

Stories and Lessons from a Foot Soldier in the Climate Wars

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This, like everything else, is still a work in progress.

*Active links to the papers that I cite or list are available
by number through my CV at <https://gyohe.faculty.wesleyan.edu>.*

Preface:

So why am I writing about the climate “wars”? Why am I a foot soldier in the climate wars?

To answer the first question, I write because people have died in “projectable” floods and storms and fires when we were not persuasive. Others, like Steve Schneider, died on airplanes trying to maintain defenses against people who would rather make things up for their own well-being than save some unknown person’s life today or sometime in the future.

Failing in the ability to defend publicly against Steve and others, because Steve and they always caught their lies in real time (because they knew ALL of the recent literature), these opponents would make threats on line and in other media against anybody that appeared on their radar screen. We are the foot soldiers.

Ben Santer endured threats, but he was and still is an officer.

So did Michael Moore, and he was and still is an officer.

So, for sure, did Stephen Schneider, and he was the general.

I am not in the same category as these people, but I am still alive because opponents have failed to damage me and what I have been writing for nearly 40 years. They have also failed to damage my family, though they have tried.

The stories that follow reflect what I did, where I was, and with whom; there are more stories in an annotated CV that is still kicking around.

I learned a lot over my life, and hopefully that will be clear. I think that I contributed some lessons to the common global good. I hope that that perception is not a delusion. I had a good time; that part cannot be denied given the hundreds of friends and colleagues and collaborators that I have enjoyed from six (and maybe seven) continents.

And I am still around for my granddaughters. They will ask, “Papa, what did you do?”

What could be better than that? I am alive to know them, and I can tell them when they ask (and they will ask) that I tried. What follows are memories as well as highlights of my contributions to the greater good, organized in chapters of unequal length. This is sort of a Table of Contents without page numbers. One chapter is in bold italic, because I think that it is my most important contribution to saving the lives of people I do not even know. Some haven’t even been born yet.

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Most of these contributions changed the way that scientists framed their research questions and the way that decision-makers framed their negotiations and framed their deliberations – across the world across from rich to poor for more than 3 decades.

Each chapter begins with a paragraph that does not bury the lead. Many highlight papers on my CV with references to specific numbers. Most are available by year of publication as pdf-files at gyohe.faculty.wesleyan.edu.

0. Basic training – The value of a liberal arts education

The lead – the value of a liberal education broadly defined cannot be overstated. Speaking to colleagues from many disciplines has been a challenge for me over more than 40 years since graduate school, but knowing a little bit of their language and recognizing that their perspectives are just as valid as mine turned out to be very important.

This first section is about the academic freedom that allowed me to “follow my nose” from the “other side of the desk”. It is a gift from Wesleyan University and my family.

I learned the vocabulary and the value of scholarship from wherever it came across my random course selections at Penn. I majored in English, then Philosophy, then Chemistry, then Chemical Engineering, and then Mathematics with a passing thought towards Physics. Some of my decisions were based on my participation in D-1 athletics – golf. Some were based on looking forward to what I might be doing at age 40 – I did not know then that I would also be doing it when I was close to age 70. Some highlights:

- *Fred Sanfillio and organic chemistry*: We worked together on everything but exams. We were, though, separated in exams because I leaned so much from him preparing for exams; just give us the periodic chart (hanging on the classroom wall), and Fred and I could cope with just about anything. As we studied, Fred suggested some patterns of thought, and I would check them. By the time we took the exam, we had maybe 5 or 6 patterns of thought. That is all we had to remember. They were so sad that neither of us wanted to major in chemistry.

- *Intercollegiate golf (D-1) – 22 away matches in April of my junior year*: This was before the internet, but fax technology worked so that I could get my assignments to very gracious professors on time. I was in Philadelphia one day that entire month, but I kept up in five courses and earned 5 A's. I was elected to Phi Beta Kappa, to my surprise, despite golf. It was the 1960's, so the rules were different.

- *What do I want to do in academics (lessons from commuter train rides determined my general vocational trajectory decision to go into academia)?* There were so many sad faces on the morning train from Paoli to Penn Station in Philly when I traveled back to campus from weekend visits with my parents and the practice range. Most were reading something like National Geographic articles for relaxation and distraction. I decided that I did not want that. I wanted work to be fun. I wanted to look forward to the part of the day when the commute was done.

- Academics seemed like a plan on those train rides. There was, though, difficulty conveying to my educator parents what it would mean to be an academic in a university setting. I was not going to be just a teacher. I was going to expand the knowledge frontier because that would be what was expected of me. “YOU?”, they asked. When I was an Assistant Professor, I accepted my first invitation from another campus - to give a talk about my work at Lehigh University. I spent the night before the talk with my parents in Hershey's Mill just outside West Chester, PA. When I got up for breakfast, my father joined. I remember nothing about what we ate, but I do remember his question when I was collecting my things, my thoughts, and my nerve to leave – “Why do they want to listen to you, anyway?” Thanks, dad; I was already nervous enough.

Backtracking to how I prepared, I ultimately went to grad school in math at SUNY Stony Brook, but I wanted a job on the other end. I worked hard and I was good at math, but some of my classmates saw everything intuitively. They did not appear, to me, to work at all; and they got everything right. They were mathematicians. I was a mechanic. A good mechanic, but I did not see a job in mathematics in my the future. I changed majors *again* - economics????.

After some advice from the SUNY math department, I switched to economics (with one, first semester intro econ course at Penn to my name). I applied to PhD programs at Penn, Harvard, Princeton and Yale (Stony Brook told me that I could just switch, so I had a safety school). I was accepted by Penn and Yale. Penn offered money, but Yale was Yale – no support other than a graduate teaching position. The Yale admissions committee included Joseph Stiglitz and Herbert Scarf (more on them, later; but Stiglitz won Nobel Prizes in Economics). I was selected to be part of an experiment in which they pushed for me and Andy Rosenburg, as math majors without much economics to speak of, to be accepted to one of the best economics programs in the country. I chose Yale.

When I arrived at, as I would say, in “New Haven for graduate work”, the economics vocabulary was foreign. It follows that I was ahead in the running for “Who from my entering class learned the most?” I could study with friends because I could teach them the math; they taught me the economics. Thanks Willem.

Willem Buitter, Robert Wilson and I were the last (as far as we know) to complete Yale PhD program in economics in 4 years; I am the last by actual count, since Willem and Bob got their degrees before me (B<W<Y).

Linda and I married in September of my 4th year, and she was not about to stand in my way to my completing on time. I wrote my dissertation on a “desk” in our apartment that was simply a panel door placed on top of boxes of books. Linda protected me from students and supplied coffee, and I worked on the arithmetic of “prices versus quantities under uncertainty” (that is now know a taxes versus cap-and-trade).

We stayed in the infirmary (thanks again to Willem Buitter) when we went to New Haven to consult with William Brainard (my dissertation adviser) and others on dissertation progress in the fall of 1975. One day, while we were looking for a typist, Gerome le Chat went missing. We looked and looked – wandering around the neighborhood calling his name. Willem, Linda, me, etc... we had no luck. It turned out that Gerome was under the armoire in our room the whole time.

Our other cat, Neige d’automne, had earlier climbed out an open back window in Albany (where we were living while I was teaching two courses at SUNY) in a snow storm. Looking for a white cat it a serious snowstorm was not fun, but she came back. She had escaped into the field behind the apartment, but she sprinted back. She ran up and down the front of the apartments trying one door at a time – at breakneck speed. They all looked the same to her (and she was right), so she stopped at every door. We eventually caught her when she ran into the patio of our apartment. She never tried that again, even though she was not the sharpest tack in the drawer.

As suggested above, my multidisciplinary background at Penn later supported my interdisciplinary work with natural and physical scientists, as well as other social scientists, in climate change. I could talk to them because I knew a little bit about lots of things; and I could write with them (with help from Linda), and it became the foundation of my life.

I found a home at Wesleyan University because they applied the same liberal education perspective to its faculty. I stopped publishing in economics journals late in the 1980’s (though I had unusual success with some big deal journals early on). I started to publish a lot in climate and science journals. That was OK with my colleagues even though I had come to them as an economic theorist. Thank you for the freedom – Wesleyan was, after all, the place where “academic freedom” was invented.

Later into my tenure at Wesleyan, I gave a 12 minute talk to the trustees (the Chair was an attorney, so bill-able hours were measured in tenths of an hour) about tenure for junior faculty in the same position – working inter-disciplinarily. I had published 25 papers in the previous five years (none in economics, *per se*), and a positive tenure decision on the basis of that record would have been impossible in a standard economics department. It was, and still is, possible at Wesleyan, but it is still a problem to do interdisciplinary work as a junior scholar just about anywhere else on the planet. Wesleyan had been a leader for the academy for many decades, and they were with me, too.

Ultimately, as I look back to my boot camp experiences, they led to collaborations with friends from all around the world via the emerging internet that made the difference for somebody from a small but well-respected university in Connecticut. If you look down my CV, you will see that I have stayed at Wesleyan for more than 40 years, and I have had collaborators and co-authors from six continents (maybe 7, since some have been to Antarctica – I don't know how to count them). I would venture to say that few others could make the same claim – except those who work in my climate change community.

1. **Prices versus Quantities** (for reference from the CV, see numbers 1, 3, 4, 7, 8, 16, 17, 24, and 26 for active links to the actual papers on my website.)

The lead – “Prices versus Quantities under Uncertainty” started as a microeconomic theory question for my dissertation with a focus on decision-making under uncertainty. The questions were really: “Who knows what, when do they know it, and how do they respond?” The answer is “It depends” (that’s the answer to every economics question worthy of consideration), but the intuition generated by these papers framed what has become the focus of a discussions that compare a carbon tax with “cap and trade” program; the intuition still applies 40 years later.

The intuition – variable output under a tax generates benefit for suppliers (emitters) but increases expected costs for ordinary citizens. For sulfur emissions, thresholds of acidity matter from year to year, so annual variability causes harm – permit markets that limit total emissions are preferred, in this case, especially if the total number of allowed permits declines from year to year. For carbon emissions, damages depend on temperature increases which themselves depend on cumulative emissions. It follows that annual variability in emissions does not add to expected costs as long as cumulative totals over a specified relatively long-term time horizon are constrained. Here, based on straight up economics, a carbon tax increasing predictably at the rate of interest would be preferred. EXCEPT that only the Congress can impose a tax and change its value over time. Imagine the current Congress doing that. It follows now that the political economy of the United States brings preference back to cap and trade with gradually diminished total constraints – decisions and standards that can be issued by the Executive Branch through the Environmental Protection Agency under the Clean Air Act because the Supreme Court has decided that carbon emissions are a pollutant.

“Prices versus Quantities un Uncertainty” was the topic of my PhD dissertation, and I published a number of papers on that topic in big deal economics journals coming out of graduate school.

Along the way, I developed an intuitive explanation of the result – about why “It depends” is the right answer, and about how to explain “Upon what does it depend?”

The equations from that work provided some of that insight. They said that

- the significance of the choice depends upon the variance of total output under a price control (as opposed to strict quantity standard), and that
- the direction of the significance depends on the difference between the slopes of the marginal benefit and marginal cost curves.

What does that mean? I always lapse into jargon. Argh. In the climate world, as we all discovered later, the significance still depends on the variance of emissions from year to year, but the marginal cost curve is now the marginal *social* cost curve. Moreover, the choice now applies to taxing carbon versus creating a cap-and-trade structure. How can the abstract model provide accessible insight into a real world problem?

My dissertation (#7) and my early papers (#1, 3, 4, 6 and 8) were all derivative of a paper that Martin Weitzman published in the *Review of Economic Studies* in 1974. Marty wrote the paper because a

“prices vs. quantities” question was part of the microeconomic theory comprehensive exam for first year graduate students at Yale the year before. Nobody got it right, so Marty published the question and an answer. As usual, as is his talent, he reduced the complication of the question to a simple model – regulators have to decide to set a price or a quantity restriction before they know what the state of the world will actually occur; a quantity standard gives the regulated actors no flexibility, but a price decree allows them to adjust their behaviors subject to a constraint. What are the costs and benefits of this observation for whom?

My dissertation added a second source of uncertainty, and a “covariance” term emerged in the result. I also included multiple actors. The first addition to the Weitzman piece turned out not to be very important, but the second made all the difference – and it was the foundation of the intuition.

Ultimately, the intuition is so simple that you can teach it in introductory economics (and I have). In a Weitzman world, actors respond to any price in their own best interest, so there is the possibility of social value to any flexibility that they exercise. Variability in their actions, though, increase the “expected” cost of those who suffer from their actions (the victims), and so there is a downside. The Weitzman result therefore provides a rigorous “way to weigh” the private value to the actors (in expected value from the perspective of the regulators who have to decide price or quantity control before they know what will happen) against the extra (expected) cost to the downstream victims. A price or quantity will be preferred on the basis of whether *the benefits of flexibility exceed the costs*.

Things get a little more complicated with multiple sources. The tradeoff still hinges (now) on their collective actions. With a price control, they all face the same financial constraint. But with a cap-and-trade environment, they can buy or sell permits, and so they can respond as much as they want subject to the constraint that their total activity is fixed so that victims see no variance in the aggregate outcome.

It follows that a cap-and-trade regulation always dominates strict standards for every actor because aggregate outcome is fixed under both. However, cap-and-trade regulation allows some flexibility between actors; the key here is that responses will only occur if they are in somebody’s best interest so that their welfare will increase. Nonetheless, the Weitzman tradeoff still applies to the choice between a price (a tax) and a total quantity constraint with a permit market. In the environmental world, the policy tradeoff therefore comes down to the extra damage caused by the sum of variable total activity under the tax.

Applied to pollution, to be more specific, think about carbon emissions and sulfur emissions through the lens of variable outcomes’ (emissions) from year to year being the critical outcome:

- for carbon emissions, it is cumulative emissions that cause temperatures to rise and cause damage, so variation from year to year does not add expected cost as long as average activity conforms to the quantity control totals; but
- for sulfur emissions, there are damage thresholds for each year; going above those thresholds in any year produces extra cost that can be enormous.

It follows that quantity controls on sulfur emissions per year (even with a cap-and-trade program within an air-shed) is the better policy approach so that total emissions are constrained below the threshold. For carbon emissions, though, a price (a tax) is the better choice as long as it changes over time to track a least cost emissions trajectory.

Richard Schmalensee (an MIT economics professor and member of the Council of Economic Advisors under #41 – GHW Bush) and I had a conversation on a morning bus ride going to an America’s Climate Choices meeting hosted by the National Academies of Science sometime around 2009. He agreed with my economics-based conclusion that a carbon tax should be preferred, on the basis of the economics articulate above, but he pointed out a critical political economy reality. It turns out that only the House of Representatives can impose a tax or change a tax; and they do not respond very quickly. Nor are they inclined to take climate change seriously. Nationally, he argued convincingly, a carbon tax

is therefore really a bad idea. Something like a cap-and-trade with maximum flexibility across emission sources from year to year and defined over time by a cumulative emissions constraint that would become more restrictive (think REGI in New England) would be a better idea. It would minimize economic costs, and it would inspire innovation in alternative energy as well as its marketing. It might be a second best option according to theory, but it would be a much a preferred choice in the real world even for carbon. How so? Because the Supreme Court of the US decided that carbon dioxide is a pollutant, and so the Environmental Protection Agency can therefore restrict cumulative carbon emissions however it wants (with justification but without permission from the Congress). In short, the Clean Air Act applies.

Thirty minutes of traffic delayed conversation in the middle of a bus, and I learned something really important. Like my father used to say, "You will learn something every day if you're not careful." My father also used to say that you were a "damned fool" if you make the same mistake twice. Dick Schmalensee taught me a lesson about political economy that I have never forgotten.

2. **Carbon emissions, concentrations, and temperature trajectories** (for reference from the CV, see numbers 10, 12, 13, 15, 19, 21, 27, 30, 33, 36, 39, 47, 65, and 69 for active links to the actual papers on my website.)

The lead – William Nordhaus got me involved in climate issues by inviting me to participate in a National Academy of Science study in 1982 where we were asked to projecting a range of emissions scenarios for carbon; we took that to mean that we would explore a range of scenarios and investigate the most significant sources of uncertainty across those scenarios. Our work still defines rigorous emissions modeling; and our spaghetti graphs are still the standard not just for climate scientists, but also for others (e.g., meteorologists on TV)

Linda and I bought a piano with just about the only external money that I have ever received for climate work (except for some modest EPA funding on SLR and some occasional consulting work). Work for the Intergovernmental Panel on Climate Change, the National Climate Assessment, Risky Business, the New York Panel on Climate Change, and so on was free time except for travel expenses. I added it up once in 2016; using my current consulting fees, it totaled more than \$2 million.

In #10, Nordhaus and I produced spaghetti graphs (meteorologists now use them in their coverage if where hurricanes might go). In #13, I described a fix for a rigid result on production functions with more than 2 inputs – in the weeds, but it made our simulations work.

Coming out of the weeds, this entire experience led to my playing in “scenario-land” and worrying (privately at first) about how a decision maker might try to cope with too much information. Nobody can cope with hundreds or thousands of “not implausible” scenarios, but *everybody* should try to cope with an image of the entire distribution of possible futures – good extremes and bad extremes as well as all the stuff in the middle.

I worked on how, statistically, to define representative scenarios #21). I also invented the notion of “not-implausible” futures in #39 and 47). Specifically, this led to a thought collaboration with Steve Schneider about how to describe and what to do along the damaging tails of “not-implausible” futures in an economic context.

Returning to the Academy committee chaired by William Nuremburg, we all prepared and released a National Academy report named *Changing Climate* in 1982. Bill Nordhaus had called out of the clear blue sky to ask if I wanted to collaborate on the project. I accepted, took the piano, and the rest (my interest in all things climate change) is history.

The Academy paid me \$5000, so that is how we could afford the piano – it was “money rain” at that time in my life with Linda and my daughters, so why not?. Bill and I created probabilistic scenarios of carbon emissions and atmospheric concentrations – this may not have been the invention of spaghetti graphs, but certainly it raised them to the fore. We do not show up on Wikipedia under “spaghetti plots”, but all of their references are after 1988 and most are after 2011; and most of those papers cite our work.

Included on the committee were the leaders of two research groups with competing estimates of the “airborne fraction” (the fraction of a ton of emissions that remains in the atmosphere after one year (and then persists with a half-life of about 100 years). This parameter was one of ten sources of uncertainty that Bill and I had included in our planning process and calibrated in our modeling; and we included a wide bi-modal range to reflect scientific disagreement about the airborne fraction. One of our experiments was to rank these sources in terms of how much they explained of the total variation in concentrations (hold everything else at the median, and see what remains – assuming all were independently distributed (sorry – back in the weeds). Our simulations ranked the airborne fraction 10th

of 10 in significance in terms of explaining variation in projected concentration and temperature increases.

When it was time to present that result to the committee, Bill turned the presentation over to me – the rookie. I explained our method and displayed the results – and the room erupted in argument and chaos that lasted for hours – spilling over through the next morning (but not disrupting dinner). I looked over during the chaos when nobody was talking to me, and Bill was leaning back in his chair - laughing and smiling. I looked at Nuremburg, and he smiled. “Welcome to the big-time,” he said later (know your audience, Nordhaus said later). It turns out that the two debating scientists were looking at the possibility of an Academy report costing them significant government support for their research into which estimate of the fraction was right. They were right to worry. Both lost funding when our report was issued.

The committee went out to dinner in the middle of the airborne fraction debate to a restaurant located on the first floor of the Watergate complex – we were staying at the nearby River Inn. It was a spectacular dinner. Nuremburg showed off his knowledge of wine by ordering many offerings (one for each course); and he was enough of a big deal that the Academy paid for the entire meal including the wine. To my calculation, it was \$500+ or so per person. *Perhaps most importantly, this was the first time I had ever tasted cinnamon ice cream – still a favorite.*

Authors contributing to the climate literature are still be citing our chapter in the spring of 2018; and spaghetti graphs are still the norm well beyond climate. William Clark of Harvard commented several years ago – “Have we not progressed at all?” remembering the 1982 piece. I am still working on that; see for example #175.

3. **Sea Level Rise** (for reference from the CV, see numbers 18, 22, 28, 29, 32, 35, 37, 56, 123, 138, and 139 for active links to the actual papers on my website.)

The lead – sea level rise (SLR) was my first foray into impacts and adaptation; in a developed country like the United States; coastal locations are the perfect laboratory – detection and attribution are solid, but local acceptance is all over the map.

My early work on sea level rise recognized a range of assumptions from “dumb farmer” to “smart markets” (autonomous market based adaptation and the implications for cost). Later work actually put humans and their institutions into the mix, with particular emphasis on New York City.

Sea level rise and coastal zone management especially given intense coastal storms (not only hurricanes) is still the perfect laboratory within which to include adaptation considerations (autonomous and anticipatory adaptation – Harvey versus Irma versus Maria in 2017) into damage (along many dimensions from currency to human lives) estimates. My understanding evolved to include losses from more than SLR alone to include losses from storm surge. Jason West and Hadi Dowlatabadi were among the first to put this on the table with a case study of the outer banks of North Carolina. I had a focus on economic metrics and C-B motivated adaptations for a long time; but eventually I began to worry about social policies and “tolerable risk” thresholds written and articulated by human decision-makers. These conventions define several levels of the determinants of adaptive capacity – ability to separate signal from noise, availability to response options and resources, willingness to accept decision-making responsibility, and credibility in social and political capital constructs.

This is the context where it became clear to me that taking account of the “dark tails” a la Steve Schneider was critical and depended upon well-established “not-implausible” possibilities that assessments reported in support of managing risk. You don’t prepare to protect against the historical record bad event, but you should not simply prepare for protecting against the median expectation of the future, either. If you accept any non-zero possibility that social definitions of “tolerable risk” will be violated by something that might not-implausibly occur in the future, then you must respond – this was the welcome conclusion of Mayor Bloomberg of New York City who made billions of dollars managing financial risk (the same problem).

This is still a work in progress, but it did not take very many seconds to convince Mayor Bloomberg in New York City that climate change was a risk management problem. Once that happened, evacuation plans (historically: get millions in the subway and tell them to go to higher ground) were changed (go the third floor of the nearest tall building). By executive order in response to this insight, he shut down the subways 8 hours before Hurricane Sandy made landfall. As a result, in Manhattan, 10 trains with 10 cars each with 100 passengers in each car were not in flooding tunnels at the height of the storm. Ten thousand people were waiting things out on the third floors of the highest nearby building. He saved 10,000 lives – not to mention hundreds of thousands of dollars in equipment and electronic damage.

Here is an interesting fact: my quadratic SLR cost function (vis a vis temperature) has been widely accepted as the standard form in calibrating economic damages as a function of temperature change in many integrated assessment models for many sectors (not by Richard Tol, though). It was part of #46, but only as a footnote. It was an estimate based on dumb or clairvoyant markets for a sample of developed property scattered along the coastline of the United States; it was never meant to be an estimate or even a form of a damage function that would apply more broadly.

4. Reasons for concern (for reference from the CV, see numbers 53, 85, 115, 118, 124, 164, 165, 169, and 175)

The lead: Reasons for Concern, and their illustrative “burning embers” diagrams, were invented leading up the publication of the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC) in 2001. Their emergence from Chapter 19 of the Report of Working Group II began a process of calibration impacts and vulnerabilities in a variety of metrics: currency, species, lives in jeopardy or lost, and so on. They thereby laid the foundation for changing the analytic and assessment landscapes for scholars and, by implication, an increasing number of decision-making platforms around the world. Cost-benefit analysis was no longer the standard; something more diffuse and less single number certain was accepted by the decision-makers of the world and the country.

The history of the IPCC reasons for concern (RFC’s) is perhaps most effectively tracked by relating the series of “burning ember” representations of the content of underlying assessments that began in 2001 with the Third Assessment Report (#53). The last iteration included explicit recognition of eight key risks (taken directly from Table 1 in O’Neill et al (#169)):

- (i) Risk of death, injury, ill-health, or disrupted livelihoods in low-lying coastal zones and small island developing states and other small islands due to storm surges, coastal flooding, and sea-level rise;
- (ii) Risk of severe ill-health and disrupted livelihoods for large urban populations due to inland flooding in some regions;
- (iii) Systemic risks due to extreme weather events leading to breakdown of infrastructure networks and critical services such as electricity, water supply, and health and emergency services;
- (iv) Risk of mortality and morbidity during periods of extreme heat, particularly for vulnerable urban populations and those working outdoors in urban or rural areas;
- (v) Risk of food insecurity and the breakdown of food systems linked to warming, drought, flooding, and precipitation variability and extremes, particularly for poorer populations in urban and rural settings;
- (vi) Risk of loss of rural livelihoods and income due to insufficient access to drinking and irrigation water and reduced agricultural productivity, particularly for farmers and pastoralists with minimal capital in semi-arid regions;
- (vii) Risk of loss of marine and coastal ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for coastal livelihoods, especially for fishing communities in the tropics and the Arctic; and
- (viii) Risk of loss of terrestrial and inland water ecosystems, biodiversity, and the ecosystem goods, functions, and services they provide for livelihoods.

The shading of each ember still provides a qualitative indication of the increase in risk with temperature for each individual “reason.” Undetectable risk (white) indicates no associated impacts are detectable and attributable to climate change. Moderate risk (yellow) indicates that associated impacts are both detectable and attributable to climate change with at least medium confidence, also accounting for the other specific criteria for key risks. High risk (red) indicates severe and widespread impacts, also accounting for the other specific criteria for key risks. Purple, introduced in the most recent assessment

and #172, indicates very high risk for which it was possible to assign all eight specific criteria for all of key risks.

Reasons for concern were designed in 2001 by the authors of Chapter 19 of the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change to expand the list of possible metrics for calibrating impacts and vulnerabilities from climate change (#53). Two of the original “Reasons” targeted economic distributions and aggregate economic values measured in currency: risks associated with the distribution of impacts (RFC3) and risks associated with global aggregate impacts (RFC4) (using current names from (#169). Others were drawn from different literature: risks to unique and threatened systems (RFC1), risks associated with extreme weather events (RFC2), and risks associated with large-scale singular events (RFC5). Insights drawn from this qualitative and subjective expansion of broad potential vulnerabilities were elevated to the Technical Summary and further to the Synthesis Report of the entire Fourth Assessment. For reference, see Figure SPM-3, Figure TS-12 and the supporting text on pages 284-289 in the technical summary.

As noted in Yohe (#124) and (#175), reasons for concern have evolved over time. Each category was expanded in the Fourth Assessment Report of the IPCC (#85); and (#124) introduced a sixth “Reason” for the United States – national security (FRC6). For example, among the original five, concern about risks to unique and threatened systems was no longer derived exclusively from natural systems; communities and other human systems that were threatened by climate change were included in RFC1. Distributions of impacts were calibrated in metrics other than currency that could be aggregated across nations (e.g., human lives at risk); these new categories were included in both RFC3 and RFC4. Given the emphasis across the AR4 to support risk management approaches to adaptation and mitigation, the concept of the RFC’s were supported by parallel application of a preliminary and anticipatory list of “key vulnerabilities” (magnitude, timing, persistence/irreversibility, the potential for adaptation, distributional aspects, likelihood, and importance) in Chapter 19. The Synthesis Report of the entire Fourth Assessment Report (#85) again highlighted RFC’s in the text, (pages 18-19), but the illuminating visual did not appear. That image, displayed in their Figure 1, is the focal point of Smith et al (#118).

The Fifth Assessment Report further advanced the application of RFC’s (Chapter 18) with better support on detection and attribution (#164) as well as increased global coverage in the impacts, adaptation and vulnerability literature (#165). IPCC (2014) as well as O’Neill et al (#169)) reported these updated and extended versions that explicitly incorporated a list of “key risks”. (#169) also illustrated the sensitivity of the RFC’s to two RCP emissions scenarios, but it did not provide corresponding portraits of risk over time.

Yohe (#175) displays as much of the O’Neill et al information as possible along transient temperature trajectories tied to achieving temperature targets as well as a no-policy baseline. A highlighted table, for example, indicates decadal levels of concern for risks to unique and threatened systems (RFC1) along transient temperature trajectories whose medians achieve four different temperature targets by 2100 as well as “no-policy baseline that mimics Fawcett et al (2015). Cells in the table were color-coded to indicate changes in levels of concern that mirror O’Neill et al (#169). It is thereby possible to infer the degree to which increasingly ambitious temperature targets delay crossing thresholds of concern, but accompanying figures are perhaps a bit more illustrative (RFC1 in the text, and the others in supplementary material). For each RFC, the median and 95th percentile trajectories are drawn across the same color-coding for a 2 degree C temperature target trajectory and the no-policy baseline. It is clear that the baseline produces high levels of concern late in the first half of this century and very high concern around 2060. Only the 95th percentile pathways reach the very high concern threshold and the end of the century for the 2-degree target, but high concern is still apparent mid-century despite aggressive mitigation.

Evidence of the significance of the “Reasons for Concern” is plentiful. For one, the United States strenuously resisted their inclusion across the Fourth Assessment in 2007. They were successful in keeping the “embers” diagram out of any part of the report, but not descriptions in the text. Smith, et al (#115) responded by publishing documentation of continuing evolution of the categories of risk as well as updated “embers” in the Proceedings of the National Academies of Science in 2009 (#115); that

paper had achieved nearly 550 citations as of the spring of 2018. The figure below is from the latest iteration post the AR5 (#169).

The concept of matrices also played a role in informing the world about risk. Matrices are the bane of students who take a course in linear algebra, but moving from the technicalities of that context to something qualitative. I was involved in inventing “risk matrices” for New York City in the First assessment by the New York Panel on Climate Change; they were adopted by the Adaptation Panel of the National Academies of Science in America’s Climate Choices. They simply work with the definition of risk (the product of likelihood and consequence) with suggesting qualitative scales for both from low to very high. It turns out that placing public and private infrastructure within such a matrix and then plotting the ranges of how the future might unfold was instrumental in prioritizing city and private investment in adaptation. The second iteration, in the Sixth IPCC Assessment, asked authors to place studies in a matrix that plotted confidence in detection against confidence in attribution to human sources of climate change. Across multiple sectoral and regional chapters, a robust conclusion emerged: given understanding of social and climate processes, the scientific community was (and still is) more confident in attribution in the future than it was in attribution to observed data.

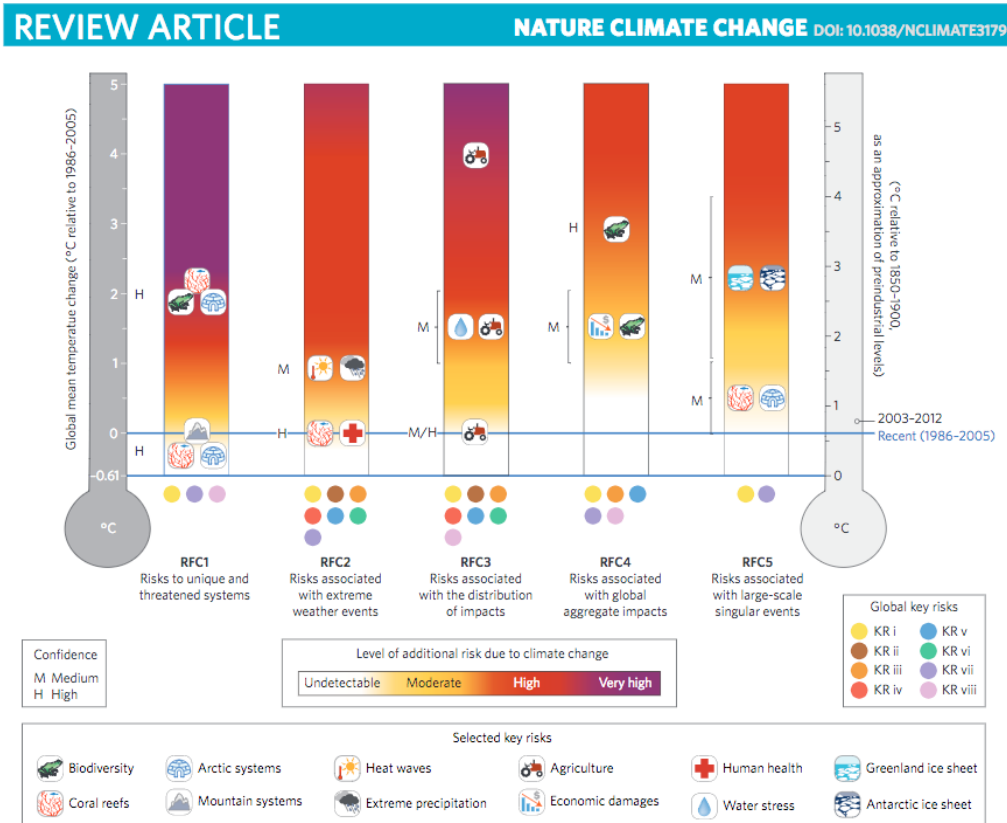


Figure 1 | The enhanced burning embers diagram, providing a global perspective on climate-related risks. Levels of risk associated with 5 different reasons for concern are illustrated for increasing global mean temperature and are the same as those presented in the IPCC Working Group II report. Icons indicate selected risks that played an important role in locating transitions between levels of risks. Coloured dots indicate overarching key risk categories that were considered in the assessment for each RFC (see Table 1). Confidence in the judgments of risk transitions is indicated as medium (M) or high (H) as provided in ref. 93 and supplemented here, and the range over which transitions take place is indicated with brackets. For example, RFC1 is underpinned by overarching key risks (i), (vii), and (viii) from Table 1; there is high confidence in the location of the transition from Undetectable to Moderate risk, which is informed by impacts to coral reef, Arctic and mountain systems; and there is high confidence in the location of the transition from High to Very High risk, which is informed by impacts to coral reef and Arctic systems as well as to species associated with unique and threatened systems.

5. Determinants of adaptive and mitigative capacity (for reference from the CV, see numbers 52, 55, 62, 63, 76, 77, 78, 79, 80, and 88)

The lead – The creation of a list of underlying determinants of adaptive and mitigative capacities has been used by researchers from around the world to organize the thoughts. Identifying determinants helped (#55); confirming the “weakest link” hypothesis (#80) provided focus. (#55) with Richard Tol is one of my most cited papers; (#80) with Richard is also widely cited given its support of the “weakest link”.

Unintended consequences - It turns out that confirmed empirical work ((#55) following up on insights from borne of the discussions that produced #52)) hampered nations’ living up to their (incremental) national commitments under the United Nations Framework Convention on Climate Change (UNFCCC) toward both mitigation (#48) and adaptation (#55). Why? Because they double-counted general aid expenditures as climate contributions. How? Because aid contributions could improve weak determinants of capacity to respond to climate change (and so should count). Responding to the unintended consequences of our work, this insight subsequently framed more honest international policy deliberations from Copenhagen and beyond; double counting was not allowed.

This entire topic could surely sound like it is in the “weeds”, but it was just as surely an unintended consequence that effected negotiations under the United Nations Framework Convention on Climate Change (the UNFCCC) – outside of the weeds. The determinants of adaptive capacity that were cited in the negotiations were derived from (#55); they include:

- (1) access to resources,
- (2) availability of response options,
- (3) strong human, social, and political capital (# 3, 4, and 5),
- (6) a decision-making structure taking responsibility,
- (7) an ability to separate signal from noise, and
- (8) a population that supported all of the above.

It turns out that the determinants of mitigative capacity are essentially the same as the determinants of adaptive capacity (#48); and both sets parallel match well into the long-known precursors of successful public health institutions (#62 and #79); if only we had done our homework.

On the basis of this coincidence, to be more precise, I wrote that support for improving human and social and political capital and statistical training would be good climate policy. It is. I never thought that this conclusion would be used by countries like the United States in UNFCCC negotiations to support government claims that “we are supporting climate policy” because we provide “this (or that) aid for improved government or educating children” and we have been doing so for years. The result was providing nothing incremental in overall international aid. Even though countries like the United States were already doing this, I do not think that they can double count under the UNFCCC.

I worked with Richard Tol to publish a paper on a “weakest link” hypothesis for adaptive capacity (#80) – the idea was that the adaptive (and/or mitigative) capacity of a country or community is fundamentally determined by the weakest of the underlying determinants. We suggested a way to implement this to organize thoughts about how to frame policy fpr decision-makers with scarce resources. The hypothesis has been confirmed widely, and (#80) is still being widely cited (more than 1100 citations and counting).

Looking at the underlying determinants, I wrote that the US is strong in adaptive capacity and weak in mitigative capacity because the costs and benefits of the two responses are differently distributed (#48). In the US, public investment in adaptation spreads the cost widely for the benefit of a few well-

connected victims of climate change. Public mitigation, by contrast, spreads the cost on a few well-connected energy companies while the victims who benefit are distributed widely across the globe and into the future. Richard Schmalensee had already taught me that political economics was critical (see Section 1 above). Calculate (or qualitatively surmise) the political economy of these observations, and you can explain a lot – the US adapts, but is reluctant to mitigate, for example. Happily, the evidence for low mitigative capacity is weakening. Corporations across the country are (as of 2018) committing to achieve their shares of the Paris Agreement mitigation targets even without leadership from DC. Why? Not because of concern about the climate, but because doing so is good for the bottom line. Why? The world is moving to price carbon at a rate that grows over time even without the United States' being in the Paris Accord.

6. **Iterative risk management** (for reference from the CV, see numbers 40, 58, 60, 64, 65, 68, 69, 83, 85, 94, 100, 103, 106, 108, 110, 111, 113, 116, 117, **118**, 121, 128, 141, 150 and 155)

The lead – This sounds like it is also in the weeds, but it is NOT. ***This is my most important contribution to the planet.***

The Intergovernmental Panel on Climate Change had concluded in 2007 that warming was unequivocal and that our authors had very high confidence that human emissions of greenhouse gases were the primary cause. Skeptics had moved from “the world is not warming” and “human activity has played no role” to “So what? impacts are negligible”. Mentioning extremes was, to their minds and their polemics, shameless “fear-mongering” by a conspiracy of climate change researchers – like we talk among ourselves and agree on a view of the world.

In the midst of this, and even in response to this, IPCC AR4 SYN SPM page 22 (#85) reported that: ***“Responding to climate change involves an iterative risk management process that includes both adaptation and mitigation and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes to risk”*** (bold italics are my emphasis). To our minds, therefore, reporting on extremes was responding to the needs of our clients – the nations of the world. This is perhaps the most important conclusion from any IPCC report with respect to its impact on policy negotiations. These 30 words crafted in Colorado in the middle of many nights by several of us (Steve Schneider and Bill Hare with support from Pachauri) certainly changed forever the way that decision-makers across the planet look at climate change as a policy issue. Cost-benefit analysis was finished. Risk management was the way forward. It took years for some. It took 30 seconds for Michael Bloomberg.

I personally thought at the time (in 2007), and I still think (in 2018), that this is the most significant conclusion of the six IPCC assessments that have been produced so far. Steve Schneider agreed and sacrificed his health trying to sell the message until his passing; on an airplane; he would go anywhere to talk.

Acceptance in an IPCC plenary or the words above in ***bold italics*** meant to us that our clients (the UNFCCC countries) wanted to be informed about *risk*. Since the definition of risk was included in a footnote to those words and the footnote was accepted without exception, these words meant that 169 countries of the world had agreed by consensus that risk was the product of *likelihood and consequence*.

And so, they all ALSO agreed that mitigation is not a cost-benefit problem – it is a risk management problem.

And so, they ALSO agreed that funding adaptation investments in the most vulnerable countries (or the most vulnerable communities in the world’s richest countries) was not strictly a cost benefit problem – not unless you accounted for “co-benefits, equity and attitudes to risk”.

And so, the clients of our work agreed we us that reporting low likelihood but high consequence possibilities was not fear-mongering; it was listening to our engaged clients who were worried about the future of the planet.

Steve, Bill, and I worked to frame this language in Estes Park. We also worked, with Pachauri, in Valencia to defend it. Pachauri brilliantly put those words on the calendar for the morning of day “one” of the IPCC plenary in front of 169 countries so that we and the world would have as much time as possible to meet with admirers and detractors of each and every word to hammer out some satisfactory

language – word for word by consensus. The United States pushed back, but their delegation was met in an off line discussion in a room populated by Pachauri (the host), Schneider, Yohe, and Hare. The United States delegation was expecting to see Steve in the room, but not the rest of us... “We did not know that more than one world respected author would be here” (Ko Barrett said those words). She did not say much more. It was a short meeting; the US agreed.

It turned out, after multiple iterations, that all thirty of the original words (from Estes Park) ultimately achieved consensus approval on the last afternoon of the plenary – that is to say, not a single country objected to a single word. That is to say, we did a good job in CO.

Please understand that, moving forward, these words were the motivation of the Paris Agreement in December of 2015, and they do not depend, in the US or across the globe, on leadership from DC.

Please also understand that these words do not expel cost-benefit approaches *to adaptation* (see # 65, – decisions can be C-B in the short-run if they are designed to be reactive depending upon detection). In the long-run, though, attribution to human activity comes into play so that only wide ranges of projections are possible. Here, risk management is the correct lens, and it has become the standard across the country and around the world.

So as not to leave any confusion, here are a few additional basic insights from the myriad of papers noted above and from the language that was accepted:

We cannot write policy for 100 years, *so we have to iterate*; but that is not new news to corporations and communities who can respond in the medium term based on risk-based mid-course corrections. Secondly, risk is likelihood times consequence – risk matrices allow for qualitative or quantitative evaluation; and “tolerable risk” is a working example of an appropriate version of the precautionary principle.

The final message: do not plan for the worst, but do consider something in the upper extremes. See numbers 40, 100, 103, 118, and 150 for some idea about how hard of a climb that can be.

7. **Snowmass** (for reference from the CV, see numbers 50, 55, 58, 62, 68, 69,73, 77, 78, 79, 80, 96, 97, 105, 108, and 142)

The Lead: John Weyant, James Sweeney, Alan Manne, Richard Richels and friends organized and secured funding for two weeks of meetings that were convened early every August for two decades in Snowmass, CO – at about 9500 feet of altitude with meetings under a tent. Funding came from the National Science Foundation, Japan, Chevron, Exxon-Mobile, the Electric Power Research Institute, and many other sources. The rules were clear - one-third of the attendees each year would be new participants from new academic fields (not the usual suspects) so that discussions about integrated assessment, impacts, and climate risks would always see new perspectives. Some participants never returned from their initial time under the tent, but others engaged in discussions and returned year after year. Participants presented their work, and then collaborated on new science. As of 2016 or so, more than 1000 published peer-reviewed articles were produced from the interactions that were consummated in Snowmass. I can trace more than 20 papers on my CV from collaborations that began in Snowmass, including some with many more than 200 citations; see numbers on my CV (adding to the list above #51, #56, #59, #70, #74, #84, #103, #105, #109, #113, and #116).

I helped organize the “Uncertainty Working Group” for many years. Our task was for integrated assessment modelers to agree to specific input trajectories of critical drivers of impacts. They would run their models with those trajectories, and then report alternative results designated as “modelers’ choices”. We discovered that variances in outcomes (emissions, temperature, etc...) were larger across the participating modelers for their common driver runs than it was across their modelers’ choices. Apparently, modelers were truncating drivers’ distributions so that their results would not be outliers in the grand scheme of things. This was big news, and lead many modelers to change their research protocols.

In addition to the organizers, my memory of collaborators that were attracted to Snowmass include Susan Sweeney, Richard Tol, Jae Edmonds, Hugh Pitcher, Terry Rood, Stephen Schneider, Natasha Andronova, Michael Schlesinger, Brian O’Neill, William Nordhaus, Kenneth Strzepek, Richard Moss, Jerry Melillo, Jake Jacoby, Sally Kane, Kritie Ebi, Thomas Willbanks, Anthony Janetos, Saleemul Huq, Linda Mearns, Hadi Dowlatabadi, Camille Parmesan, Joel Smith, William Easterling, and many more

Snowmass was also family time. My younger daughter Courtney worked for Susan Sweeney to make several of the two week sessions work well. She also learned to ride a horse from Alan Manne. I played golf with many at altitude – what a hoot.

I also had a standing \$1 bet with Jim Sweeney on straight up games between UCONN and Stanford; we also agreed to pay \$1 if UCONN or Stanford won a national championship without playing. Except for the Tampa Final Four game, I collected – publically under the tent at the beginning of one of my annual presentations or two. One dollar piled up, so Jim and I negotiated a present value calculation to end the embarrassment. Jim paid twenty dollars (with a negotiated 5% discount rate) ended my tendency to show a picture of UCONN cutting down the nets as the first slide in my presentation. Turns out, that was a pretty good deal for both of us.

One vivid memory: many of the new participants were young scholars. I always sat at the back of the tent, and so did they. At a break, I frequently spoke with one or more who conveyed the impression of most of the “newbies”. “Half of the bibliography of my dissertation is sitting under the tent. What do I do?” “Introduce yourself and see what happens!” was my response.... They went on to contribute part of the 1000 papers.

8. IPCC, NCA3 and the Meaning of Consensus in a Risk Management World.

The lead – I always got more out of my investments in assessments than it cost me in time and energy, even though I was NOT paid. None of us were paid (except the top of the food chain in the Secretariats) – also except for travel and per diem when meetings were held essentially anywhere in the world that would have us.

That said, before going into some detail of the value of participating in the Intergovernmental Panel on Climate Change (IPCC) in the next chapter, it is important to cover one large public misperception. It turns out that the applicable concept of consensus is completely misunderstood across the collection of casual observers and critical skeptics. Assessment rules (IPCC and NCA3, at least) abide by the definition of consensus employed in all international negotiations: anyone in the room can object to any word, number or line in a graph. If that happens, the entire room works on that word until nobody in the room objects to whatever revision emerges from the process. Then, and only then, can the room move on to considering the next word or line or number.

IPCC was bound to this approach in its charter. The NCA3 accepted this approach immediately, as well. The NCA3 version required that anyone who objected to any word (or line on a graph or entry in a table, etc...) had to suggest and defend an alternative; that suggestion would immediately become the topic on the table. Iteration from word to word could take hours, and frequently ended back at the starting point (i.e., the original language). Still, the end result was consensus on the content of any particular conclusion – another deliberate double negative: “Nobody disagreed”.

To be clear, consensus did not mean that nobody in the room disagreed with a conclusion that “climate change *would* do this, or that”. The “not disagreed to” language always included confidence statements – so the room was asserting that nobody disagreed with a statement like “with x degree of confidence, this or that conclusion that something could be a manifestation of climate change (that had been detected and attributed.” After 2014, when “iterative risk management” language was approved by consensus, the room would allow “x degree of confidence” to be very small if the consequences of the manifestations could be very large – because that is what the client nations wanted to know because risk is likelihood times consequence.

It seems to me that understanding that IPCC and NCA3 conclusions were consensus conclusions, as well as those from other assessments like America’s Climate Choices, Risky Business, and the New York Panel on Climate Change is essential. It is also essential that the meaning is communicated accurately to people who understand the process by which a reported conclusion had been approved.

IPCC and the NCA (National Climate Assessment for the United States - #3 in 2014 and #4 in 2018) are not policy prescriptive. America’s Climate Choices (2010 from the National Academies of Science) and NPCC (New York Panel on Climate Change - #1, #2, and #3 in 2008, 2012 and 2018) were and will be prescriptive by request of their sponsors.

To emphasize my point, accepting an “iterative risk management” approach meant that the clients of assessments from whatever source wanted authors to report low confidence possibilities if there were potentially high consequences because low likelihood times consequence could mean high risk. This led to reporting what could happen in the dark tails of climate futures without embarrassment, and without vulnerability to claims of fear mongering. Assessments’ reporting of high risk from any calculation simply had to display significant value added and provide credibility for decision-makers who understand risk (see # 69, 70, 84, 85, 86, 111, 113, 114, 115 and 117).

“Reasons for Concern” (see Chapter 4 above) were invented by the IPCC in 2001, and they have been updated periodically through at least 2017 in IPCC assessments and peer reviewed literature. They report consequences calibrated in multiple metrics (not just economic) in what has emerged as a historical record of the evolution of thought. From the third IPCC assessment through the sixth, their

content has achieved consensus. In 2017, time trajectories for all five RfC's along ideal pathways to temperature targets have now been published (see #115, 124, and 169, for example).

Increases in the frequency and intensity of extreme weather events were detected and attributed in NCA3 and the Climate Science Special Report (2017). Recent events (like Hurricanes Harvey and Irma and Maria in 2017 within 4 weeks) have been raised as evidence of notable manifestations of climate change within the risk-based framing. To be sure, consequences depend on preparedness; Houston and Miami are examples on opposite poles. Houston did less than not prepare. City government had encouraged expensive development in locations vulnerable to heavy rain for decades. Then they got three 500-year storms in 5 years, and they allowed rebuilding in place after all three. Their most recent experience last one was Harvey, but the enormous damage was locked into the consequence system when they ignored climate change and emerging weather patterns in their planning. Miami, on the other hand, had experienced Hurricane Andrew in 1992. They revised building codes and evacuation plans, and so they were more than ready in 2017 ready. People died and billions of dollars were lost in both places, but the difference across the two locations in both metrics was more than a factor of two.

To expand on this point, it is important to note that nobody was claiming that climate change causes the hurricanes. Rather, the claim is that climate change has been shown to influence both the intensity (historically warm water on the surface and lower layers) and behavior (diminished steering currents in TX and Mexico). It follows that one Cat 5 could follow another and another through warm water that was distributed down many meters from the top layer. Maria was the third storm through the Caribbean in 4 weeks; and it was therefore stronger than it would have been a decade earlier (when the lower layers of water were cooler and mixing would have worked to lessen Maria's strength. In 2007, damage to Puerto Rico would therefore have been less severe. In a world that has warmed, though, it was no surprise to see how strong Maria was because multiple layers of water were at historical highs. And it was no surprise that a wandering hurricane named Harvey with nothing telling it where to go after it made landfall in Texas could drop 50 inches of rain on one spot over two days because the steering wind currents had gone north to Kansas for barbecue.

9. IPCC – the experience on a personal level

To repeat an earlier lead, I always got more out of all IPCC experiences than I put in; and I put in quite a bit. I enjoyed the collaboration, but I also enjoyed many experiences that I could not have imagined before I travelled. I had not traveled abroad until after graduate school, but I certainly made up for lost time. Here are a few selected experiences drawn from my annotated CV for selected years:

2000

Eisenach, Germany (Intergovernmental Panel on Climate Change): February 8-11.

Ferenc Toth got really sick in the middle of the night. He called me in my room for help. I got him calm, spoke with his family, found the next train home, and walked him to the train station (not a long walk, but before dawn and not to the hospital. He refused that. He was admitted to the hospital when he arrived home.

I saw Martin Luther's room in the nearby church complex during an excursion from the meeting dinner. Nothing nailed to the door, but very chilling in its start-ness.

Antigua and Barbuda: June 4-6:

This was a special meeting of the Chapter 18 author team (Barry Smit, Salem Huq, Ian Burton, et al. I paid for one dinner, and never had to pay for another dinner with Chapter 18. Ian Burton danced with a bride on a bet with Barry Smit. We all left a nice wedding present.

I solidified the concept of the “eight determinants of adaptive capacity” with the Adaptation Chapter 18 author team; it is still an anchor for organizing thoughts about who might adapt ---- positively.

Montreal, Canada (Intergovernmental Panel on Climate Change): May 6-8.

I snuck out for a round of golf with Joel Smith and Barry Smit; we finished with a gallery of meeting participants along the 17th and 18th holes. My shot to the green go VERY close.

Lisbon, Portugal (Intergovernmental Panel on Climate Change): August 8-11.

I had dinner with Steve and others at Steve's favorite restaurant in Lisbon; we had giant prawns and that was it. Just outside the hotel, fishermen would bring their day's catch onto the beach in afternoon; you could pick your dinner fish and take it to a local restaurant for preparation. I don't know if Steve selected out prawn.

A big fight erupted between ecologists and economists at the authors' meeting. Conferring with Camille about how to approach the source of the conflict, Lisbon became the *birthplace of the Parmesan and Yohe paper in Nature*. This experience and the subsequent collaboration is perfect evidence of “getting more out of IPCC than you put in, even if you *not paid*). We got our first referee report from Steve, who was also hanging in the back of the room – “Sounds like a Nature paper, to me.”

I also played golf with Bill Easterling on a course that regularly hosts the Portugal Open – a regular stop on the European Tour.

2003

Colombo, Sri Lanka (Intergovernmental Panel on Climate Change): March 5-7.

Another Intercontinental Hotel in Colombo. I took a day-long country excursion (seeing elephants and cobras and Buddha temples and bombed out buses) with Richard Moss and two or three others. We were there during the civil war. During a coastline walk near the hotel, I witnessed the arrest of

somebody by heavily armed soldiers. The episode began with my being stopped by a soldier. “Let me see your papers”. When a single walker approached from the opposite direction, he added “Maybe you should stand behind that shack.” The shack had ¼ inch plywood. “How about that stone wall?”. I retreated behind the stones when he agreed, leaving my passport with the soldier. Six or seven armed soldiers appeared from nowhere with machine guns pointed at the approaching walker. When they took the walker away, my soldier friend signaled for me to come out. “Here is your passport. Why don’t you go back to the hotel, now?”.

The flight home left at 3AM; highway markings and laws are just suggestive and the hotel driver played ‘chicken’ all the way to the airport.

We were served curry all the time for an entire week; even eggs for breakfast tasted like curry. I liked curry, but not so much, now.

The airplane to and from Sri Lanka was serviced at the far end of a double security check point hallway in the Frankfurt Airport.

“The worst trip I’ve ever been on” is in my head still whenever I think of Colombo.

2004

Maynooth, Ireland (Intergovernmental Panel on Climate Change): May 18-20.

I took a daylong excursion to pyramids and Dublin with Camille Parmesan and Roger Jones. Camille and I were still working on the *Nature* paper, but I spent a lot of time in my hotel room working on the modeling and text for the hedging paper with Natasha Andronova and Michael Schlesinger that ended up in *Science*. Not a bad week for an economist.

2006

Merida, Mexico (Intergovernmental Panel on Climate Change): January 16-19.

Linda and I traveled here with Bob and Joan Wilson. We took multiple day trips together to pyramids and other sights before the meetings started. They were wonderful.

We all attended an IPCC official dinner with children singing and a candle-lit path to the US consulate for a reception – all hosted by Mexico. We all ate at the table with Pachauri and a very few others. Joan chatted Patchy up, and he was very happy. This was a wonderful trip.

Geneva, Switzerland (Intergovernmental Panel on Climate Change): August 1-3.

I created a “haiku” Summary for Policy Makers:

Climate is changing;
Humans are to blame;
The poor will suffer most;
The rich don’t care.

Pachauri suggested an alternative last line on a scribbled note: “The rich don’t give a damn”. Pick your version. He put it on his slides. The Synthesis Report author team worked for another 8 months to produce a report whose conclusions used many more words to say something like this.

Capetown, South Africa (Intergovernmental Panel on Climate Change)

Bob Kates got very sick – dehydration. He recently passed (May of 2018). That was a loss. Bob served as our review editor on the first order draft. That is why he was in Capetown, and he broke the rules of non-engagement. As we began our first discussions, I asked for his thoughts. He said “You are all very smart, so stop trying to show everybody that you are very smart. Start over and do something

useful”. I started a thorough revision process by going first tearing up my submissions to the zero order draft. I was the Convening Lead Author (CLA), so everyone followed; and our chapter was much better for it.

I took a countryside excursion with Chris Hope; we saw countryside, coastline with seals, small communities and shanty-towns. It turns out that you can book a week in a shanty. I cannot decide whether or not that is a good idea, but I have thought about it.

2007

London, United Kingdom (Intergovernmental Panel on Climate Change)

This was a WGII SPM and TS final authors’ meeting. Amanda Palmer’s insight made the cut. Amanda Palmer* thereby became a contribution author of Chapter 18. Her insight, from work she did for a First Year Initiative course at Wesleyan (mine): climate impacts pile up along the southeastern coast of Africa, and their impacts are likely to compound each other; that is, sum of the parts is smaller than the collective effect of taking them all together (and so adaptation is more difficult and needs to be coordinated). Amanda was called out by skeptics at the Heartland Institute for having no credentials; James Taylor wrote something like: “How can you believe the IPCC if she is a contributing author?”).

Estes Park, Colorado ((Intergovernmental Panel on Climate Change): July 31 – August 3

This one is important. It was a meeting of the core writing team for the AR4 SYN-SPM. Susan Solomon and Bert Metz chaired in the absence of Martin Parry (fit of pique); Steve and I worked together so that this was the birthplace of the IPCC “iterative risk management” language: “Responding to climate change Responding to climate change involves an *iterative risk management* process that includes both adaptation and mitigation and takes into account climate change damages, *co-benefits, sustainability, equity* and attitudes to risk.” Emphasis is mine; Source: IPCC AR4 Synthesis Report Summary for Policymakers (2007; pg 22) I remember working with Steve early into the morning, and he asked to see what we had produced. My computer stopped, and I could not show him; but I had learned always to save early and often, and our work was on a flash drive. Phew!

Brussels, Belgium ((Intergovernmental Panel on Climate Change): April 2-5.

This was the plenary meeting of UNFCCC member nations to approve the contribution of WGII to the AR4. I was before the meeting for a midnight review of the Stern Review. I asserted over and over in the face of opposition from the UK that Stern Review had not been peer reviewed. “How do you know that?” was finally asked by David Warlow. “I know because Sir Nicholas told me at the Yale event in February”. Debate over “high confidence” about impacts on ecosystems with Saudi Arabia, China, Kuwait erupted. Steve and I suggest that no confidence statement be attached after Cynthia Rosenzweig walked out and Roger Jones branded insisting on “medium confidence” was an exercise in “intellectual vandalism”. Authors are at the “childrens’ table” in these proceedings, so they cannot speak unless spoken to. I get Trig Talley to arrange with the Bush White House to agree to have the US propose this compromise. After Trigg arranges a mid-night conference call discussion with the WH, the US does just that and the first ever footnote alternative (protocol when authors’ language is amended without their approval of the science) is avoided.

Valencia, Spain (Intergovernmental Panel on Climate Change): November 12-17.

Plenary approval of the AR4 is accomplished. After the last session, I enjoyed a dinner and nighttime tour with President of Valencia, Pachauri, and others. I celebrate because the “iterative risk management” language has been accepted; it will therefore be the foundation for subsequent UNFCCC negotiations. I met Zubin Mehta during a midnight interruption by the President of Valencia in the Opera House, and I had imported 3 bottles of wine that were a gift that he presented to us at dinner.

2009

Venice, Italy (Scoping Meeting for AR5): July 13-17.

I had imported a glass sculpture; I played hooky to buy it, but it is still in the living room. There was a failed terrorist attack (not) at San Marco Square; they climbed the clock tower with machine guns and shouted down at the square; nobody paid any attention, so they packed up and went home. Rob Mendelsohn insisted that max B-C is the only way to do the economics of climate change in front of Pachauri. Charlie Kolstad resisted and finally convinced everyone that a Special Report on C-B would be a lot of work and a waste of time. Chris Field invented an abbreviation code for chapter coverage of cross cutting themes. One was “CSTDRMPT”; I asked, in plenary, “What is ‘costed armpit’?” Kris Ebi almost fell off the stage in laughter at the question and Chris’s perplexed look.

2010

Jasper Ridge, California ((IPPC): July 14/16.

An uncertainty guidance document was prepared for the AR5. *This was the last time I would see Steve.* In the initial presentation, Chris Field (our host) warned us about five local hazards: fire, cougars, snakes, and poison ivy. We were careful during coffee breaks. Kevin Trenbreth fake pushed me into some weeds as we viewed Chris’s field experiment site out in the “wild”. Not funny.

2011

San Francisco, California ((IPCC): December 12-15

Governor Jerry Brown attended the reception and related the Reagan-IPCC story (IPCC is “intergovernmental” to avoid picking up UN baggage). This was the birthplace of the adoption of detection/attribution confidence matrices.

Tsukuba, Japan (Intergovernmental Panel on Climate Change): January 11-14.

On the way to Japan, Chris Field and I presented climate change risks to Bill Gates (Seattle, January 7) on the way there. David Keith arranged the meeting; he worked with a colleague of Mr. Gates - the person who wrote the original Excel code for Microsoft. Mr. Gates had given us the entire month of January for a window for scheduling, and he extended the actual meeting by 2 hours. For what was 4 hours, I sat next to him, and saw the questions that he had scribbled on his printed text of the papers that Chris and I had sent along for his homework reading. He had read them all very carefully (but not in electronic versions). The session felt like an oral final exam for which we had defined the reading list but not the questions. At least I could anticipate his questions by glancing at his notes. Mr. Gates concluded that climate change was the first issue that he had ever confronted for which technology was not the solution. The room went silent (2 of us, and 10 of his long-time colleagues). I endured a delayed plane ride home (upgraded to first class courtesy of Rich Richels).

Lima, Peru (Intergovernmental Panel on Climate Change): June 23-26.

We took motorcades to the meetings. I found Hillary’s pen in a draw in a drawer of a big table in a conference room in the Foreign Ministry building. She had been in Peru the week before. I presented on the economics of iterative risk management to an expert meeting on costing and ethics; I met Geoff Heal who was not yet convinced. It turns out that the only quick way from downtown Lima to the airport is through residential communities.

2012

Buenos Aires, Argentina (IPCC): October 23-26.

I hosted a private dinner for authors who had accepted and employed the detection/attribution matrix that I had invented for the D&A chapter of the AR5; the idea was for as many chapters as possible to accept the visual and use it in their contributions. The dinner recognized a collaboration that spanned more than 50% of the chapters.

10. The Social Cost of Carbon (for reference from the CV, see numbers 90, 106, 113, 116, 126, and 144)

The Lead: The social cost of carbon (SCC) is an estimate of the damage caused by another ton of carbon emissions along a specific future emissions projection based on specifications of attitudes toward risk, discounting the future, climate sensitivity, global mitigation patterns, and so on. I was involved in helping the EPA to understand what it was and what it was not – consulting with Stephen Rose and Benjamin Deangelis, for example. It was both a difficult and simple concept to accept. . It was, though, the foundation of the Supreme Court’s decision to classify carbon dioxide as a pollutant so that (1) the Clean Air Act applied and (2) the social value of reduced carbon emissions from, for example from that case increased mileage standards for vehicle fleets.

The SCC was never intended to be an estimate of the efficient price of carbon; that calculation would require some characterization of the cost of mitigation. Ranges of estimates of the SCC were, though, appropriate for quantifying ranges of value added from a climate perspective of policies or programs that would reduce or increase carbon emissions as a side effect – for example, increased mileage standards (CAFÉ standards) for automobiles would increase mileage and therefore reduce emissions of lots of things, including carbon. Some measure of the economic value of such an effect on carbon emissions should certainly be included in a benefit-cost calculation for such a policy or program proposal.

There came a time when the SCC was elevated to the highest level. Laurence Summers, then the Secretary of the Treasury for President Obama and a regular at the 6:30 AM presidential briefings, had seen some estimates that reported a negative SCC (that is, a benefit from warming). “If that is true, why are we worried about this?” was his question at a morning briefing with the president.

The call went out to respond about the distribution of estimates (ranging from -\$12 per ton of carbon emitted to +\$300 per ton and more). The question: why was a negative SCC estimate possible (agriculture and energy benefits in the short run with a very high discount rate because the long-term is bleak) but not plausible (because CO₂ fertilization would peak, agriculture needs water, and high discount rates are inappropriate). We were asked to provide a collection of papers that were on these points. The President was known to take 300 pages of academic reading to the residence for bedtime reading in preparation of the next day’s 6:30 AM briefing.

I got such a call from Anthony Janetos one morning – drop everything and deal with this and submit something before COB; and I did. I had been important in developing the EPA’s understanding of what the SCC meant and how it should be used – they interrupted a shopping trip to the Westbrook outlets as I recall. I wrote a paragraph for Tony, and sent some papers along. The next day, our response to Secretary Summers was presented to the president at the morning briefing. He was engaged, and wanted some reading. So the papers that I sent were among the 300 pages of reading that President Obama took up to the residence that night. These were not 300 pages of press coverage and newspaper clippings; these were 300 pages of scholarly work published in the peer reviewed scientific literature. Questions that I got from that next day briefing (at 7:30 AM) indicated that this president had done his reading, synthesized its content, and engaged in the debate. You cannot imagine what it felt like to know that dropping everything mattered.

Secretary Summers agreed that climate change was not a positive thing and never objected to taking it into account. His questions were exactly on point; and his accepting science and economics was not a surprise. Based on a median estimate of SCC, CAFÉ standards were increased from 32 to 36 mpg because of the economic value of reduced carbon emissions – compared on the

margin with the cost of compliance. The Department of Transportation was taken to court on this. The penultimate hearing was an appeals court in Massachusetts. Justice Sotomayor participated in a three judge panel that decided that carbon dioxide was a pollutant. The automobile industry took that decision to the Supreme Court. Justice Sotomayor had been promoted, so she had to recuse herself. The Supreme Court, in a 5-3 decision for which Chief Justice Roberts wrote the decision, agreed that carbon dioxide fell under the Clean Air Act as a pollutant. Nobody, until Trump and Pruitt, has objected. It remains to be seen how that will turn out, but right now, all three branches of the Federal government are on the same page. Pulling out of the Paris Accord did not take on the Supreme Court or the Congress.

11. The Nobel Prize

The Lead: I will always remember that I should have heard the news from the TV or the Internet early in the morning, but that is wrong. I heard the details from the Internet and TV, but only after....

I was at the computer upstairs doing ordinary early morning stuff for a teaching day, and ***Linda came up the stairs and asked if I had heard the breaking news that the IPCC had won a share of the Peace Prize for 2007. "No-Way?" I said. And then we hugged.***

So really, I heard the news from Linda.

I prepared something like a statement before I got in the car to go to school, since I was senior member of the IPCC and I was well trained to prepare for media. But then I went to school.

Stuart Shlien was the first to call (on my cell while I was driving to school). I pulled over into the Valley View Parking lot (it was still very early). "Do I really know somebody that just won a Nobel Prize?" he asked. "Well yes, but a small part", I responded. "That is more than anybody else that I know" was the response.

Andy Revkin, then at the New York Times, was second to call when I got to my office, and it was from whom it became real. He made me feel that I had accomplished something. Andy quoted me in his NYT coverage the Prize – my sharing with Al Gore (and many others, I still emphasized). Thanks Andy.

I received more than 100 e-mail congratulations from 6 continents (the only time I received that many from friends who live all over the world was after 911 – more than 100 expressions of sorrow and sympathy). And Wesleyan held a reception at the president's house. Wow! The picture of college row that they gave me hangs in my office, right next to a 4" by 6" copy of the prize certificate. No need to dwarf the office with the real certificate.

I missed out on attending the Oslo ceremony because I did not win a lottery (roughly 15 spots were still open for 40 senior IPCC members after members of the IPCC bureau were finished making sure that they were invited). That is, fifteen "foot soldiers" from a list of 40 or so senior members as of 2007 got to attend. Good for them. Linda and I saw Richard Moss interviewed from the ceremony on TV – a very good thing. Richard was among some really good friends who were there, and I watched on TV with enormous pride from home with Linda. What could be better than that?]

Sorry, I already offered suggestions to that question on page 1; so you must know that this event is no more than second, no third, no fifth on the list of best things – family, granddaughters, knowing that lives have been saved from my work, knowing some of the real heroes in this story are friends of mine... then, the Prize as confirmation that I have made a difference in communicating the climate issue.

12. Hedging (for reference from the CV, see numbers 59, 64, 73, 77, 94, 106, 108, 110, and 118)

The lead – the insurance analogy works for conceptualizing investment in adaptation and mitigation, but it does not communicate very well. The insurance analogy did, however, frame some significant research.

I never understood why the insurance analogy did not communicate well. Maybe it is because, in the United States, people generally buy insurance because somebody tells them to. You can't drive a car without insurance. You can't get a mortgage without insurance. You cannot get health insurance if you have a pre-existing condition. In the insurance metaphor, there was always somebody telling us what to do.

I now have two thoughts about that.

One, the insurance analogy communicates with smart people. For example, Fred Singer. He came by my office at the Forestry School at Yale one day, and we argued. No loud voices, but no common ground, either. I finally asked him if he was absolutely sure that his contrarian view was right. "No," he said. "What are you so afraid of?" I asked. "Economic models indicate that it would be very expensive to reduce emissions, and I don't believe the dire science", he replied. "You believe economic models but not climate models?", I asked. "Hmmm," he murmured. "I don't", so I had the high ground. Again, "Are you 100% sure that you are right?". "No, but I am 95% sure." "Fred, 5% is all I need to sell you some insurance".

Of course, I don't have an hour to spend with every contrarian, and insurance is not an unencumbered alternative.

Two, from above, I had a thought. Always a dangerous possibility, but what if we thought of insurance as a metaphor for hedging, and used it to think about dark tails? How does a rational being respond to the chance that something really bad might happen? Risk is defined likelihood times consequence. Investments in insurance or hedging take the full range of futures into account – reduce likelihood or reduce consequence. Have a look at a squirrel when a fox or coyote lives in the neighborhood. Every squirrel knows that there is no guarantee that the predator is going to be walking by, but always stay close to a tree just in case.

The point here is that hedging in its most extreme is a way to keep (potentially valuable) doors open. And there is value there. That is what I wrote about.

13. Detection and attribution (For reference, see numbers 58, 165, and 166.)

The lead – It has long been known that climate change has advanced beyond the point where mitigation alone could ameliorate the problem. From above in Section 6, recall the fundamental conclusion of the Fifth Assessment Report of the IPCC: “Responding to climate change involves an iterative risk management process that *includes both mitigation and adaptation* and takes into account climate change damages, co-benefits, sustainability, equity, and attitudes toward risk”. It turns out that decision makers cannot adapt to anthropogenic climate change looking into an uncertain future without being able to attribute to that change to a specific source of stress, like climate change or population growth. It is impossible to project ranges of future climate driven impacts without an understanding the correlation between markers of human induced climate change (e.g., global mean temperature reflected in local or regional temperatures) and the detected impact. {#58, #165 and #166}

This section descends into some technical weeds, but they are critically important weeds. Understanding the definition and application of the statistical definitions of “attribution,” “prediction,” and “projection” is essential. “Prediction” denotes model-derived estimated values for an output variable given a vector of input values usually selected from within (or close to) the domain of detected data (the observations). “Projection” denotes estimates of the output variable from input values that are expected to lie outside their observed domains based on confidence in our understanding of underlying processes. Confidence there depends on the strength of “attributing” observed outputs to climate variability and perhaps to trending anthropogenic climate change as compared to other confounding factors like population growth or economic development.

My first foray into detection and attribution came in a joint paper with Camille Parmesan published in *Nature* in 2003 (#58). There we worked on distinguishing the causes of detected changes in the ranges of butterflies between anthropogenic climate change (warming) and other stressors like local pollution, population, or new development patterns. The data were nearly 300 papers in the published literature from authors who tried to make that distinction in a particular location somewhere in the world. The question was – does the collection of these localized attribution studies (to local climate change from whatever source) support high confidence in a conclusion that we have discovered a global coherent signal of the influence of anthropogenic climate change. Confounding factors were a problem, so our novel statistical construction could produce only medium confidence without some help from another source. The other source? Camille had observed that ranges of Edith’s Checkerspot butterfly (a widely studied butterfly) typically moved north or up mountains. That meant that, while populations were declining along say, the southern (warming from ideal) boundary, they were expanding along the northern one (warming toward ideal). Only anthropogenic climate change could switch signs like that; and since a large fraction of our data set detected this duality in their data, we could finally report very high confidence in the global signal. Why? Because we were certain, in those studies, that the authors had correctly attributed all of the detected range change to human induced global climate change. As an aside, this paper is my most cited referenced piece of work with nearly 8000 citations in the fall of 2018.

The IPCC conclusion about iterative risk management mentioned in the lead makes it clear that investments in adaptation (or mitigation, for that matter) depend upon efficiently processing information about the magnitudes of the consequences of observed and projected climate change as well as descriptions of the relative likelihoods of both – characteristics that will have been detected and quantified from historical data and then, perhaps, attributed to climate change and its anthropogenic sources so that ranges of future projections can be authored. From the perspective of real time *reactive* adaptation, simply detecting changes that may have been driven by local climate change and/or other factors may be sufficient to inform effective responsive decisions. Information

required to assess decisions about anticipatory adaptation, as well as long-term development projects, are more complicated. By their very nature, they rely on the attribution of detected changes to human sources of climate change that can be differentiated statistically from attribution to other confounding factors and driven predictably by underlying drivers like economic growth and population growth. Confidence in attribution and its quantitative calibration is therefore critical to efforts designed to project ranges of possible risks that adaptation and investment decision-makers do, or at least should, take into account.

Chapter 1 of the contribution of Working Group II to the IPCC AR5 (#165) reported the possibility of assigning greater confidence to the projection of climate change related phenomena than to the detection and attribution of changes that have already been observed. Their Figure 1 is a representative visual from that chapter. Working from this conclusion, I saw several fundamental questions:

- How can the confidence in projected vulnerabilities and impacts be greater than the confidence in attributing what has heretofore been observed in ways that are consistent with expectations derived from first principles of statistical analysis?
- Are there characteristics of recent historical data series that do or do not portend achieving high confidence in attribution to climate change in support of framing adaptation decisions for sometime in an uncertain future?
- What can analysis of confidence in attribution tell us about ranges of “not-implausible” extreme futures (that are found in the tails of the distributions of impacts) vis a vis a static (but stochastic) future assumed from a static climate system?

Answering these questions in an adaptation context is essential because of the long-term nature of some adaptations as well as for plans to reduce greenhouse gas emissions. All three answers require an understanding of the underlying physical and social processes by which confidence in impact projections can legitimately be evaluated to illuminate the foundations of strategies for iterative risk management. That is to say, this understanding is necessary if the science and subsequent defense of adaptive and mitigative response decisions can navigate what might otherwise be viewed as both a contradiction of statistical rigor and an obstacle for rigorous policy evaluation of adaptation strategies. These are the questions whose answers can explain why the science can support attribution of the recent drought in Texas (from 2011 through the end of 2013) to anthropogenic warming while it cannot yet support a similar conclusion for the recent five year California drought that also began in 2011 – a location where diverse topography and the proximity of an ocean confound the statistics of what would seem at first blush to be a “no-brainer” attribution.

The key to the answer to all three questions is a reasonable expectation that, based on a growing number of observations indicating the unequivocal anthropogenic drivers of the observed climate warming trend, researchers should expect that the impact of more micro scale climate changes, and consequentially the micro scale manifestation of a globally coherent “climate signal,” will increase with time while the impact of confounding variables like geographical characteristics could remain constant (or at least trend less significantly in line with observable socio-economic variables).

So, what are the answers? For the first, including robust understanding of underlying processes that describe output risk along projected ranges of how the future might unfold can, in some cases, uncover bifurcations between the distributions of outcomes calculated with and without anthropogenic drivers. As a result, forward-looking adaptation can be well-informed of what the future might bring. These bifurcations are likely to emerge along high climate change scenarios (so they may be delayed by effective mitigation); in other words, we cannot forget that mitigation matters. Conversely, bifurcations may be obscured by confounding factors, especially if distributions of climate change uncertainty grow slowly as the future unfolds.

And the second question? The characteristics just noted show the answer here is positive. Bifurcation can add urgency to adaptation decisions that might otherwise be questionably appropriate when only current climate variability can describe the decision-making environment.

And the third? Looking for bifurcations means focusing attention on the tails of impacts distributions. By their very construction, bifurcations occur when the high 95th percentile future assuming no climate change deviates measurably from the 5th percentile future assuming that anthropogenic climate change is driving the future. Put another way, the worst possible future becomes the best possible future – an unsettling conclusion for long-term adaptation planning. It follows that anticipated dates of bifurcation assume even more significance because they can signal a discontinuous change in the decision environment.

The takeaway from all of all of this is still that determining whether a given magnitude of output risk can be attributed to a high climate signal or a high confounding factors baseline can be a daunting challenge. This is particularly true with respect to carefully distinguishing cases where responses to climate induced risks can only be informed by predictions of growing collections of current observations rather than effectively extended data sets that include credible ranges of future projections.

14. Engaging in the public discourse (For reference, see numbers 63, 91, 92, 93, 99, 100, 101, 102, 147, 148, 170, 171, 172, 173, 174, 176)

The lead – It turns out that communicating climate science and climate policy is difficult. It takes lots of concentration and discipline and attention to detail; otherwise, it is easy to look or sound foolish or self-important. There are frustrations over inappropriate homage to the mantra of “fair and balanced” coverage by media outlets that feel obliged to tell both sides of a story even when the consensus is 97% on one side. In the Federal Register, it looks like the climate debate is at best a 50-50 proposition because both sides usually get to choose the same number of witnesses. There are also frustrations over alternative facts created by skeptics to sow doubt and uncertainty in the minds of the public – for example, sunspots, or population growth, or the misalignment of the earth’s orbit cause global warming. Steve Schneider was the only one who was immune to that in one-on-one debates because he read everything and remembered everything he read.

In my work on the third National Climate Assessment (NCA3), assessments of the Intergovernmental Panel on Climate Change (IPCC), the New York (City) Panel on Climate Change (NPCC), various panels and committees of the National Academy of Sciences (NAS), other government committees from within the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the Environmental Protection Agency (EPA), the Department of Commerce, etc, we always worked very hard never to publish “slow moving targets”. The aspirational goal was “no mistakes anywhere in the text”. That did not mean that we didn’t report on low probability but high consequence risks; it just meant that we were honest describing the science that supported assessments of both components of risk. I never understood why the skeptical side did not have to play by those rules. The Heartland Institute or Fred Singer can cherry-pick data or studies or just make things up and get away with it. Jon Christy kept citing one of his papers in his public talks for years after he was forced to publish a retraction.

Bjorn Lomborg is an exception. He is not quite a skeptic, but he does worship at the holy grail of cost-benefit analysis in his Copenhagen Consensus exercise and so he does not think that climate change is particularly important (certainly not existential). I contributed three times to the exercise, writing two position papers four years apart in support of climate change and discussing the process before John Bolton among others in between. He agreed that climate change is a problem, but he did not think that it should be a priority for a world facing multiple critical stresses and problems with an artificial budget constraint of \$X billion in one year. With the first paper, written with Richard Tol, we finished last, but later I criticized Bjorn for his characterization of our work in the *Guardian*. I wrote a critical opinion piece for the same venue which highlighted the mischaracterization. It caused Bjorn trouble at home, and so he responded. We could have gone back and forth for quite a while, but we spoke on the phone and decided to write a joint piece. A week later, the *Guardian* published something called “It is not about us” where we both agreed that the climate was changing and that humans were largely to blame (#102). Choosing the right response was just a matter of degree – especially since a few billion could really help reduce the incidence of, for example, malaria in Africa. We have been sort of friends since.

One episode at the end of the NCA3 process shows how seriously we took these aspirations. We had divided the country into 8 regions on the North American continent and Hawaii; and we prepared two page overview documents for climate and impacts for each of those regions. Two or three weeks before the June release in 2014, John Podesta (President Obama’s Chief of Staff) got the idea of publishing 2 page summaries for all 50 states derived from our 8 page chapters and associated traceable accounts for each region. He wanted to assign White House interns to specific states so that they could cover the could one state at a time. Kansas was the trial balloon for the idea, and repeated drafts used climate change descriptions for the entire Midwest region. The

trouble was that the Midwest region extended from Minnesota to Texas, so most of the climate descriptions include in the Kansas summary were misplaced and so completely wrong. Repeated attempts to fix the problem all failed, but Mr. Podesta persisted up to the day before the June 6th release of the NCA3 (www.nca2014.globalchange.gov). Jerry Melillo, T.C. Richmond, and I (as the leadership troika for the three year NCA3 project) finally had to make a stand. We sent word to the White House through John Holdren that their releasing the hopelessly inaccurate state summaries would cause us to take our names off the Assessment; and we told them that we fully understood that we, and not the release of the Assessment, would be tomorrow's news story across the country. It took very little time for the White House to blink, and the state summaries were not released. We could have done that if we had started 18 months earlier, but 3 weeks and limited coverage at the requisite level of detail were simply inadequate.

Living with skeptics on the planet means that I had to be prepared to speak with one or many. Few of them are open to changing their minds in the face of scientific facts. They are more interested in make audiences unsure about what is true. You have to be prepared with a rigorous and accessible retort and a library of references. So when they say:

“Climate change is a hoax!”, then you say “Have you ever taken a look at the temperature record? “Every decade since 1950 has been warmer than the last, and 12 of the hottest 15 years on record have occurred during the last 15 years.”

“Well the climate may be changing, but that causes little harm.”, then you say “Do you ever watch TV? The intensity and frequency of extreme weather events that have been linked to human induced climate change (droughts, flash floods, riverine flooding events, extreme heat waves, coastal storms, cyclones and hurricanes, severe cold snaps, wildfires, etc..) have exploded over the past 4 years, accounting for more than 50% of the \$1.5 trillion in disaster losses suffered across the United States since 1980. Coverage of these events is on every night, from home and abroad; it demonstrates that loss of life is a real and frequently unnecessary if you stay well-informed.”

“Even if damages are occurring, there is nothing that we can do”, then you say “Reducing emissions of heat-trapping gases slows the change; that is unequivocal. And careful forward-looking investment in adaptation saves lives and treasure.”

“Even if there is something that can be done, it is too late. We should just give up and enjoy the ride without worrying,” then you say “Don't give up! Don't ever give up!” and cite Jim Valvano.

I have enjoyed occasional appearances on live and taped TV: Ray Suarez on Al Jazeera after the release of NCA3. Al Jazeera in Brussels after a successful IPCC plenary. I saw myself in the background of Gwen Ifill's coverage of the White House release of NCA3. I appeared on tape with Charlie Rose. I appeared on RT television in New York City before I knew what it was. Local news has interviewed me many times – usual on tape where you record for 30 minutes for a 90 second segment.

Radio interviews were equally fun, and not as involved (you can do them on the phone). Some are just Q&A, but others are call in where you never know what to expect (except on NPR). Newspaper and electronic media interviews are similar.

Writing op-eds, other opinion pieces, and letters to the editor sometimes emerges as a good idea, and so I would occasionally drop everything and work on an idea that had crossed my mind in the middle of the night when I could not sleep. Success rates are not high, but persistence pays off. Recently, web-based outlets like *The Hill* or *The Conversation* will accept an idea a 1000 word piece. I always enjoyed working with their editors whose job it is to prepare a piece equipped with smooth language and live links to references or data. Those experiences actually felt like I was writing an academic paper with a coauthor who would polish the prose and suggest some catchy language in real time. These never took more than 2 days from germ of an idea to the publication of a finished product.

Congressional testimony is fun and a heady; but the invitations never come with more than three days' notice, testimony text is due COB tomorrow, and travel and lodging costs are never covered. Public talks are fun and unpredictable. Working with media outlets and giving interviews to reporters is also fun, but only if you are prepared for the questions. I learned in media training that you never take an interview on a cold call. Instead, you say "Thank you for finding me. I am busy at the moment, but what do you want to talk about? Can I call you back in 30 minutes". Then I would agree or not and organize my thoughts around a few key points and a few key words.

Bringing truth to power is hard, fulfilling sometimes, but frustrating other times. Sometimes power asks, and sometimes that means that they want to listen to you - congressional testimony, discussions in the EOB with staffers or higher, conversations with staffers across Capital Hill, etc. In one visit with The Nature Conservancy, Senator Murphy came into the room, saw me sitting at the conference table and said "Professor"; I nodded and said "Senator". We both smiled, and my TNC colleagues were pleased. Sometimes power just wants to be able to say that they consulted experts. At the beginning of the Trump Administration, for example, the national office of The Nature Conservancy was invited to send a representative to a small lunch inside the White House with the President, the Vice-President, three cabinet members, and White House staff to talk about infrastructure. The TNC was asked to talk about natural infrastructure, prepare a thought piece, and catalogue successful examples from around the country. So some of us worked to prepare for the lunch show and draft the two documents against stiff deadlines, but with no success. It turns out that they were using us so that they could say that they had consulted with the TNC and others, and had support that building a new interstate in a flood plain near the Gulf Coast in Louisiana was a fine idea.

Contacts from students from all over the country and six continents have been highlights, because they always made my day. Usually a cold call e-mail (from a graduate student writing a paper or a dissertation or an undergraduate doing a class project or a senior thesis) explaining interest in climate change and specific interests in the climate change universe shows up in the morning. I cannot ever remember saying no. We then arrange sending a preliminary set of questions, a call or facetime or just written questions to which I respond, and a deadline that informs scheduling. Sometimes it is "one and done", but other times a conversation is born. I can report that I say "I don't know" more to this audience than any of the others, because these are the untethered free thinkers. I can also report that the conversations sometimes end up crafting new models to confront new questions. Let's just say that these random episodes are enormous fun.

I am not sure that this, the end of the stories, is the place to write this down, but I was not paid for most of the work I did for IPCC, NPCC, NAS, NCA, NASA, NOAA, etc. I once applied my usual contemporaneous consulting fee (for the little consulting that I did for a few firms and several participants publicly motivated court cases) to the hours that I gave to all of them one month at a time - \$150 an hour early in the 1980's and 1990's up to \$250 after 2010. The total of these calculations now stands somewhere in excess of \$2 million. No regrets. Not at all. This was my service to my country and my planet.

15. The Nobel Prize, again.

The lead: Professor William Nordhaus won the 2018 Nobel Prize in Economics on October 8, 2018. That news was exciting enough, because it validated his and my spending much of our lives working on climate change and framing climate policy. It got more exciting when, on October 15th, Bill invited me to be one of his four non-family guests at the Awards Ceremonies and Events in Stockholm. His invitation indicated dates (December 8th through the 10th were most important), and I made sure that I was available to travel abroad spanning those dates – my first time abroad in 2 years or so.

To be precise and formal, William D. Nordhaus was awarded the *Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel* for 2018 – otherwise known as the 2018 Nobel Prize in Economics. The short attribution justifying his award was amazingly short: for “integrating climate change into long-run macroeconomic analysis”. Bill shared the Prize with Paul Romer from NYU who was selected for “integrating technological innovation into long-run macroeconomic analysis”. Nice symmetry that did not go unnoticed in their Nobel Lectures.

For the record, the longer description of his work added some of the details that caught the Nobel Committee’s attention: “Nordhaus’ findings deal with interactions between society and nature. Nordhaus decided to work on this topic in the 1970s, as scientists had become increasingly worried about the combustion of fossil fuel resulting in a warmer climate. In the mid-1990s, he became the first person to create an *integrated assessment model*, i.e. a quantitative model that describes the global interplay between the economy and the climate. His model integrates theories and empirical results from physics, chemistry and economics. Nordhaus’ model is now widely spread and is used to simulate how the economy and the climate co-evolve. It is used to examine the consequences of climate policy interventions, for example carbon taxes.”

All of this is true. I use DICE and RICE (his two ever-evolving models) to this day to support some of my work. I *always* use the insights that he derived from his modeling in all that I do. We have come to coexist on the interface of two approaches to the climate problem. His grows from dynamic cost-benefit maximization that he now uses to explore alternative approaches (like shooting to hold warming below 2 degrees Centigrade to maintain tolerable risk profiles at minimum cost). Mine works from an iterative risk-management perspective calibrated in many different metrics (like currency, or human lives or...) that always keeps track of the Bill’s “optimal” solution for grounding.

On October 8th, before noon, I sent a Tiffany pen to Bill in recognition of the Prize. It arrived at Humphrey Street the next day to the puzzlement of Bill and Barbara (I found out later). I was inspired by the scene in “A Beautiful Mind” where, just after winning the same Prize, John Nash sat down at a table in the Princeton Faculty Club. Many of his colleagues approached him at his table and gave him their congratulations embodied in their personal pens. Barbara thought that I knew that Bill is fascinated by pens and that I wanted to contribute to his collection.

My invitation arrived on October 15th:

Dear Gary,

I have the opportunity to invite a handful of guests to the ceremonies in Stockholm in December.

The key days are December 8 through 10. I would love to have you both for being a central participant in work at the National Academy and for a continuous distinguished work on the integrated assessment of climate change.

If you can join us, I will send more details on the plans, dates, and ceremonies.

Best,
Bill

Once Barbara and I began to communicate about my impending trip to be part of the 14 person Nordhaus tribe that would name itself the “Stockholm 2018 Climate Club”, I was able to explain my motivation for the gift. She let Bill know. An appendix to this chapter lists the members of the Club.

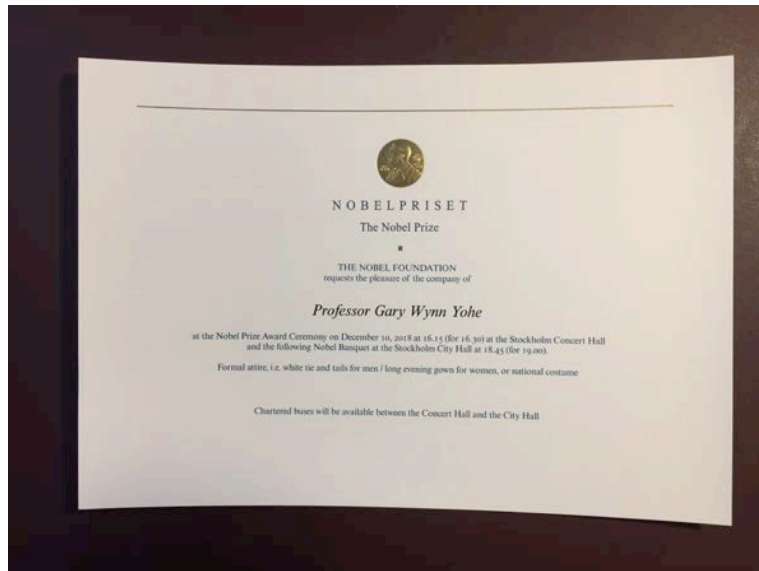
The dates conflicted with a professional trip that Mari had on her calendar; Linda and I had agreed that we would take care of the twins in her absence. I was torn, but everyone agreed that I had to go because this opportunity was not to be missed, and so I began to prepare. They would manage, but not without some cost.

My passport was the next source of concern. I had sent my expired passport to the government to be renewed a few weeks earlier, but I had not asked for expedited service. Now, suddenly, I needed expedited service to make hotel and plane reservations. I called Senator Murphy’s office for help. They jumped at the prospect making it possible for me to get to the Nobel ceremonies. They sent me a privacy form to complete, and then went to work expediting. Their contact in the Atlanta office was also impressed with the reason for the trip, found my application in backlog, processed it, and put my new passport in Federal Express in about 3 hours. Within 24 hours of my request for help, my new passport arrived at the door of our apartment in Rockville, MD. Unbelievable. Thank you Senator.

The Nobel Committee soon sent 12 pages of instructions, schedules, and other information for Laureates’ guests. Since I had a new passport number in hand, I quickly followed their advice about using SAS for the transatlantic flight. I also decided that it was essential that I stay at the Grand Hotel in Stockholm – the headquarters hotel for the Prize infrastructure that was equipped with a “Nobel Desk” to distribute tickets and to handle all problems for any of us.

Then there was the requirement that I wear “white ties and tails” to the Award Ceremony and the Nobel Banquet. I contacted the recommended store in Stockholm, sent in my measurements, and rested assured that I could pick up the requisite apparel upon arrival. After all of that, I received word that I would be greeted with VIP service at the airport; I would be met as I disembarked from the plane and transported directly to a private office. I would not have to stand in line for customs, claim baggage, or arrange transportation to the hotel – both coming and going. They would take care of everything.

I left for Stockholm after my last Econ 310 class on the morning of December 6th. I arrived the next morning in the dark, exhausted from a busy week and a long flight. I was delivered to the Hotel, but my room was not available. So I took a cab to the tux place, had my tails and trousers fitted, and otherwise filled the morning trying to stay awake. The room was available around noon, so I got to nap before dressing for an initial reception with the Nordhaus group as well as Professor Romer and a subsequent dinner (all thankfully in the hotel). I went to bed happy about the prospect of a good rest and a good breakfast before the festival of events would begin tomorrow.



The Invitation that Awaited My Arrival at the Nobel Desk

December 8th

Most of the Nordhaus group went on a guided tour of the Royal Palace and Old Town Stockholm in the morning. Below are some pictures inside the hotel and outside the Palace.



In the lobby on day one



On the Palace-Oldtown walk

2 PM: Nobel Lectures in Economics – Bill and Paul Romer spoke for 30 minutes each outlining in more detail the work that had been celebrated in the Prize. Walking out, Annabel asked what time it was. 3:30 was the answer, and she was incredulous because it was already completely dark outside. I asked her why that might be. She did not know, so I asked her to think about it. She told me why the next morning. Here is a picture from after the talks.



After the Nobel Lectures

7 PM: Nobel Prize Concert – The Stockholm Philharmonic Orchestra and soloist Lisa Batiashvili performed a violin concerto and Tchaikovsky’s 4th Symphony under the baton of conductor Karina Canellakis. The performance was spectacular.

December 9th

We had the morning off, so Jesse, Naki, and I went to the Nobel Museum instead of taking the programmed boat ride. We found the 2007 Peace Prize description, and explored many exhibits; the dominant displays involved Martin Luther King, Jr.

3 PM: We all attended a reception at the U.S. Residence. We have no ambassador, but the Charge d'Affaires hosted more than 100 guests. I learned the Crow's Nest" and "Sock Wars" rules from Alex and Margo on the floor of the dining room. "Practicing to be 'papa'!" is what I told everybody, but in reality, I was being adopted by the twins.

6 PM: Reception for all at the Nordic Museum. I was walking from my room when Bill emerged from the elevator with Alex and Margo. "Here," he said. "Take them down to the lobby and find somebody to get them to the reception." So off we went into the chaos of 3 busloads of people in the lobby. Some family arrived, but I was in charge of the pair until we arrived at the reception.

The enormous room was jammed with hundreds of people. except for some space under a giant Christmas tree at one end of the enormous hall. The twins and I went down there and proceeded to try to count the ornaments on the tree. They divided the tree into sections, counted one section, multiplied, accounted for the other side of the tree. Their total was 3005, not taking account of the tree's triangular geometry; theirs was an estimate for a cylinder. Eventually the family collected at the tree so that we could go to dinner. The girls told Grandpa about the counting exercise, so he took a shot. He did the geometry correctly and came up with about 1500-1600. Correcting 3005 for the geometry yields 1502 or 1503. Pretty close, we decided. Grandpa was pleased.



The Christmas tree and most of the Climate Club

7:30 PM: The Nordhaus's hosted a Swedish Christmas buffet at Operakallaren. We got there late, and did not leave until well after midnight – eating and drinking through 12 courses. This was a spectacular time at a very long table. A parallel table was occupied by a collection of dentists. They gave toasts, and we did, too. I went second; my words are appended below. The dentists finally realized that they were adjacent to a party for a Nobel Laureate. And so they also toasted Bill.

Around 1:30 AM, we left the restaurant. Lint was staying at a different hotel, so we all walked her to her door. Then we walked back to our hotel arriving after 2AM. Something about a Nobel Laureate walking an invited guest back to her hotel in the dark of night after midnight, accompanied by his family and other guests, just sticks in my memory. Would be a great scene for a movie. It was certainly a sign of enormous character, I think. Anyway, it was at this dinner that the Stockholm 2018 Climate Club was formed.

December 10th

Another morning off, but a good thing. All woke up late, and barely made breakfast. I took a walk and took some pictures, but then began to worry about getting into my tails. They had been delivered to my room on the 7th, but they were still in the suit bag. We had to be on the bus at 2:50, so it was time to put it on.

I started fussing around 1 PM. Shirt sleeves were easy, and I had cuff links from Mari to wear. The studs and the collar anchor were challenging. Trousers were easy, and so were the suspenders. But the bow tie..... argh! I found hooking it properly while looking in a mirror impossible. After 15 minutes of frustration and growing anxiety, I went downstairs to the lobby where the entire staff was in tails. I asked for help from the rental store, but there was no need. The concierge took me aside, adjusted my tie, and got it on my neck properly in about 30 seconds. I went back to my room to finish dressing, and made the bus with 5 minutes to spare.

4:30 PM: The Awards Hall was spectacular. Our seats were perfect (second row mezzanine in the center). The stage filled with members of the Swedish Academy of Science on the right and former Laureates on the left. The Royal family sat up front on the right, and this year's class sat in front of the Laureates on the left. When they came on stage to trumpets and fanfare, I looked at Link and said "I think he will be nervous, now." He had taken the entire week in stride up until this. When he sat down, second chair from the right, his feet could not stay still and he could not figure out what to do with his hands. I was right, but not for long. When it was his turn, he did the choreography perfectly, and looked rightfully proud – if only for a minute.



Rightful acknowledgement – the top of the mountain

The Stockholm Philharmonic and an opera singer performed in between each discipline's awards – physics, chemistry, medicine, and economic science. The singer's name is Christina Nilsson; she sang beautifully. She would sit directly to my right during the Banquet to come; I found out that this was the fifth time that she had sung for the King in 2018.

7:00 PM: It was snowing a little when we left the Awards venue for City Hall and the Nobel Banquet for nearly 1600 people. The meal was planned for 3 courses and 3:45 hours. Entertainment emerged from all sides in between courses. As just noted, Christina Nilsson sat to my right. Valentina Bosetti sat to my left; she was a colleague of Bill's at IIASA. Naki sat across, and Jesse sat to the left of Valentina. Lint sat directly behind me at the next table, so we were all close.

We were all about 10 feet away from the King of Sweden. Across and to the left sat John Arne Hassler, a professor in Stockholm and chair of the committee that awards the Economics Prize. We

started talking shop about the social cost of carbon and what happens when net emissions fall to zero. No answers then, but I am working on a paper that may be coauthored someday soon with a Professor from Stockholm. Just like IPCC days – pay attention at dinner.

The banquet adjourned around 10:45 only to reconvene for dancing and more food upstairs in a room that was as big as the banquet hall. Two final pictures are below, but do not be fooled by their stationarity. The room was in motion until 2 AM. Another party followed, but Lint, Jesse, Naki and I went back to the hotel for some rest. We all had to travel tomorrow. When we got back to the hotel, we picked up our “Climate Club” hats at the front desk – courtesy of Monica Nordhaus and named for the location and Bill’s latest publications about a “climate club”. All game theory and the like, but the hat feels great.



Bill and Barbara and me at the Banquet party



The Stockholm 2018 Climate Club at the party

December 11th

I awoke in time for breakfast, saw Bill in the lobby one last time for a hug, and headed off for my plane. First to the VIP building with its own security belt, customs officer, and people to check bags. I was told to wait until the last minute. Then I was driven to the gate on the tarmac, went up the back stairs to the jetway, and walked onto the plane – last among all passengers. All looked at me to try to decide who I was. I knew who I was not and settled in. I slept most of the way to Newark, and most of the way in the car back to Portland.

16. Mentors and colleagues

William Nordhaus – the original one [see <https://economics.yale.edu/people/william-d-nordhaus>].

He is the reason that I got into climate change. He and I worked together early on an Academy report, the first version of DICE, and beyond. He has always seemed to be proud of me, and that makes me smile. A few stories populate the yearly CV, but they are not sufficient to cover what he did for and to me. Without his influence, my life would have been entirely different and wasted in the weeds of esoteric papers on micro-scale decisions under uncertainty. Here is one story from 1982 that expands on his getting me into this climate change war:

Bill invited me to work with him on a National Academy report on *Changing Climate* in 1982. He just called and asked if I wanted to collaborate. I accepted, and the rest (my interest in all things climate change) is history. The Academy paid me \$5000, so that is where our living room piano came from; hardly anyone plays it anymore, but it gets tuned before every Christmas just in case.

We created probabilistic scenarios of carbon emissions and atmospheric concentrations – the invention of spaghetti graphs (#10). I also wrote a simple but new bit of theory – estimating CES production functions with a time series of Cobb-Douglas functions (#13).

William Nurenburg was the chair of the Committee; also on the Committee were the leaders of two research groups with competing estimates of the “airborne fraction” (the fraction of a ton of emissions that remains in the atmosphere after one year (and then persists with a half-life of about 100 years). This parameter was one of ten sources of uncertainty in our modeling. One of our experiments was to rank these sources in terms of how much they explained of the total variation in concentrations. Our simulations ranked the airborne fraction 10th of 10.

When it was time to present that result to the Committee, Bill turned the presentation over to me. I explained the method and displayed the results – and the room erupted in argument and chaos that lasted for hours. I looked over, and Bill was leaning back in his chair laughing at me and smiling. “Welcome to the big-time.” It turns out that the two debating scientists were looking at the possibility of losing what was significant government support for their research into which estimate of the fraction was right.

Authors contributing to the climate literature will still be citing our 1982 chapter in 2017; and spaghetti graphs are the norm well beyond climate – e.g., projected hurricane tracks in 2017 (Irma and Maria) in TV weather reports.

Based on that work, Bill arranged for me to attend an International Energy Workshop (IEW) meeting at IIASA in Laxenburg. Linda came, and we stayed in Vienna next to the OPEC secretariat offices before going to Paris for a vacation. Bill took us to Demel in the Inner Stadt. He walked around pointing at pastries to show us how beautiful they were. We were very impressed, and admired every one. An attendant thought he was making a big order, and presented Bill with a large tray for his approval when we neared the front door. Bill and we declined, and walked out of the store followed down the sidewalk by much commotion. It took a decade before I could go back into Demel.

So, let me just ask just recall one question that I had been asking for years – “When does the Nobel Prize in Economics show up on his guitar?” We now know the answer. He was and is so deserving for so many reasons.

Thomas Malone – the anchor to my international engagement [see http://www.nasonline.org/publications/biographical_memoirs/memoir-pdfs/malone_thomas_pdf].

Tom was the catalyst for my children's engagement to the world beyond Portland, CT. "Hello. This is Tom Malone from the airport" he would say on the phone when one or the other would answer (way before caller ID). They would get me to the phone, and then he would play "Where in the world is" Tom Malone. "Quick. Find it on the map." Tom never told me that he was a MacArthur Fellow. Our first significant excursion was at the Second World Climate Conference (SWCC) in Geneva (October 19-November 7 in 1990). He was chair of Working Group 12 (there were multiple break out groups), and I was his staff. I wrote our report, and he edited – our proposal to create an integrated collection of research and training institutes scattered around the world...DC, Bangladesh, etc.. Our report was accepted by the SWCC, and a few months later, a session that he hosted in Bellagio came up with a formal proposal that became START – SysTem of regional networks for Analysis, Research and Training. The program still exists, and it has changed small parts of the world, tens of people at a time, for decades. Toward the end of his life, I was successful in my nomination that he receive an honorary degree from Wesleyan; I missed Angela's wedding because I had the honor of introducing him at Commencement and place OUR hood on his shoulders.

We collaborated on several papers (#23, #26, and #58); but the collaboration went far beyond that. His concern about the planet was infectious – and I learned that you can never do to little and travel too little.

Stephen Schneider (1945-2010) – the exemplar of what we all want to be. [See: https://www.youtube.com/watch?v=4_eJdX6y4hM&sns=em:
<https://stephenschneider.stanford.edu/References/Biography.html>

Steve knew everything. He took personal risks (and it killed him). He took on anybody on stage or on camera, and he was the only person alive who could convincingly debate opponent with – "You are making that up, it is wrong, and you know it." because he knew everything in the literature.

Steve never took the median or mean for an answer – not from those of us worrying about climate change, and not from his doctors. He was the "patient from hell", but he survived that one. I remember sitting under the tent in Snowmass when Terry came up to him in the audience and whispered in his ear. He picked up his stuff, and he and Terry left CO to go back to Stanford to check into the hospital. The tests had come back, and they were not good. Not many noticed his departure, but I did. And the front desk confirmed – he and Terry had gone home. We all knew that this was not good.

At the AR5 scoping meeting (I summarized this story in my comments at his memorial service) – the lead: I finally passed the entrance exam to his inner circle. I got up in plenary at a Scoping Meeting for the AR5 in Venice and said to the Chair of Working Group I who had just spoken – "What you just said (that one peer reviewed paper with a contrarian conclusion would not be assessed or included in the assessment of the AR5) made the hairs on the back of my neck stand on end. We are working in a risk management world, and a dismissing a not-implausible conclusion with high consequences is scholarly vandalism". Why? Since the Valencia plenary in 2007, our IPCC clients have said so. Our clients had made it clear that they wanted to hear about the dark (or benign) tails of "not-implausibility".

We lost that battle in WGI, but had a smile across the room after Steve made a two-fingered intervention (signaling that "my comments were germane to what was just said,") and

Pachauri (who had the microphone) acknowledged. Steve said: "What Gary was trying to say.....". Steve was very measured and polite in summarizing my thoughts until he got to the "full of shit" part. I knew, then, that I had just passed my post-doctoral exam. Steve was pleased enough with me to defend me in front of 170+ country scientists.

Michael Oppenheimer – he and I took over editing *Climatic Change* after Steve passed.

Michael called me when I was in Snowmass. I had heard of Steve's death while I was having breakfast at the River Inn attending a National Academy of Sciences meeting on America's Climate Choices. Kris Ebi had called me, and told that Steve had died on an airplane from Sweden to London. She told me of her plans to go to London to retrieve Steve's body from the US Embassy and bring him home to Terry (Root) Palo Alto. I came back to breakfast, and Diana Liverman had heard. We left the table immediately. I don't think that anybody ate anything else that day.

I was with a number of friends, and it was up to us to deliver the news of Steve's death to colleagues from one department to the next across Washington.

When we got to the Office of Science and Technology Policy, we had to tell John Holdren; I did the honors. He was stunned, but shortly (say, 15 seconds later) he got on the phone with the president – directly with no gatekeeper. He reported Steve had died; after a short call, John reported to us that the president was stunned, as well. He reported that the president would send a sympathy note to Terry – "No need for an address – I can get that". "Would you like me to draft something?" I heard John ask. "No, I can handle that, too." A day or two later, a handwritten note of sympathy was delivered to Terry at an address that none of us knew.

We all sleep walked through the rest of our day. We finished our work, and I went home to a period of enormous grief and too much wine. Linda got tired of that act, and sent me off to Snowmass a week later with an assignment – get over it and get well.

I slumped along, depressed ... and I declined an invitation to attend Steve's funeral. I did not want my profound dysfunction to be the story that everyone remembered. So I was still in Snowmass when Michael called. He wanted to know if I wanted to co-edit *Climatic Change* with him. He was the editor of *Climatic Change Letters*, and Springer had approached him with the challenge of putting together a team.

We talked on the phone for almost an hour while I looked out of the condo window at the Snowmass tent where I had spent many hours with Steve. The view did nothing for me. I felt nothing because I just wanted to stay where I was. Michael and I talked some more, and finally I agreed that I would be interested. So "Keep in touch", I said. I was trying to close the conversation. "I am sure that you have more calls to make and many more options to consider," I added; "Just let me know". Or something like that.

Michael said, for reasons that I do not know and do not want to know – maybe Kris and Terry were looking out for me... Michael said something like "If you say yes, this is my first and last call." I said "Yes", and there you have it.

A number of years later, Linda told me when the phone rang while we were on our deck that I could not say "No" to the President of the United States. But I had. I was trying to cut back. I had to call back to say "Yes" to being Vice-Chair of the Third National Climate Assessment; I am very happy that Kathy Jacobs made the first call and took the second – one of the best decisions of my life. Getting back to Steve when Michael made his offer, I could not say anything but "Yes." These were the steps that brought me back.

Eight years later, Michael and I and our Deputy and Associate Deputy Editors (turns out it takes 15+ people to replace Steve) seldom have trouble finding reviewers for the more than 800 submissions per year that come into *Climate Change*. Why? Because hundreds of people around the world are still loyal to Steve – “It is the least I can do” they frequently say. When we ask people to become Deputy Editors (quite a bit of work), they frequently ask “What took you so long? I would be honored.”

I still have many e-mail messages from Steve on my computer that I have never erased through many upgrades. I also had one phone message that I did not answer on the week that he died; that recording of his voice has gone with the phone service change, but I remember it still. I never tried to respond, but I still expect that he would have answered if I had hit “reply”. I know that he would try to answer the e-mails if I had responded. In fact, I think that he has replied all of the many times that I have wondered – “What would Steve do?”

As a general rule, the collection of referee reports and Deputy Editor comments and editor letters to those who are obviously your scholars are still two or three times as involved, even in rejection, than they are for somebody my age who should know better. Steve was a teacher, and we have to live up to the challenge of finding new talent from anywhere around the world. I cannot tell you how many 3 page “reject before review” letters we have sent out because our editorial team tries to live up to Steve’s standard.

The last time that I saw Steve was at Jasper Ridge - a Stanford research property just outside of Palo Alto noted for wildfires, poisonous snakes, cougars, and poison ivy. We were there to write uncertainty guidance for the AR5 of the IPCC, and we mostly stayed inside. Steve was bloated and having trouble standing, but he was as sharp as ever.

Terry and he had us all over for dinner on the first night of the meeting; it was a lovely, catered time – catered so that Steve and Terry could be with us and not in the kitchen. The dogs were moving from one person to another. Nobody talked shop. Everybody enjoyed just being in his home. We enjoyed his garden. Steve said that he was going on a speaking trip to Scandinavia and the UK in a week or so and that he was looking forward to advancing risk management and scientific integrity.

We finished our work the next morning and all flew away home. Little did we know that that was the last time.

I got it together enough to speak at a Symposium that Terry arranged in Boulder a few years later. It was organized around the major themes of his life, and I got to talk about the history of *Climatic Change*. The major part of my talk was to report the ten most cited articles for each of the 4+ decades of the journal – based on Google Scholar and a lot of time in the hotel room. Most of the winning authors were in the room, so an audible competition erupted as I did the David Letterman thing. “#10....#9... ..” and finally, “The most cited paper from *Climatic Change* in the 1980’s is”. Cheers and moans would erupt, and I would press on. It turns out that the Symposium was covered on the web. I found out because I heard from many authors who were not in Boulder. “My paper from 1992 had 350 citations; how did that not make your list?” “Because #10 had 452 citations”.

Before I read the lists, I gave a brief history of the founding of the journal. Drawing from Steve’s book, I related the story about when he went to the Director of NCAR and said that he wanted to create an interdisciplinary journal about climate change. The Director said something like “If you do that, you will never receive tenure at NCAR!”. Hmmm. What to do with that piece of news? Ignore it? No. My next slide had 3 big letters – only – and a punctuation mark: “WTF?” it read. There was silence for a second, but the “crowd went wild”, at least in my memory. And nobody from the webcast complained except my wife Linda. She got over it. Really? What were you thinking, NCAR? Stanford’s gain for sure.

For me, Steve shows up all over the yearly CV, and my name appears proudly with his on numbers 51, 85, and 115 – an underestimate of his influence on my thinking and his pride in “Responding to climate change involves a risk management approach including both adaptation and mitigation” Page 22 of # 85.

Thomas Wilbanks (1938-2017) – the true southern gentleman with smarts, backbone, and grace [see https://ccsi.ornl.gov/sites/default/files/wilbanks_bio.pdf].

Tom and I followed each other around the world and back and forth to Washington for two decades. IPCC meetings. National Academy meetings. National Climate Assessment meetings. He always traveled more than I, but when we ended up at the same meeting (and same hotel), we would break bread together in the morning and the evening. We would share thoughts about the meeting. Share life experiences (like he had “back door clearance” for a while for a project in the basement of the Pentagon and like Mari and Courtney went to Geno’s basketball camp). Tom was an avid Lady Vol fan, and I was not. I made quite a few dollar bills on games when Tennessee and UCONN used to play three times a year.

I think that we learned a lot from each other; I certainly did. But what I remember most is his humanity. Tom was retiring from chairing an Academy Committee on climate adaptation and resilience or something like that. He had chaired his last meeting, and we arranged to have dinner. I had arranged to have a pewter Jefferson Cup from Williamsburg engraved to commemorate his service and his retirement; and I gave it to him at dinner. No fanfare or hype. I just wanted him to know how much he meant to me.

One vivid memory - Linda and I had a quiet dinner with Tom just outside of Merida after Bob and Joan left. It was one of the highlights of what turned out to be a wonderful (top 5 in my life) trip. Dinner was relaxed and wonderful. We talked about family and basketball and NOT work. A few hours later, we all took a carriage ride back to the hotel campus. We passed Ian Burton and Barry Smit having a drink on a sidewalk table. They shouted out. We waved and all smiled. We all laughed the next morning at a shared table for breakfast. This was the IPCC community at its best – save the planet one chapter at a time, but make life-long friends as you go.

Jerry Millilo – another extraordinary mentor (see <http://www.nasonline.org/member-directory/members/3435.html>)

Jerry came to influence my late, though I had known of him for decades (seeing him present and engage many times). Our close association was born of my participation as one of his two vice-chairs for the Third National Climate Assessment (NCA3) for President Obama (T.C. Richmond was the other vice-chair). He gently taught me about how you behave, how to lead by bringing others to their own conclusions (the 44 member National Climate Assessment Development and Advisory Committee (NCADAC), and how to make the world a better place.

A giant in the scientific world for his research, Jerry had vast experience in leading and organizing large and small groups of “strong, scientific and private industry cats”. Herding them was a challenge, but listening and responding respectfully was the key. NCA3 decided early on, with my encouragement, that the NCADAC would operate on the basis of consensus. I had IPCC experience in that, so he let me lead meetings where we would seek consensus. To be clear, that meant that for a particular word or sentence or conclusion or instruction... anyone in the room could object if he or she could propose an alternative. It took a while for the Committee members to understand their responsibilities in this process. Early decisions took hours. Eventually, it worked efficiently. The final NCA3 report and their two derivative documents passed with little drama.

Except on source of drama. The NCA3 had divided the US into eight sometimes very large regions. The Administration, in an effort lead by John Podesta, wanted to release state by state “two-pagers” derived from the report. Jerry and T.C. and I, as well as our small Secretariat, agreed that we could not do that. NCA3 did not have sufficient skill to do that credibly. We rejected draft after draft for an illustrative example – Kansas. Finally, when we got one more edit that was still not credible and heard that the White House would do it anyway, Jerry, T.C., and I decided that (to protect the entire report from being shot down with false statements in the ancillary state by state releases), that we would withhold our names from the cover pages of the entire report if the White House prevailed in this project. The report was to be released the next day. Our refusal would be the news story – we decided that we could easily make that happen. Long story short, the White House blinked, and the NCA3 was released at 8:30 the next morning by consensus. Jerry went to the Rose Garden with the President, and the rest of us watched the electronic release of our 1600 page report (#162). By 9:00, our site had seen 20,000 hits, and we handled every one.

In the press briefing that afternoon in the Eisenhower Executive Office Building auditorium, John Podesta declared something like: “See, this White House can roll out something electronic and handle all comers. The Affordable Care Act experience was still in the public consciousness.

Kristie Ebi – honest and sincere soul who is generous to a fault; and she is very, very smart (and street smart – they are not the same thing), and an anchor for my sanity and productivity (see <https://globalhealth.washington.edu/faculty/kristie-ebi>).

Kris and I have shared National Academy of Sciences (including the Institute of Medicine), IPCC, National Climate Assessment, and Climatic Change experiences around the world for more than three decades and many co-authored papers; stories abound in the Yearly CV, but here are some references.

She has seen my highs and my lows, and was always there for me; I have shared her highs and lows, and hope that I have always been there for her. She travels too much, but replaced Tom Malone for the game – “Where in the world is ...?” This time, it is Kris Ebi. She has been an anchor of stability and love for me and my family.

One story to supplement the many that populate the yearly CV - Katie and Snowmass:

Katie worked for Susan Sweeney for many years making the Snowmass meetings work smoothly. One early night at dinner under the tent, Kris and I were chatting (probably about a presentation or an upcoming collaboration, and Katie came up to talk to her mom. “Yo, Mama!”, she said. “That be us”, I replied; I had heard “Yohe, Mama”, and I could not resist. Everyone close to us laughed out loud, and Katie became my friend for life because I was so cool (???)

Kris was always pushing health issue in impacts meetings. For a very long time, health was the last impact considered at impacts meetings when everyone was collecting baggage to catch a flight. I like to think that our work to map the “determinants of adaptive capacity” to the “precursors of public health” helped bring health to the fore. But it has been a long climb up a steep hill – and perhaps we were half way up the mountain when the Trump Administration declared it all a hoax. With their persistent funding of the NIH, perhaps Congress saw something different.

Perhaps the real overlap is that the climate change community, finally, in 2007, saw its problem in terms of risk management, adaptation and mitigation. It turns out that public health had been viewing its mandate through the risk management lens for nearly a century. An issue, though, is that medicine has created flow charts to organize standard decisions at anticipated outcome bifurcations designed to handle the “normal” (in a statistical sense), patient. As Steve emphasized from personal and successful experience, no patient is normal.

Alan Manne (1925-2005) – a kind and demanding mentor and friend [see <https://msande.stanford.edu/people/alan-manne>].

Alan was a leading scholar in his field when I first met him, and continued to be so until his death in 2005. He was then expanding his influence to integrated assessment (of climate change) through the creation and evolution of a model named MERGE. Through this model and access, I met and came to enjoy the friendship of Richard Richels – one of Alan’s students – and many others.

Alan was a gentle tutor when I was new to the game. Alan was a dogged, constructive skeptic of my work when I had been promoted to a more mature level. He did not suffer educated fools well, and so achieving that threshold of stature, I was vulnerable to his questioning, even in public. That was fine, though, because I always prepared, when I was working on a presentation particularly in Snowmass, for the Alan questions. Just anticipating what he would ask made my work and my presentations better; and so it made the science better. By the end, I could get through a talk without a question; and you cannot imagine how much I learned for my research by being prepared. Bill Nordhaus was in the same category. Later, Richard Schmalensee was similarly elevated in my brain. Just like Waino Fillback when I was President of the First Congregational Church of Portland. “What will they ask?” was always the source of the last round of revisions of any presentation and the first round of questions at the beginning of a thought exercise.

Alan and I worked together to frame modeling exercises for the Energy Modeling Forum (EMF) uncertainty group. The exercises were designed to support statistically based model comparisons. We discovered one important tendency. Given the opportunity to pick driving variables instead of using specified characterizations – the distribution of outcomes like carbon emissions was wider when everyone used the same inputs. Modeler’s choice, therefore, displayed an instinct not to stand out from the crowd. And so, distributions of outcomes from modelers’ choices were NOT accurate measures of uncertainty. This insight was a big deal.

My memories of Alan are not confined to academics. He arranged for my daughter (Courtney) and I to go horseback riding at Maroon Bells. I was on my own, but Courtney got personal instruction and was comfortable on a horse in rugged countryside within 30 minutes. Alan and I, in our last time together, enjoyed croque-monsieur in a Brussels café (after an EMF meeting). After eating and chatting about important people in our lives, we wandered back to the hotel slowly – picking up presents for home (to those people) along the way. We bought chocolate and lace to take home, and we enjoyed the smiles from the locals.

My most precious memory of my time with Alan was taking him as the guest of our family to a concert in the Musikverein in Vienna. He fell asleep for a bit, but he awoke in time to buy us *all* champagne at intermission. Mari and Courtney were in heaven. Then there was the meeting at a Subway (restaurant) in Vienna – we met there by accident in the dark way after dinner time because we were both looking for a touch of home - italian grinder for me and tuna salad for him.

Needless to say, I miss him. His number is also still on my cell phone list. The list of derivative papers from his collaboration is long: numbers 12, 15, 19, 21, 25, 31, 32, 34, 37, 40, 42, 51, 62, and 68). All were presented before him, and all were better because of his anticipated and actual scrutiny.

Lots of others – please do not be offended if this list goes beyond my family. Golf buddies **Barry Smit, Joel Smith and Bill Easterling**, for example. I remember Barry’s hitting a fox on the butt with a shot. I remember clapping wallabies who were apparently very pleased and surprised by a straight (but short) drive. I remember a very angry **Martin Parry** who caught us playing hooky. I also remember our working together

long into the night and starting very early the next morning. Rich Richels from IPCC and Snowmass days is another good friend with whom I have just written a “climate fable”. And then there is Baba Brinkman who arranged my only off-Broadway appearance in “Rap Guide to Climate Chaos”; I commissioned two raps, “Erosion” and “Destruction”, that were released at noon on January 20, 2017, and noon on January 20, 2018 – just so everyone knows what their about.