaved trees in the left and bottom right foreground are elms. They naturally shed their leaves early during our hottest summers and September is still summertime in Central Texas! The fall leaf drop does not start until October. This year is different however. Normal drought stress creates a leaf drop where elms go dormant, their leaves yellow and fall to the ground, very similar to the normal autumn leaf drop. In this year's unprecedented drought however, many of the elms around Austin turned bright brown or reddish brown. This more than likely means they have died. In the middle ground of the photo you can also see many yellow, brown and gray trees that have already gone dormant or died. A preliminary report by the Texas Forest Service has looked at forest mortality across Texas and tells us that up to a half billion (with a "B") trees may have died in this drought.]

AUSTIN -- The driest 12 month period in Austin, since record keeping began in 1854, happened October 2010 to September 2011. The 100 degree day record was more than shattered, it was obliterated. Three times in the last six years Lake Travis inflows have fallen below the minimum levels set in the Drought of the 50s.

The Lower Colorado River Authority Board of Directors has voted to take drastic measures. They have received permission to deviate from the Water Management Plan to significantly cut back or even cut off water to farmers next year.

Obviously, this string of droughts is as bad as they come, or is it? The news that the drought will be over when La Nina goes away is ever present, but will it really go away when La Nina leaves?

And what about all this heat? What about all of these 100 degree plus days that we have had recently? How big was this 100 degree day record that we broke and how does all this unprecedented heat influence this string of droughts?

The official record shows that we beat the 100 degree day record by at least 30 percent this year. The previous top two records for Austin were 69 set in 1925 and 66 set in 1923. The state climatologist (John Nielson-Gammon) calls 2011 an outlier because we endured 21 more days of 100 degree temperatures than the previous record of 69 days set in 1925. So, what is an outlier and what do scientists do with them? Outliers are pieces of data that for some reason do not belong to the sample being analyzed. In this case we are analyzing the number of days every year with high temperatures above 100 degrees.

An example describing outliers could be the normal water level in the closed basin lakes in Nevada and Utah. The Great Salt Lake is a 1,700 square mile remnant of the great 8,500 mile Lake Lahontan from ice age times. Lake Lahontan grew and shrank maybe dozens of times over the last 100,000 or so years. The evidence is clear in the raised beaches hundreds of feet above the existing water level and the submerged forests of preserved stumps hundreds of feet below current water levels.

The Great Basin has no natural discharge in this area so the level of Lake Lohontan is an indicator of how much precipitation falls there. When the climate was really warm (like today) or really cold, like any of the two dozen or more abrupt climate changes over the period, rainfall was low. Statistically, rainfall data from the wet periods would be deemed outlier if they were mixed in with rainfall data from the dry periods. Different climates create different data. Another example would be a broken thermometer. If it is 165 degrees in February, something is broken.

Our State climatologists calling the 2011 heat wave of 90 days of 100 degree plus temperature an outliers means that this piece of data is suspect and is likely the result of an error or fundamental system change. The years 1923 and 1925 were certainly hot, but surrounding weather stations from Del Rio to Dallas come nowhere near the intensity of heat experienced at the Austin weather station.

Has our regional climate seen a fundamental change? Why did this outlier occur and what does it mean? What's up with 1923 and 1925? To try and answer these questions we need to first clean up the rest of the data. If we look at 100 degree days before the year 2000, we find that 1923 and 1925 were 65 and 73 percent greater than the 3rd ranked most extreme summer ever recorded in Texas. So if 2011's 90 days of 100 degree heat was an outlier, and 2011 was 30 percent greater than the previous record, then 1923 and 1925 are outliers two times over!

Now you are thinking, why did I say before 2000? The weather really started freaking out about the turn of the century. This is when "The Big Melt," as the climate scientists call it, started in Greenland. It's when the great pine beetle pandemic in the Rockies really got going. Just a few years later is when we started having snowmaggedons and snowtastrophes in the northeast and northern Europe where Arctic warming has enhanced the jet stream increasing winter storms across the Northeast and other areas.

100 Degree Days Austin Prior to1999		
Rank	Days	Year
1	69	1925
2	66	1923
3	40	1963
4	38	1998
5	34	1956
6	34	1924
7	33	1951
8	32	1980

The ranking of 100 degree days in Austin prior to 1999 shows that the tremendous gap between the 1923 and 1925 records and the rest of the pack. These records stood for 75 years. But if you disregard the 1923 and 1925 outliers, seven of the top ten 100 degree day records have been set since 1998.

100 Degree Days Austin		
Rank	Days	Year
1	90	2011
2	69	1925
3	68	2009
4	66	1923
5	50	2008
6	42	2000
7	40	2001
8	40	1963
9	38	1998
10	34	2006
11	34	1956
12	34	1924
13	33	1951
14	32	1980

Beyond rational association, as well as using statistical data validation tools, it is significantly likely that these two records are in error for some reason and should be ignored. When the true nature of the 1923 and 1925 records is understood, the incredible record smashing that we thought happened with 100 degree days in 2011 more than doubles! What I am getting at here is that we have likely crossed one of those climate thresholds the climate scientists keep talking about.

Does more evidence cast doubt on the 1923 and 1925 records? The years 1922, 1923, 1925 and 1926 are incomplete. They have a lot of missing data. These are the last years in the record to have missing data and there were no years for the previous 18 years that had missing data. Prior to 1903, years with missing data were much more common.

Then there are the rainfall records. Rainfall is an excellent indicator of extreme heat. The hotter it is, the greater is the evaporation and the drier things are. This allows the temperature to become even hotter because moisture in the air prevents the temperature from going even higher. It's a feedback loop. Nielson-Gammon says that the extreme heat was responsible for 90% of our unprecedented heat records in Texas in 2011 and that climate change was only responsible for 10% (0.5 degrees.) (Nielson-Gammon's 90% is 4.9 degrees out of the 5.4 degrees Texas' temperature was above average in the summer of 2011.)

[This visually startling photo was taken in southwest Austin. These trees are young elms and they have very likely been killed by the drought and have not just gone dormant. They are maybe fifteen to twenty years old. The photo was taken in mid-September and these trees normally do not ever turn this color especially at this time of year. When these trees go dormant, their leaves yellow, not redden before they fall. Young trees are especially susceptible to the effects of drought because of their immature root systems. It is also important to note that the 500 million trees killed by the drought, cited by the Texas Forest Services, are all trees with a trunk diameter greater than 5 inches. None, or very few of these trees, or countless others across the state come close to five inches.]

Based on numerous evaluations of ongoing climate changes from Stanford, Purdue, the National Center for Atmospheric Research (NCAR) and the U.S. Global Change Research Program (USGCRP), Nielson-Gammon's evaluation is dated. According to the IPCC and the Climate Change Congress in Copenhagen, our climate is progressing along the worst-case scenario.

These assessments and evaluations (Diffenbaugh and Ashfaq 2010) show that we can expect the hottest season experienced since 1950 (including the drought of the 1950s) to happen two to three times within the next century, four to five times in the 2020s and largely become average conditions after 2030.

Aigou Dia (NCAR) tells us that we will see Dust Bowl conditions as the average climate across much of the nation by the decade 2020 to 2030. By 2030 to 2040, Dia says the Palmer Drought Severity Index for most of the country will be worse than during the Dust Bowl, with some parts of the country being unimaginable worse than the Dust Bowl.

The USGCRP, founded by President Reagan, says that Austin will be nearly 50 percent hotter than the Sonoran Desert Researcher Station (the one with the giant saguaro cactus outside of Tuscon) beginning about 2080. We can expect every year to have 90 to 120 days of 100 degree heat. The average number of days of 100 degree plus at the Research Station is 87. In Austin the average number of days over 100 degrees is 11.

Also remember, the three studies above are an excellent demonstration of the "conservative climate science" reality. All three (as do almost all climate research) show the results of modeling that is based on the A1B scenario. This scenario is what is commonly referred to as the "most likely" scenario. It is one where we follow a path similar to Kyoto. This is the climate path that we were expected to follow. But the United States refusal to ratify Kyoto, as the only nation on the planet to do so, has almost certainly relegated the A1B scenario to the infeasible category. The path that our actual global emissions are on is the A1FI (Fossil Intensive) scenario, otherwise known as the worst-case scenario. So as outrageous as it sounds, these projections are conservative—impacts will likely be more extreme.

Back to last summer: Rainfall makes a huge difference with summer temperatures. May, June and July of 2008 saw 22 inches of rain. That summer we only experienced three days of 100 degree heat in Austin.

The second driest period of the drought of the 50s had just an inch more rain than we had here in 2011 (1956 at 12.2 inches) and they had 34 days of 100 degree heat. We had nearly three times that many days over 100 last summer with virtually the same rainfall. What about the big heat waves in 1923 and 1925?

100 Degree Days City	in 2011	Previous Record
Dallas/Fort Worth	71	69 in 1980
San Angelo	100	60 in 1969
Abilene	80	46 in 1934
Wichita Falls	100	79 in 1980
Midland	65	52 in 1964
Lubbock	48	29 in 1934
Childress	99	71 in 1934
Austin	90	69 in 1925
San Antonio	57	59 in 2009
Del Rio	85	78 in 1953
Houston	46	32 in 1980
College Station	68	58 in 1917
Laredo	145	115 in 1998
Victoria	57	47 in 1912
Waco	89	63 in 1980
Amarillo	50	26 in 1953

In 1925 we had almost 13 inches of rain. This was great for the heat wave inducing temperature feedback that supposedly produced 69 days of 100 degrees plus temps that year. But what happened in 1923 with 66 days over 100? It rained 51 inches in 1923! Why in the world were there so many 100 degree days in that year? May through August 1923 had 6 inches including 3 inches plus in July. February through April saw 12.5 inches. In 1923 there was no extreme dryness contributing to the 66 days over 100 degrees supposedly recorded.

The years where 100 degree days do not match up with extremely low rainfall in the record are too numerous to print here. The relationship that our State Climatologists talks about simply is not well supported. So glaringly, there is a problem with Nielson-Gammon's hypothesis. Extreme drought may be responsible for the heat wave feedback, but it does not appear to have a definitive relationship with the 14 most extreme 100 degree day years in the record. What about the rest of Texas in 2011?

The only number 2 ranked record was San Antonio. They had 57 days of 100 plus this year, second to 59 days they endured in 2009. Prior to 1998, the most San Antonio had seen was 33 days over 100 in 1948. All the rest suffered through the hottest summer ever. A few of them shattered their previous records. The

remainder annihilated their records. But most important for this discussion, notice how the 1920's are completely absent from the previous record list except for Austin.

Even if Austin's 1923 and 1925 records are absolutely valid, something big has happened across Texas. Have we really crossed a climate threshold? As unambiguous as all of these obliterated 100 degree day records seem to be, it may be decades before we know. Remember when the climate change debate began 30 years ago and the climate scientists said it could be 20 or 30 years before we knew for sure if it was real? Same smell here. A scientific certainty requires lots of data.

Scientific truths and moral truths however, are very different things. A murder suspect sentenced to death based on circumstantial evidence ... is sentenced to death by moral truths. But circumstantial evidence -- moral truths -- are almost never allowed in science.

Climate scientists have been telling us for nearly three decades that these kinds of things would happen: that the weather would become more extreme, that droughts would become the norm, that extreme heat waves would surpass all heat waves of the past, that we would see desertification and forest die-off, agricultural failure and unimaginable water shortages. They told us that all of these things would be unprecedentedly extreme. They have been telling us that the longer we delayed the greater would be the extremeness of the changes that we would have to endure. They told us that it was not the average temperature increase that would be the problem, it would be the extremes.

Many of us have heard by now that it was much drier during the droughts of the 1600s, 1700s and 1800s before reliable record keeping began in Texas. These droughts however, do not hold a candle to what scientists have discovered to be true "megadroughts." Two of them happened between the 900s and about 1350. These droughts saw rainfall drop to 25% of normal and they lasted for centuries -- hundreds of years! These periods were when Lake Lahontan dropped so low.

There is also evidence that large portions of the Great Plains desertified, changing to a sea of shifting sand. This desertification was much larger than that at the turn of the 19th century that fostered the term "Great American Desert."

Sure, there have been bigger droughts and bigger fires in the early 1900s or the 1800s or the 1300 hundreds or 3,000 years BC, but our complicated society did not have 1.7 million people in the Austin - Round Rock Metropolitan Area then. Now the climate scientists are warning us of upcoming weather far more extreme than our civilization has ever experienced.

This is no longer business as usual. We have to do something. The only way that we are going to overcome the momentum of political ignorance though is for each and every one of us to do something. I'm not talking about fluorescent light bulbs or Priuses. Each and every one of us *CAN* make a difference. Contact your local, state and national leaders and tell them to listen to what the people, not corporations, are telling them to do about our climate. Tell them that this is the single most important issue of our time and they need to treat it like it is so.

Tell them what professor Alley says in his book *Earth: The Operators Manual*. Alley says that fixing our climate will be no more difficult than creating our planetary wastewater collection and treatment infrastructure. Then tell them that those who say it will ruin our economy are the same ones who tell us that climate change is not real, it is not bad, it is good for us or it is a world-wide conspiracy by almost all climate scientists. And ask them why is it that we still believe these climate change deniers when they tell us the solutions to the climate challenge will ruin our economy?

Bruce Melton is a professional engineer, environmental researcher, filmmaker, writer and front man for the band Climate Change. You can see his climate change outreach, films, writing and music at www.meltonengineering.com Bruce's new book, Climate Discovery Chronicles, detailing 41 recent discoveries in climate science with 100 color photos, was published in November and is available on line

at Amazon and Barnes and Noble and can be ordered from any bookstore through Ingram Publishing. For more information go to:
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Welcome to Climate Change Texas: Part Three

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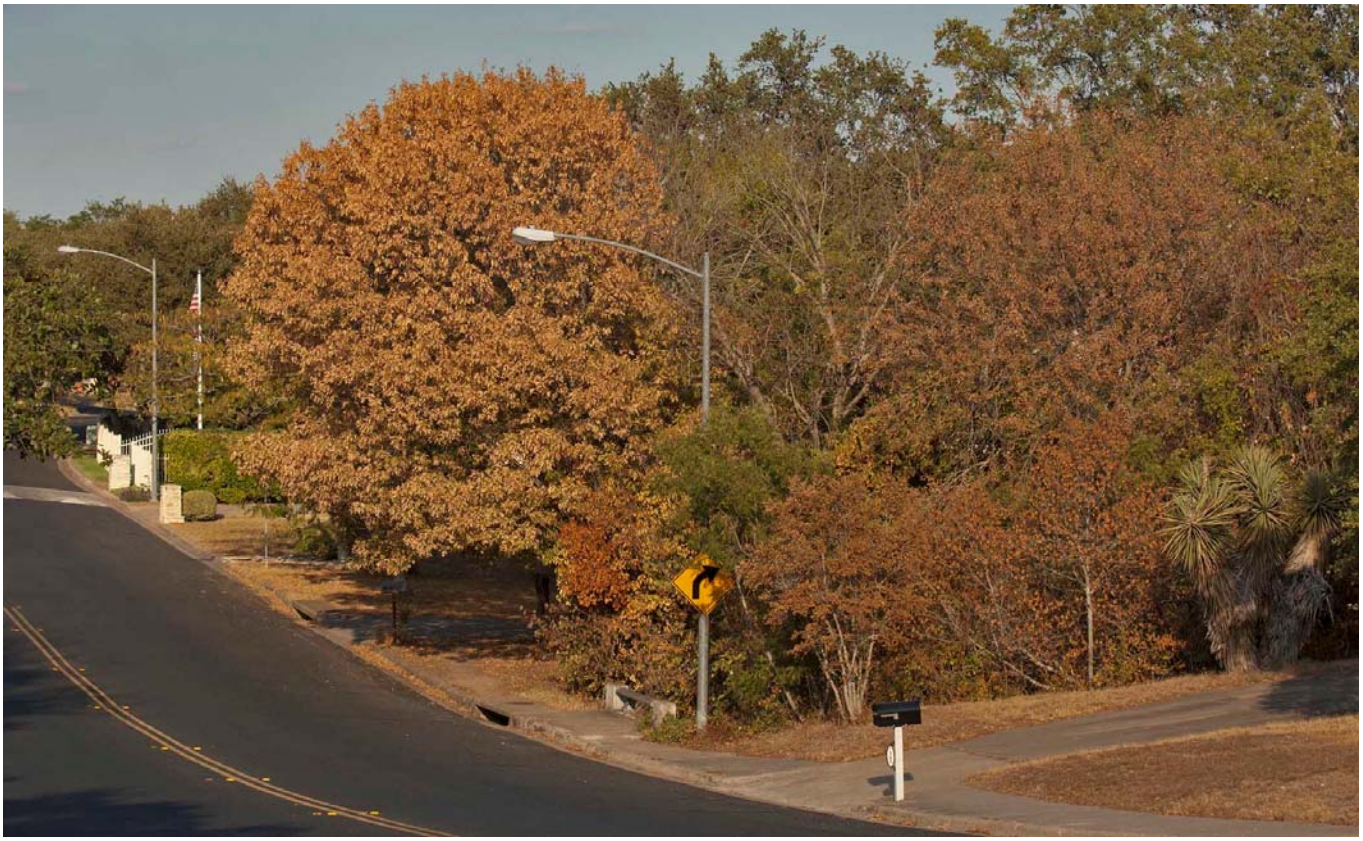


[Caption: What a mess. Even without the fires, our natural environment has been devastated by these droughts. This scene was taken in late August just around the corner from my house in southwest Austin. Fortunately I have only lost a handful of immature trees and a few 12 foot shrubs.]

Austin -- The Texas Forest Service tells us that a half a billion trees are dead across Texas. The drought and heat that killed them was similar to the heat wave in Moscow (central western Russia) in 2010 that killed 56,000 and created $15 billion (US$) in damages. Academic evaluation of the (Russian) event shows it was 80 percent caused by climate change.

Damage to agriculture and from the drought tops $10 billion here in Texas with another billion and a half in fire damages. Thankfully, the deaths were not near as high here because of the predominance of air conditioning in the drought area in Texas and the Southwest.

As I have been saying in the first two installments of this series, climate change is already much more extreme than most scientists have been predicting. This is mainly because the majority of predictions are based on the “most likely” emissions scenario and because we have not reduced our emissions like climate scientists told us to do we are now on the worst-case emissions scenario path. The bad comes with good though. The solutions to climate change are going to be much less difficult and costly than have been popularized. I will get to the cost and difficulty aspect in a minute but first; one of the biggest reasons that climate change is much more extreme than we thought would be that almost all of the predictions have been based on the “most likely scenario. This “most likely scenario” is just one of about

28 computer scenarios that climate scientists use in dozens of different climate models to look into the future.

The "most likely scenario" sometimes known as the "middle of the road scenario" is roughly based on Kyoto. In other words, if we would have started reducing our greenhouse gas emissions when the consensus of scientific knowledge said we should, these droughts and heat waves would not have happened. Climate scientists began warning us about dangerous climate changes if we control our emissions levels in the mid 1970s. By the time the Rio Earth Summit happened, the modelers knew that the safe zone was likely one with a carbon dioxide concentration similar to that of the 1980s at the most.

KYOTO: The Kyoto Protocol started at the Earth Summit in Rio de Janeiro in 1992 and all 154 member nations had signed by 1997. Climate scientists' began their official warnings in the late 1970s and early 1980s.

Instead of listening and acting though, our emissions have grown fifty percent greater than 1990 levels. And unexpectedly in 2011 (climate scientist warn us that these unexpected things will happen more frequently) annual global emissions rose to six percent--a level not seen since 1970. This is why we are on the worst-case scenario path. Along this path we should expect weather to be much more extreme. We are nearing the point where our already changed climate could be considered dangerous, maybe we have passed it.

The links to climate change are being made in the scholarly findings at an increasing rate. A summary of such works prepared by Kevin Trenberth and a roster of distinguished colleagues summarizes 61 scholarly findings since the turn of the 21st century. The conclusion of the paper reads:

> Human-induced climate change has contributed to changing patterns of extreme weather across the globe, from longer and hotter heat waves to heavier rains. From a broad perspective, all weather events are now connected to climate change. While natural variability continues to play a key role in extreme weather, climate change has shifted the odds and changed the natural limits, making certain types of extreme weather more frequent and more intense.

It is no longer valid to say that we cannot blame any one individual weather event on climate change. From statistical evaluation of historic weather events to the results projected from computer climate models our scientists can now say that climate change is to blame for the ultra-extreme weather we have been having. The models show that without our climate having changed already, the costly snowtastrophes in the Northeast and northern Europe would not have happened; billions of trees would not have died in the Rockies because of a native beetle infestation gone berserk; billions of trees would not have died in the Alaskan boreal forest because of extreme fires caused by warming; and billions of trees would not have died in the Amazon because of drought—the results being annual greenhouse gas emissions from the Amazon alone equal to three-quarters of annual U.S. emissions.

Part of the reason that climate scientists can say this with certainty is that their computer models include these unprecedented events, whereas when they run the models without the extra greenhouse gases emitted by our civilization, these unprecedented events do not appear.

How do the scientists know their models are accurate when weather forecasting models so often fail after only four or five days? Climate models show us that they are much more accurate than weather models

because climate scientists can start them up in the ancient past and recreate climate faithfully according to evidence from ocean and lake sediments, ice cores, stalagmites, tree rings, pollen records, fossil shells, soil carbon.

But climate models and weather models are basically the same aren't they? Yes they are, but climate modelers run dozens of models for hundreds or thousands of years with varying input criteria and average the results all together to get climate. (These are called ensembles.) The key here is that climate modelers average their results of many different model runs together. Weather forecasting models used by meteorologists in what is in reality a very different field of science than climate, only run one or a few models and then hope that by the fifth day the chaos has not left their seven day forecast in shambles. The two modeling techniques could hardly be more different. For climate, the averaging of so many different model runs together makes the chaos (or inaccuracy) of weather models moot.

Our climate scientists have known since the beginning that climate change could certainly be as bad as it is now, this was evident by the results of their worst-case scenario model runs as well as the vast amount of evidence of radically abrupt climate changes in ancient history. To prevent these worst-case impacts from happening though, climate scientists expected us to take their sage advice and do something.

Instead we have done almost nothing. But in this realization we must understand that our innocence in this affair is real. The counterituitiveness of climate change alone is enough to create a great debate, never mind the doubt spread by vested interest in the form of negative false propaganda about climate science, and even personal attacks against individual scientists. These tactics are virtually identical to past deceitful propaganda campaigns concerning acid rain, ozone depleting chemicals, pesticide reform and smoking. In many cases these campaigns were perpetrated by the same institutions and individuals who are attacking climate science today.

So our climate scientists said that if we did nothing, things would be much worse, that our bread basket regions would change to deserts, that wildland fires would increase dramatically, deaths from heat skyrocket, insect infestations would cripple ecosystems, feedback mechanisms would kick in and there would be war over resources. They told us these things would happen much sooner if we did nothing whereas if we reduced our emissions we could likely forego these things altogether.

Surprise! All of this has now happened or is in progress. We did nothing and our emissions path is along the worst-case scenario. Civil war in Somalia has been the latest to be added to the lists of things that have been caused by climate change, so said the head of the African Development Bank last August.

Climate scientists have been telling us for a long time and they continue to warn today, that it *will* get worse faster. They are now telling us that the threshold to dangerous climate change is no longer 2 degrees C of warming, but one degree C. Two degrees should now be considered the threshold to *extremely dangerous climate change*. The 2001 IPCC repot told us that 550 ppm CO2 was the safe limit in our atmosphere to hold our temperature down to 2 degrees C of warming. The 2007 IPCC report pushed that down to 450 ppm. Since the 2007 IPCC report, some of the most distinguished scientists in the world have been telling us that 350 ppm CO2 is the safe limit and now, the latest papers from the scholarly journals tell us that 300 ppm may be the safe limit. (We are current at about 392 ppm and in preindustrial times it was about 280 ppm.)

Why? Because we didn't do what the climate scientists told us we should do. We are on the wrong path.

What we are seeing across the globe today with these unprecedented and extreme weather events is the beginning of dangerous climate change. It is now indisputable and if we do not act fast, impacts will be unimaginable. Which leads me to my second message from the world of academia:

The solutions will not be as difficult or costly as what the public understands.

Fixing our climate will be no more difficult than installing toilets across the world like we have done over about the last 100 years. It will cost no more, and in what is becoming an indisputable truth, it will be vastly profitable for our society.

Why is this message so different than the one we have all heard? The answer rolls back to those moneyed interests and their propaganda. A few simple statements explain this conundrum clearly: The same voices that simultaneously bring us the radically different and designed to be confusing talking points that: climate change is not real, it is all just a natural cycle, it is a scientific conspiracy and that it will be good for us are the same voices that tell us that the solutions to climate change will ruin our economies.

It is very simple. Not only are these voices telling us all of these vastly conflicting things at the same time, but they were wrong about the causes and effects of climate change. So given the conflict, and the accuracy of these voices and their "beliefs" about the sciences of climate, why would their "beliefs" about the solutions to the climate crisis be any less wrong?

Climate scientists are saying nothing about the solutions ruining our economies. The academic evaluations of the economics of the solutions to climate change do not tell us anything like what is so prevalent in the public's understanding. All of this darned propaganda and counterintuitivity is blotting out the truth. The climate scientists do not have the resources to mount an outreach campaign anywhere close to the size and extent needed to counter the efforts by the "voices."

The most current assessments of the cost and scope of fixing our out of control climate tell us that it will take about one percent of global Gross Domestic Product (GDP) per year for a hundred years to create the infrastructure needed to clean up our greenhouse gas pollution. This is a very similar to the installed costs of toilets and wastewater collection and treatment systems around the world today. Now listen up, it took me weeks for the reality of this statement to set in; Climate scientists are telling us that the solutions to the climate crisis are not really so different from the solutions to the toilet crisis.

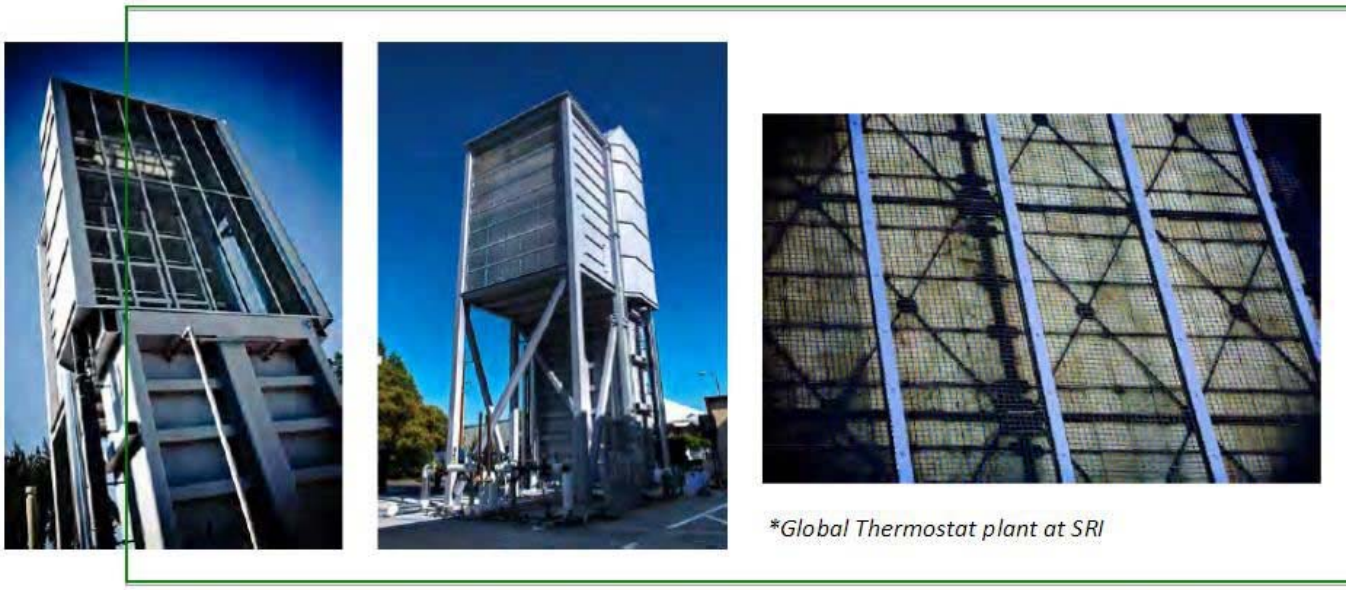
Another excellent example of the scope of the challenge ahead is the Great Wall of China. Our civilization has built many things of the scope of what needs to be built to remove our greenhouse gas pollutants from our atmosphere. If it is hard to visualize all of the toilets, pipes and treatment plants, it is not too hard to visualize the Great Wall of China.

[Willie Nelson's Biodiesel Plant at Kline's Corners, 80 miles south of Dallas. Biodiesel will play a roll, just as solar concentrators, algae, tidewater generators, wind, hot/dry geothermal, wave power, photovoltaic, fuel cells and goodness knows what else.]

A few simple chemical processes, based on those that are widespread in industry today and simpler than that used to create biodiesel would be all that are needed. The technology is officially called air capture and mineral sequestration and it is really nothing more than mining carbon from the sky.

Think of thousands and thousands of railroad boxcars lined up end to end, something the size of the Great Wall of China (which was built by hand, over several different periods totaling much less than a hundred years). Each one of these boxcar sized processes would capture CO2 directly from the atmosphere. A couple of scientists from Columbia University, and Gary Comer's foundation (Gary Comer was the founder of Land's End), have developed and scale tested a process to do just this. Another outfit called Carbon Engineering has done the same thing. Another called Global Thermostat has done the same. What's more, these technologies can very easily be retrofitted onto existing coal fired power plants or industrial processes creating a sequestration solution much less expensive than what ongoing developments in the energy industry suggest.

All of these individual boxcar sized processes, in another example, are probably no larger than the size of all of the chemical plant installations at the Ship Channel complex in Houston. These facilities could remove half of the total carbon dioxide emissions created by all of us earthlings every year. (Why half? Efficiency gains and carbon source capture at power plants can be done, but point source capture from all



[Global Thermostat is another start up that uses a proprietary fluid to create a more efficient process than has traditionally been available. The feasibility of these processes is certain. It is the motivation of our leaders that is uncertain.]

transportation sources, or energy lost due to inefficient buildings cannot yet be done on this planet. We must use air capture if we are to get our CO2 emissions down anywhere below about 50 percent of what we emit. This is a very simple piece of the puzzle that is not taken into consideration almost exclusively by the politics of climate science.)

The final costs would be far, far less than the cost of building all of the coal fired power plants on Earth alone, much less the vast network of hundreds of thousands of miles of power lines used to distribute the energy that we needed to achieve the greatness of our civilization. Another comparison would be that the total disposal costs of all of this CO2 pollution would be far, far less than what were required to build all of our roads and gas stations.

But, what about that two-year study by the American Physical Society (APS) last summer? The press release, not typical of the Massachusetts Institute of Technology, called our air capture scientists “snake-oil salesman.” The APS’s widely publicized findings appear to show that air capture is actually 20 times more expensive than the air capture “snake-oil salesman” would have us believe (the press release actually said that.) So the public now understands that air capture snake-oil salesman now have no more credibility than some product on the shopping network that promises to be both a floor polish *and* desert topping. At least, this is the reporting we get from the conservatively controlled megamedia

conglomerates and from the “voices” that would have us believe that climate change is simultaneously “not real”, a “conspiracy” and “good for the planet.”

What “the voices” and the media do not tell us however is the APS study simply did not look at any processes other than traditional ones—and the authors of the study tell us so. The study also falsely leads us to believe that there are no current pilot processes in existence, an observation easily argued with a quick Googling of the subject. What the study should possibly have said is that there are no pilot study processes in existence that use the traditional costly process that they evaluated. The traditional processes use giant fans to move air, highly caustic lye or expensive synthetic chemicals to capture CO2 and 350 to 800 degrees of heat to regenerate the capture chemicals. The alternatives used in the actual pilot processes already constructed and proven in the field often use the wind for moving air, require chemicals that are much less caustic and use room temperature reactions, or temperatures less than the boiling point of water to regenerate the absorbing materials. The Lackner model, being developed by Kilimanjaro Energy, uses a simple everyday plastic material to absorb carbon dioxide and water to release the carbon dioxide from the plastic. These are all very simple ideas and they have been proven with scale tests to be affordable. The Lackner model for example costs about $30 to remove a ton of CO2 and this cost will likely fall drastically with massive industrialization.

[Air capture technologies exist. They use what I like to think of as “organic” techniques that have 20 times less energy requirements than traditional atmospheric CO2 capture technologies. These new techniques used to accomplish a traditional process will become far more widespread if we could just start investing an appropriate amount of resources into finding solutions. The popular understanding that the solutions to climate change will ruin our economies is a manufactured belief, unfounded in science.]

So just to be clear, why does this big two-year study tell us that the costs are $600 a ton? It is because the new air capture technologies have not been published in the peer review literature. The developers of these technologies are concerned that this would compromise their secret processes. The APS study simply looked at using the old highly caustic lye process, using big fans and 800 degree regeneration temperatures. But did the media tell us this? No. Did the “voices” tell us this? Certainly not!

There will be billions of dollars to be made from these processes in the very near future. Statoil in the North Sea has spent $80 million to build a plant to capture and inject supercooled quasi-liquid CO2 deep beneath the sediments of the North Sea to avoid a $50 a ton carbon tax in Norway. The CO2 is coming from natural gas Statoil is producing. The process sequesters a million tons of CO2 per year and its development and installation cost was paid back in less than two years. Another very

important thing to remember is that Statoil uses the traditional expensive air capture process and 800 degree regeneration temperatures.

Once the CO2 is captured from the air it must be disposed of. How does one dispose of 10 gigatons of carbon every year? One of the best ways takes the solid carbonates collected with the new air capture techniques and piles them up in mountains at the collection site. This is an immense job, but one that is done every year at a coal mine near you.

In a little more detail, 10 gigatons of carbon turns into 30 gigatons of calcium carbonate or limestone. Changing carbon dioxide into limestone is also a much more permanent way to solve the problem than disposing of (or storing) the gas underground. We mine 7 gigatons of coal to feed our power plants every year. Much of this mining is from pits or mountaintops. The amount of rock and soil that must be removed to get to the coal is usually much more than the amount of coal mined itself, so the total amount of material moved is far larger than the 7 gigatons that we mine. We would be coal unmining on a scale that at the most, is as large as the coal mining industry today.

A big job this certainly is, but comparing it to something known really gives us a sense that somewhere, somebody has been getting their facts confused. Another comparison is even simpler: Why don't we visualize all of the CO2 pollution emitted by humans every year and compare it to all of the human waste pollution created every year? I am talking about those wastes from human bodily functions that go into our sinks and toilets and then miraculously and thankfully vanish from our lives.

The amount of carbon dioxide, converted to liquid that we emit globally every year would cover the island of Manhattan to the 85th floor of the Empire State Building. If we collected all of the toilet and other wastes that flow into our wastewater collection systems every year, just in the United States, the amount would be far above the top of the antenna on the Empire State building (eeeewe.)

Real costs are hard to say, sort-of like predicting the cost of wastewater treatment today as we sat in our outhouses a hundred years ago (eeeewe.) The best knowledge we have though tells us that $0.25 to $0.50 per gallon of gas would do the trick. This would be $20 to $30 per ton of carbon. In the North Sea, Statoil has proven the feasibility and profitability of disposing of a million tons of CO2 a year to avoid Norway's $50 a ton carbon tax which is equal to about $0.50 per gallon of gasoline.

Yet another example comes from one of the most important climate scientists of our times: Wallace Broecker at Columbia University. Broecker has been instrumental in explaining ocean current processes and their relationships to past abrupt climate changes. Broecker is a great proponent of this process of mountaintop reinstallation called atmospheric capture and mineral sequestration. He says that if we used wind energy to substitute for coal, it would take an area of wind the size of a barn to provide enough electricity for the average family for a year. Compare this to the cost of burning coal and *then* removing the carbon dioxide from the atmosphere. The amount of energy needed could be thought of as being the same as the wind can generate through a barn window! The cost is something near 170 times less!

My story has strayed a bit from the current climate change impacts in Texas, but the solutions to the climate change challenge are just as important as understanding that climate change is real, it is happening now and it happening along the lines of the worst-case scenario. The reason the solutions are so important is the broad understanding that the solutions will ruin our economies. To understand why the propaganda has been able to so heavily influence society is a topic that I have barely skimmed, but is well documented

in many books (see references) and articles (my own and many, many others) citing public tax records from the Internal Revenue Service showing who donated how much to what institutes supporting beliefs contrary to the consensus of climate scientists. And once again, understand that the vast majority of folks supporting the non-climate change position base their beliefs on the positions of their authority figures. These good folks, including most of their authority figures, are innocent.

Our great innocence in this matter does not change reality though. We are polluting, but we are not paying. One percent of global GDP per year is what the scientists and economists are focusing on as the cost of fixing climate pollution. Professor Richard Alley of Penn State and one of the coolest ice science geeks on the planet tells us there are about 100 economic assessments of the solutions now. One percent of GDP is about $600 billion a year, or about as much as the annual U.S. military budget—*without wars.* We simply need to help our leaders understand that the risks from climate change are at least as high as the risks from war. Having the courage to spend the money is easy once the real risks are known.

So make those calls and write those letters and talk with your friends and neighbors and get downtown and stand with the Occupy Movement. The only way to beat the propaganda, the counterintuitiveness and the pure innocence of ignorance is through a groundswell of activism and a transfer of knowledge. This is real, we are responsible, we must provide the solutions, the solutions are already devised and waiting for industrialization and the costs and difficulty will be no greater than many other things our civilization has accomplished.

And always remember that these "easy" solutions to the climate change challenge do not give us the right to emit *more* pollution, any more than toilets and wastewater treatment systems give us the right to make more of that kind of pollution. One more thing: greenhouse gas pollution is very much like that "other" type of pollution. It is an intimate part of our lives and it will not go away by itself.

Bruce Melton is a professional engineer, environmental researcher, filmmaker, writer and front man for the band Climate Change. You can see his latest climate change outreach, films, writing and music at www.meltonengineering.com Bruce's new book, Climate Discovery Chronicles, detailing 41 recent discoveries in climate science with 100 color photos, was published in November and is available from Amazon or Barnes and Noble's website. It can also be ordered from any bookstore through Ingram Publishing. For more information go to: http://www.meltonengineering.com/Climate%20Discovery%20Chronicles%20Book%20Series.html

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