

Diagnosis Earth: The Climate Change Debate

by William R. L. Anderegg

Note: William R. L. Anderegg and Stephen H. Schneider agreed to co-author this article for Thought & Action earlier this year. Sadly, Dr. Schneider passed away in July before the article could be completed. William Anderegg finished the piece and has dedicated it to Stephen Schneider's memory, noting his contributions to the field of climate study and his passion for teaching.

“*M*an-made global warming is a hoax.” The expression gets bandied about everywhere from daily conversation to commentators on mainstream news, from the vitriolic blogosphere to the only-slightly-more-civil U.S. Senate floor. Yet, for all the rhetoric and raised voices, where do climate scientists actually stand? In the scrum of popular and political discourse on global warming, the scholarship of climate science is often left sitting on the sideline. Yet understanding the science and the scientists presents our best chance of developing an informed opinion about climate change. Confusion about the science, misunderstanding of risk assessment and management as they apply to global warming, and either a lack of knowledge about who the experts are or a mistrust of these experts, all hinder our understanding and response to the threat of global warming. Along with a leading climate scientist, Dr. Stephen H. Schneider, and two co-authors, I recently published a study in the Proceedings of the National Academy of Sciences, entitled “Expert Credibility in Climate Change,” that

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examined where the climate scientists stand and the credentials of all those claiming expertise in the climate system, including those who doubt man-made global warming. In addition to understanding the experts, however, we must also consider the roles of expert perspective, risk assessment, and risk management in our societal decisions on global warming.

Regarding climate change, scientists have reached several very well-accepted conclusions. In 2007, prior to winning the Nobel Peace Prize, which it shared with

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Al Gore, the leading international scientific panel on climate change, the Intergovernmental Panel on Climate Change (IPCC), sent a resounding message to the world. The panel wrote:

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level... Most of the observed increase in global average temperatures since the mid-20th century is very likely [>90% chance] due to the observed increase in anthropogenic greenhouse gas concentrations.¹

The IPCC reached these two conclusions—that global warming is unequivocal and, with more than nine out of ten odds, due mostly to human-emitted greenhouse gases—from reviewing thousands of peer-reviewed studies. While these conclusions are clear, the persistent problem in public comprehension of the threat of climate change lies in a misunderstanding of expert knowledge, as well as risk assessment and management as they relate to global warming. To get a better sense, consider a parallel case involving personal medical decisions.

During a routine examination, your doctor finds a suspicious lump. A few anxious weeks later, the biopsy comes back with ambiguous results—it might be cancer or it might not. Suddenly, you are faced with a terrible set of possibilities—and choices. One thing is very clear: your life could be at risk. Most of us would take this quite seriously. We'd want another biopsy, a second set of expert eyes and opinion, and all the information we could possibly get about what was happening. We'd want to know the symptoms of the cancer, the odds of survival, the treatment possibilities, the oncologists who specialize in this cancer, and the scientific research about this cancer. Most importantly, we'd want to know whether we have

this cancer and, if we can't get a definitive answer, if we should hedge our bets with a treatment, which could be costly and painful.

When the oncologist walks into the doctor's office to offer a second opinion, we will probably listen closely. She has four years of college, another four years of medical school, several years of specialized post-medical school training and residency, and experience with hundreds of cases under her belt. In medicine, that's about the best opinion we're going to get. What if we could know more? After all, our life may depend on it. What is her success rate in diagnosis? Better yet, what if we could find out what a thousand different doctors thought about our case and

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what their diagnostic success rates were? And, finally, we'd want to recognize the importance of relevant expertise among those thousand doctors—when picking a cancer treatment, we pay more attention to the opinion of oncologists than those of pediatricians.

When you step back and consider it, we trust expert opinion and manage risk in many, many areas of our life. We get on an airplane trusting that well-trained airplane mechanics and engineers have checked over the aircraft and certified it for flight. We trust the pilot's training and experience to get us safely from one place to another. We trust our lawyer's knowledge of the legal code and seek out lawyers with expertise in the specific area of law within which falls our case. Naturally, experts are not always right, and individual experts can violate our trust, but seldom is the large body of knowledge within a community of experts wrong. In fact, the more complicated the area, and the more that rides on any decision, the more we put weight on expert opinion.

In the cancer metaphor we rely on the oncologist's expertise to answer key questions about our predicament. Do I have cancer? What happens if I don't treat it? What are the outcomes and probabilities of success of different treatments? And we use a personal risk management framework to make our own decision about what to do. Do I want to accept the risk of not treating the cancer versus the physical pain, side-effects, and cost of a variety of treatments?

For my study co-author and mentor Dr. Schneider, this situation wasn't a metaphor. In 2001, he was diagnosed with a rare form of lymphoma and given only a short time to live. Stubbornly, he refused to go gently into that good night. He worked with doctors to understand treatments, probabilities, and dosages of medication. He sought the best medical care he could get and the most special-

ized oncologists. And he exemplified living by his ideals in his cancer battle. “Am I going to apply to my own treatment the principles that I’m advising government and industries to apply to deal with climate change uncertainties?” he asked, in an interview with the National Academy of Sciences. “Hell, yes.” He focused his ever-present risk management framework on the cancer. Despite the uncertainties, he examined the probabilities and consequences of all the treatment options and designed his own treatment as a cocktail that most increased his chances of living. It worked. Recounted in his book *The Patient from Hell*, Dr. Schneider’s treatment pushed the cancer into a sustained remission, something no person had ever before done.

While Dr. Schneider passed away this July, he continues to stand as a shining example of how one person can change the world. In both his life and most recent work, he was deeply concerned about climate change in the public discourse, the role of expertise, and the power and urgency of teaching about climate to the next generation. In particular, two strategies that he championed—expert assessment of the risks and managing risks—need to be at the core of how we think about and react to human-caused global warming.

WHAT’S IN A RISK?

With climate change, just like in our cancer metaphor, we understand the basics but significant uncertainties remain about the details. How much will the planet warm? What will the impacts be on agriculture, health, national security, ice-sheets, and other species? What are the costs of slowing global warming and what are the damages if we don’t? All of these questions are complex, but our uncertainty in answering them in no way precludes the importance of taking action.



Risk is probability multiplied by consequence. We are no stranger to risks in our lives, but we can be notoriously bad at judging and reacting to some of them. For each possible impact of global warming—let's pick sea-level rise—there's a whole bell-curve of possibilities. On one tail of the curve (meaning not likely but certainly possible) is a slight increase of one to two dozen centimeters over several centuries, something that societies could handle. On the other tail (equally unlikely but possible) is several meters in the next century or two, which would be devastating to population centers, countries, and economies around the globe. But it's hardly a dichotomous choice—it's a bell-curve of possible outcomes. Some parts of sea-level rise, such as the

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thermal expansion of water at higher temperatures, are very well known and predictable. Others, like melt-rates of Greenland's ice sheets and tunneling behavior of water through the ice are not well understood, but the consequences could be dire.²

Scientists will never have the exact answers to many of these questions. They use sophisticated mathematical representations of our understanding of how the world works to model the future, but they aren't clairvoyant. They can, however, study and communicate the probabilities and consequences of events, the risk, to society. And society can assess the risk and decide how much we want to gamble with our planet's life-support system. Thus, even with uncertainty and incomplete knowledge, we can make decisions to avoid catastrophic outcomes in the future, just like our cancer metaphor.

This risk management approach is something we practice all the time in our daily lives. Dr. Schneider polled the audience at nearly every talk he gave. *What's the probability of our house burning down in our lifetime? Perhaps one percent. What are the consequences if such a fire does happen? Devastating. There's the risk. So here's the risk management. How many of us have homeowner's insurance?*

CLIMATE CHANGE IN THE PUBLIC ARENA

Here then is our predicament. Despite the accumulating scientific evidence over the past four decades, much of the American public remains confused about global warming. Many of our citizens remain unsure of whether the planet actually is warming, whether humans are causing it, and whether it might affect them. Polls typically suggest that only 40-50 percent of Americans believe that humans are causing climate change, a figure substantially below the 70-80 percent averages of all other developed countries.³

Imagine the dismay if you had to present numbers like these on lung cancer

to a group of oncologists. “Fellow doctors, we’ve surveyed the public and fewer than three in five Americans think lung cancer exists. Only a half believe that smoking has anything to do with lung cancer. Less than a quarter, even among smokers, think that lung cancer will ever be a problem for them. Many of those have been told that even if they do get lung cancer, it will be beneficial.” This is the communication disconnect and challenge that we as educators and communicators face with climate change.

At least four factors influence this confusion. First, human-caused climate change is intangible. On a day-to-day basis, we experience weather, not climate.

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Studies have found that much of what Americans believe about global warming depends on how hot a summer they’ve been having or how cold the winter is.⁴ Even trickier is that when severe hurricanes or heat-waves strike, we cannot claim climate change “caused” those events. Climate change likely contributed to the increased severity, and we will see a lot more severe weather in the future due to climate change, but nature “causes” hurricanes.

Second, the impacts of global warming are inherently dispersed and many will be in other countries. For example, the grim outlook for the world’s coral reefs, which seem likely to become highly threatened and irreversibly damaged within the century,⁵ does not concern many Americans. Even the appeal that coral reefs provide the protein sources for millions of people does not compel many people to act.

Third, the impacts of climate change will be back-loaded. Many of the worst impacts are two, four, or eight decades down the road, but we have to act now to avoid them. Because the climate system probably has thresholds and irreversibilities, we could be committed to a great many destructive impacts if we wait to act until they are upon us.⁶ Considering sea-level rise impact, scientists suspect that places like the Greenland ice sheet have “tipping points,” beyond which the sheets will melt irreversibly for centuries, committing us to meters of sea-level rise.

Perhaps the most frustrating reason that such misunderstanding persists among the public is an active campaign of misinformation funded by interests who stand to lose in a transition to cleaner energy. Modeled after the same campaign that sowed confusion about whether smoking causes cancer, and with a number of the same players, this campaign of climate change denial has been exceptionally well-organized, well-funded, and successful.⁷

The evolution of this campaign has been well-documented. Two recent books—*Science as a Contact Sport* by Dr. Schneider and *Merchants of Doubt* by Naomi Oreskes and Erik Conway—provide excellent overviews.⁸ The global warming misinformation campaign began in the early 1990s. The goal: spread confusion and uncertainty about climate change to delay regulation as long as possible. Leaked internal documents and external reported tax information reveal that the efforts were backed by companies like ExxonMobil, General Motors, American Petroleum Institute, and Koch Industries.⁹ The campaign consisted of misleadingly named coalitions, a web of conservative think-tanks, and a small

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group of vocal scientists willing to cast themselves as “experts” in climate change. Among many other efforts, this network of doubt churned out newspaper op-ed pieces, distributed strategy memos and talking points to policy-makers, sponsored full-page major newspaper ads, and sent their “experts” to appear on major news networks and Congressional hearings. It continues to do so to this day.¹⁰

JUST WHO ARE THE EXPERTS?

Given this backdrop of public confusion and misrepresented expertise, my co-authors and I felt that a crystal clear distillation of who are the experts and what do the experts believe was greatly needed.¹¹ We designed our study to directly evaluate the level of agreement and quality of expertise of a large sample of researchers claiming expertise in climate science, differentiating between those who accepted and those who disputed the view that humans are causing climate change.¹²

We first compiled the names of researchers skeptical of mainstream climate science from every public statement, petition, and open-letter that we could find. This comprehensive listing covered twelve major public declarations skeptical of climate change, each declaration claiming that the signers constituted experts in the climate system. On the mainstream side, we compiled four public statements and the contributors to Working Group I of the IPCC’s Fourth Assessment Report, the group that synthesized humans’ role in climate change. We termed our skeptical group as those researchers Unconvinced by the Evidence presented by the IPCC, or UE, and our mainstream group as those Convinced by the Evidence—CE.

While expert perspective on climate change is understandably complex and these two groups are a simplification, the groups were nonetheless meaningful, internally consistent, and largely mutually exclusive. Only three of 1,372 researchers examined fell into both groups, two of whom because the researchers unwittingly signed a statement with which they did not agree.¹³

Why use these UE and CE terms? They were both accurate and neutral in tone. All good scientists are skeptics, so the label climate change skeptic is not appropriate, nor in this case is the more technically correct label climate change contrarian or climate change denier.¹⁴

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We used metrics of expertise that are standard in the academic world for hiring and tenure decisions—researchers’ publication and citation records. We chose the broadest academic search engine available, Google Scholar, because it was available to anyone to use to repeat our study and because it was likely to include the widest range of journals. We tallied a researcher’s publications in climate as a measure of the researcher’s productivity and climate-specific expertise, as well as each researcher’s four most-cited papers, which captures an element of scientific prominence and contribution.

Much of the UE group had published close to nothing. Over 35 percent had published zero papers in climate and 54 percent had published fewer than three papers. This is a revealing result in itself, but we wanted to focus only on those researchers most likely to have relevant expertise (the potential oncologists you might listen to in our cancer analogy). Thus, we chose to analyze those researchers who had published a minimum of twenty peer-reviewed papers on climate. This would favor the UE group by removing the less-credentialed researchers who had published very little.

In our final dataset of 908 researchers, the results were striking. In ranking the scientists by expertise, 97 percent of the top 200 scientists were convinced by the evidence of human-caused climate change. The UE group had published on average half of the number of papers and been cited a fraction of the times the CE group had been. Not only could we say with reasonable confidence that climate change skeptics/contrarians represented 3 percent or less of the top climate scientists, we demonstrated using standard metrics that they simply weren’t experts in the climate system. A substantial fraction weren’t even scientists.

Several other studies have found similar results using independent and com-

plementary methods. In 2004, Naomi Oreskes surveyed all 964 papers retrieved in a different academic database under “global climate change” and found that none of them contradicted the mainstream scientific understanding of human-caused climate change.¹⁵

A 2009 study that surveyed 3,184 members of the American Geophysical Union, the world’s largest professional society of earth sciences, found that 97 percent of actively publishing climate scientists hold that human activities are accelerating global temperature increases.¹⁶ Finally, a study published this summer directly surveyed 900 American climate scientists and found similar results.

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Importantly, this level of support did not differ by age, training, institutional employer, or political beliefs.¹⁷

Naturally, this was unwelcome news in many circles. Our study was covered in many sources—*Scientific American*, *Time*, *BBC*, *New York Times*—but attacks spread like fire across the skeptical blogs. We were called McCarthyites, the global warming inquisition, and likened to the Stasi. Hate mail poured in. We, nonetheless, responded to all legitimate comments on a well-respected climate website, *RealClimate.org*.¹⁸

The most frequent criticism of our paper’s analysis attributed the patterns we found to a systematic, potentially conspiratorial suppression of peer-reviewed research from the UE group. In general, grave charges require strong evidence, and this is no small allegation. As of yet, this criticism is an unsupported assertion backed by no data. It appears highly untenable for three lines of evidence. First, our publication and citation figures were taken from Google Scholar, one of the broadest academic databases that includes in its indexing journals that are openly receptive to papers taking a different view from the mainstream on climate.

Second, further analysis of the researchers in our study demonstrated that the UE group’s background credentials, Ph.D. topics and areas of research, differ starkly from that of the “mainstream” community. Thirty percent of the UE group sample does not have a documented Ph.D. in the natural sciences, and nearly half of those in the remaining sample have a research focus in geology.¹⁹

Third, the idea that some sort of ‘group think’ drives these patterns and could exist in science in general is far-fetched. Many of the incentives in science are exactly the opposite. If you are a young researcher and had the data to overturn any of the mainstream paradigms, or what the IPCC has done, you would become famous. Every young scientist wants to be the next Darwin, the next Einstein.

WHERE DO WE GO FROM HERE?

Understanding and communicating expert opinion on climate change is only the first step on a long road. Scientists will continue to provide the estimates of risk and the diagnosis of our planet's climate, but we as a society must do the risk management and demand that our lawmakers do so as well. To address global climate change, we will need action at all levels of society, from individual choices to international agreements, from industry's technological solutions to government policy. Each and every one of us can be a part of the climate solution. I offer four concrete suggestions.

Campaigns of misinformation will ultimately fail if the public and the media critically analyze the claims and expertise of the claimants.

First, be informed. As citizens, we have a responsibility to be informed about the issues like climate change that will define the twenty-first century. Campaigns of misinformation, such as those described here, will ultimately fail if the public and the media critically analyze the claims and expertise of the claimants.

Second, be active in our democracy. We must ensure that our policymakers act in our and our grandchildren's best interest, not according to short-term thinking or the requirements of special interests. Democracy on all levels, from city ordinances to national policy, is needed to guide our nation towards environmental sustainability and climate stability.

Third, live conscientiously. Our quotidian decisions (recycling, starting a community garden, turning off unused electrical devices, and carpooling) and consumption preferences (green energy, fuel-efficient cars, efficient appliances) can directly affect change and bring a host of positive side-effects such as stronger communities, better public health, and a more competitive national economy.

Fourth, teach others. Climate change is deeply, profoundly a human story that needs teachers, mentors, communicators. For me, this message resonates especially strongly following Dr. Schneider's passing, the man who ignited the spark of academic passion and desire to make the world better within me and so many other students. We move forward by kindling those sparks, fanning those flames. We must follow his example by teaching the next generation to think critically about tough issues, mentoring them with compassion, and communicating the risks we are taking with our planet.

The diagnosis is in. Time is short. The power to shape the future lies in our hands.

Stephen H. Schneider: In Memoriam



“Men seem to be born with a debt to humanity they can never pay,” John Steinbeck wrote. The quality of the person’s gift to humanity in payment of that debt, he concluded, was the measure of the soul. Dr. Stephen H. Schneider repaid more of that debt than any person I have ever known.

In his forty-year career, Steve Schneider was at the forefront of the scientific and public battle lines in climate science. He pioneered our understanding of aerosol (soot and dust) particle and cloud-feedback effects on the climate. He continually advocated an interdisciplinary approach to many aspects of climate change and founded and edited the first interdisciplinary climate journal *Climatic Change*. And he blazed a bold new path in engaging the public and media about climate change, urging his fellow scientists to do likewise. He wrote many popular books on climate change, authored hundreds of scientific papers, and gave thousands of public lectures.

Following his passing, I read the amazing outpouring of tributes, memories, and stories about Steve from colleagues, students, and lay people across the globe. I remember thinking, where do we go from here without such a great man? And then, I realized. The stories were the answer. Every story represented the spark of a human connection, a life Steve had touched with his teaching.

Steve cared deeply about teaching the next generation. I first remember sitting across the desk from Steve, trying desperately to absorb the many layers of brilliance that came at me like a machine gunner that never ran out of ammunition. He was a patient and rigorous teacher. When we wrote problem sets for his climate science class at Stanford University, he delighted in pressing the students, often subtly, to see if they truly and thoroughly understood the material. Steve and his wife, Terry Root, always had students over to their house for class discussions, dinners, and guitar nights.

A year ago, dozens of Stanford students separately approached Steve saying that they wanted to attend the U.N. Framework Convention on Climate Change international negotiations in Copenhagen last December. Many professors of his caliber and schedule would have said, “Wonderful, do it, but you’re on your own.” Not Steve. He and Terry arranged to teach a class entitled “Approaching Copenhagen.” Nearly fifty Stanford students, undergraduates and graduates, went to the conference with Steve and Terry as leaders. Once again, Steve went out of his way to ensure that every student had a place, an internship, and contacts so that they could get the fullest experience possible. He arranged world-renown speakers to brief the students in the mornings. He ran himself ragged, staying up often


until three o'clock in the morning guiding students and doing his other work, only to wake up at six o'clock to get to the conference center to meet the arranged speakers.

Around Copenhagen, the climate discourse took a turn for the worse. Following the manufactured controversy of the "Climategate" emails and the subsequent campaign to discredit climate scientists, I remember Steve's weariness with how ugly things had become. He wrote scores of emails to journalists in his typical style of all capital letters, where you could almost feel the force of his personality behind the words. He had a strange pride but disturbed sadness in his eyes as he showed me the hate email he got. His voice would fall when he wondered privately if it would take an environmental catastrophe of epic proportions to get the world to deal with climate change.

Above all else he was amazingly, incomprehensibly selfless. He gave his time freely to students, colleagues, reporters, and donated years of his life to defending science and contributing to the IPCC. He made sure that he provided his students with the best opportunities that he could, writing articles, giving talks, connecting them with colleagues. He exemplified what it meant to be a mentor.

People orbited around Steve. We were pulled in by his gravity, his brilliance that illuminated our lives. He was one of the most well-known professors on campus, because no one could leave his presence and forget what it felt like.

His star has gone out, but his light lives on. He gave us all something extraordinary. To his students, he gave a sextant, a compass, and a mental map to navigate, to chart, and hopefully someday to illuminate the universe. He gave us his love and infectious joy and passion for this planet. To his colleagues and peers, he gave a lasting legacy of interdisciplinary studies of climate change, the highest of academic standards, and the steadfast belief that scientists can and must communicate their science. To the world and billions who will never know him but whose lives he touched, he gave his life, his guidance, and the fire of inspiration to make the world a better place.

He left us to carry on with his fight. It is a fight that could not be nobler. A fight to push back darkness, ignorance, and greed. A fight where we must light the fusion of intellectual passion and human compassion within ourselves. A fight for the economic well-being, the happiness, and the sustainability of future humans on this planet. 

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Will, G. Dark Green Doomsayers. 2009 - The Jewish World Review. Find the top climate change scientists on both side of the debate. We list the top 10 consensus (mainstream) climate change scientists, along with the top 5 climate change skeptics (deniers). Why acknowledge the skeptics? They're not fools. To fully understand any issue, you need to know all sides of the story.Â Often called the "Grandfather of Climate Science," Broecker pioneered the study of the history of the earth's oceans since the Pleistocene epoch by means of radiocarbon and other isotope-based dating systems. This work enabled him to reconstruct the biogeochemical carbon cycle, as well as the influence of climate change on polar ice and ocean sediments, among other important results.