Profile of Stephen H. Schneider

In April 1968, Columbia University (New York) was the center of student protests so violent that faculty were assaulted and the entire university ground to a halt for the academic quarter. Hundreds of students were arrested, but Stephen H. Schneider, now a prominent climatologist, watched the riots from the sidelines as he pursued his engineering doctoral work. Yet when desperate administrators and trustees agreed to negotiate with a few elected students, Schneider felt compelled to come forward and make himself heard. As he learned on the fly to mediate between opposing groups, he unknowingly found a training ground for his future role as a controversial climate change spokesman. Here, Schneider says, he first learned that each value system has its own merits, and that some decisions boil down to a simple trade-off between value alternatives.

Thirty-four years later, in 2002, Schneider was elected to the National Academy of Sciences for his research work in climate modeling and policy applications. One of the earliest researchers in global warming, he developed models to describe the role of cloud height in climate systems and determined the need for time-evolving coupled atmosphere–ocean models. Schneider is now Melvin and Joan Lane Professor for Interdisciplinary Environmental Sciences and a professor in the Department of Biological Sciences at Stanford University (Stanford, CA), in addition to being a senior fellow in the Stanford Institute for the Environment and Professor by Courtesy in the Department of Civil and Environmental Engineering.

In his Inaugural Article in this issue of PNAS (1), Schneider and postdoctoral fellow Michael D. Mastrandrea use probabilistic models to connect economics and technology to climate change outcomes. Through their models, they attempt to quantify the value systems of various groups affected by climate change and to estimate the likelihoods of exceeding "dangerous" climate impact thresholds given alternative greenhouse gas concentration trends.

Game Theory on the Streets

Schneider grew up on Long Island, NY, in the 1950s. He recalls the thrill of twisting the eyepiece of his handmade telescope at age 13 and looking at the rings of Saturn. He planned to major in astronomy, he says, until he discovered how much mathematics was involved. At

Stephen H. Schneider

Columbia University, Schneider was nevertheless drawn to quantitative fields, and he received his bachelor's degree in mechanical engineering in 1966 and a Ph.D. in mechanical engineering and plasma physics in 1971. Engineering school gave him a problem-oriented perspective, he says, and he studied decision analysis and methods for quantifying uncertainty.

Schneider finished his doctoral qualifying examinations in 1968, shortly before violent clashes between students and police on campus. He recalls feeling frustrated by the "you are with us or against us" mantra of the activists and stayed out of the conflicts. In the aftermath of the riots, the trustees of the university agreed to consider a new senate with student and faculty representation. Schneider entered the political fray when he heard the unopposed engineering-school student candidates. "Their view was, 'Well, we're engineers, we don't have a big part in this, we mostly do our work.' In essence they wanted to quiet things down more than change the status quo," he says. "I circulated a one-page campaign poster saying, 'Yes, we're engineers, and our products make the world better. But sometimes they make it worse, and we have to think about it, and we have to be deeply involved in this issue to help choose the right paths.'"

Schneider's fellow students elected him to help restructure the university. An unknown person in the university political scene, he faced on one side trustees who dismissed student concerns outright and on the other side radical students who protested angrily about the university's purported unethical activities. "So, basically, I got in the middle of this, and I said, 'Whoa, hold it, guys; there's something on both sides here. It's true we students don't have all that much real-world experience, but it's also true that the university power structure is overly focused on the dollar.'" Schneider was quickly elected as vice chair of the committee.

He still values this academic political experience. "That, to me, was my political training," he says. "It was not in the classroom, learning game theory from theorists. It was there in the streets, so to speak, with the CEOs of banks and the radicals who took over buildings. That's when I learned that you have to hear each side, recognize that at least some element of each are legitimate, and then try to navigate as close as we can to the win–win solution." This diplomatic approach has become a guiding principle for him, he says. "Let's discover our differing value systems, and then look for a foundation of shared values where we might find a way to live together."

Speaking of the Weather

Although he was originally interested in plasma physics and rocket propulsion, Schneider's views changed on Earth Day in 1970. "Climate change looked like the big grandmother of all environmental problems," he says. Fresh on the scene at the time were new satellite systems to collect data and computers to crunch the numbers, affording a wide-open field of study.

At the time, the climatology field was in need of modelers trained in solving differential equations, which influenced Schneider's switch in his research emphasis to climate science. "It was a marriage of convenience and deep conviction," he says. "The deep conviction part was I want to make the world a better place, and I think if we mess up the climate, it will be worse. So I wanted to try to figure out how to minimize potential dangers." On the other hand, he continues, "The convenience was almost nobody has done any work in the field. My god, all that low-hanging fruit, all the simple discoveries are waiting to be made in this

This is a Profile of a recently elected member of the National Academy of Sciences to accompany the member's Inaugural Article on page 15728.

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important field. Not a bad place to be, even if it was by happenstance."

After finishing his doctorate in plasma physics, Schneider began postdoctoral study at the National Aeronautics and Space Administration (NASA) Goddard Institute for Space Studies (New York) in 1971. The next year, he gave a talk at the American Association for the Advancement of Science (AAAS) annual meeting and discussed his work, which at the time suggested that aerosols cooled the earth and greenhouse gases warmed it. He warned the audience of the results' inconclusiveness, especially concerning which effect dominates. Schneider made a joke about this uncertainty, which he adapted from Mark Twain: "Nowadays, everybody is doing something about the weather, but nobody's talking about it." The next day, an article by Walter Sullivan appeared in the *New York Times*, quoting the young scientist and his quip (2). The result, Schneider says, was instant visibility, which was all the more unusual for a postdoctoral fellow.

Not everyone was pleased with his encounter with the media. After moving to Boulder, CO, Schneider says, "I learned that the hard way, when I saw the article cut out and pasted on the wall of the map room at the National Center for Atmospheric Research with 'BS' stamped all over it." Some academics at the time considered the real world to be unfit for objective scientists, Schneider says. "For those that disdained public involvement, their view could be caricatured as, 'Lawyers are immoral, politicians are unconscionable, and the media is shallow, so scientists involved in that tainted world would lose their objectivity.' That was the implicit paradigm. Nobody talked about it directly, but that was the dominant scientific cultural standard back in the early '70s," he says.

Propelled into the limelight by Sullivan's article, Schneider accepted his role as a communicator of climate change research. He struggled to find ways to convey both the urgency and uncertainty of his climate science findings in the face of such antagonism. "I found that my science was saying something I believed the world needed to know," he says, "and I had to find ways to get the message out to the public and policymakers without either burying or overemphasizing the caveats." In 1992, Schneider was awarded a MacArthur Fellowship in part for his contributions in communicating scientific information.

Definitions of Danger

At the same time that Schneider was refining his message to the public and media, he continued his research on climate system models. After a year and a half of postdoctoral research at NASA, Schneider moved to the National Center for Atmospheric Research (NCAR, Boulder, CO) in 1972, remaining a member of the scientific staff until 1996. At NCAR, he cofounded the agency's Climate Project and in 1975 founded the interdisciplinary journal *Climatic Change*, for which he continues to be the editor. During this time, he was the first to use the phrase "cloudiness as a global climate feedback mechanism" in the title of a paper (3), and he pointed out the need for time-evolving coupled atmosphere–ocean models when examining scenarios of increasing CO_2 concentrations in the broader context for the development of the theory of climate (4–7).

Today, Schneider's research tends to be integrative and crosses disciplinary borders, searching for "emergent properties of coupled systems that explain interactive phenomena or solve real-world problems," he explains (8–11).

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He is particularly interested in risk assessment (12–17), where probabilistic analyses aim to make explicit the uncertainties inherent in coupled natural human systems modeling.

In his PNAS Inaugural Article, Schneider explores the various subjective values of the term "dangerous" as they apply to changes in the climate system (1). At one extreme, he says, global temperature rises of even 1–2°C would endanger some ecosystems, and small island states would face threats to traditional lifestyles. At the other extreme, a change of >5°C would bring about drastic changes, Schneider says, "by intensifying wildfires, melting vulnerable ice caps, and creating super-hurricanes. Most people in the world don't want to risk that. Even conservative oil companies probably wouldn't go for five or six degrees of warming."

Although mild global warming may be more easily tolerated, Schneider says, there's a point at which "people are going to cross over and say, 'This is too much.'" Finding that fulcrum requires a trade-off between groups with different value systems, he says. In his Inaugural Article, Schneider proposes aggregation methods that seek to incorporate a wide variety of climate "danger" thresholds.

Pitch for Planetary Insurance

Yet even if the global community were to come to a collective decision about what levels of greenhouse gas increases would be unequivocally "dangerous," Schneider says, changes may not be immediate. Some climate researchers speculate that greenhouse concentrations will reach unsustainable levels before the world curbs its massive emissions from fossil fuel consumption. "We're likely to go through to the end of the fossil fuel era with a grand glory, like the final burst of skyrockets at the Fourth of July," he says. The climatic equivalent is what researchers call an "overshoot" scenario, and implications for the climate are not clear.

In his Inaugural Article, Schneider explores overshoot scenarios in a probabilistic framework from the viewpoint of different stakeholders' values systems. The results suggest that the world would need to be "very lucky to get away" with delaying restrictions on greenhouse gases, he says. "Depending where you draw the threshold, we'll risk anywhere from a few percent chance up to an 80% to 90% chance of exceeding some dangerous thresholds."

Summarizing the article's results in a succinct lay-language metaphor, he says, "We buy fire insurance for a house and health insurance for our bodies. We need planetary sustainability insurance." In terms of what needs to be accomplished, he states, "Don't insult the environment at a faster rate than you understand it, when there are potential irreversible consequences. Slow it down." Schneider acknowledges that the specific numbers may change as scientists develop improved models of the climate system. But the framework is important. "We want people to look at the problem like a good business does or like the Pentagon does," he says, "as a risk management trade-off, with risks and consequences."

Personal Risk Management

Risk management is exactly how Schneider faced his greatest personal challenge: saving his own life when given only a year to live if he did not take any action. In 2001, Schneider was diagnosed with mantle cell lymphoma, a rare type of non-Hodgkin's lymphoma in which B cells become cancerous. Schneider and his wife, Terry Root, an ecologist, studied the recommended treatment protocol for his lymphoma and decided to apply decision analysis to

improve his treatment regimen. He worked with his initially wary physicians, and together they eventually agreed to modify the protocol to include such generally discouraged procedures as prophylactic chemotherapy.

By using decision analysis methods to help customize his therapy, Schneider brought his research tools into his personal life. "This was the true test of faith," he says. "Am I going to apply to my own treatment the principles that I'm advising governments and industries to apply to deal with climate change uncertainties? The answer was, 'Hell, yes.'" Four years later, with his disease in remission and no sign of return, Schneider wrote a book on the experiences (18). *The Patient from Hell* "urges all the patients of the world to do the same thing," he says. "If it's not a good fit for you, don't take a standard protocol without a fight."

Science as a Contact Sport

In the same vein of facing his personal health and research goals head-on, Schneider is also working to reconfigure academia. He wants to help make the university system more accepting of young scientists skilled at communication and interdisciplinary work, researchers who might otherwise be penalized in the traditional discipline-oriented academic reward system. That Schneider himself thrived within the traditional system is no precedent, he says. "It was usually a kiss of death for promotion to do what I was doing," he says of his public outreach efforts. "I had to be way better than average in terms of my scientific contributions to overcome the suspicions about my public persona. I worry about that when young people look to me as a model. I want them to know it is not risk-free being either a popularizer or policy advocate as a scientist."

Schneider hopes disciplinary departments will "stop defining quality only by looking in the mirror," he says, and acknowledge integrative contributions. He points to his recent *Science* article with Mastrandrea (16), which takes a climate model and an economics model—neither of which is original, he notes—and integrates them in a novel way. The work may be unimpressive to researchers looking for disciplinary originality, Schneider says, "yet it's original, and it moves us towards solutions of a problem that neither discipline can do by itself." Schneider is helping to put this philosophy into action, as he and about 60 colleagues build their fledgling interdisciplinary environmental institute at Stanford University.

Schneider has also been involved in helping launch the new Sustainability Science section of PNAS. Trade-offs and value systems need to be especially clear in this field, he says. "The objective of sustainability scientists is to make the trade-off sustainable through a compromise. What I want people to do is to admit up front what their values are. I cannot pretend that science is wholly objective," he says. To Schneider, science is simply much less subjective than any other enterprises. "What is necessary is to be explicit about our biases so that at least we can do an objective analysis within that framework."

Much of Schneider's time is taken up by what he calls his "pro bono day job" for the Intergovernmental Panel on Climate Change (IPCC). He was a Coordinating Lead Author in Working Group II of the IPCC from 1997 to 2001 and a lead author in Working Group I from 1994 to 1996. Currently, he is a Coordinating Lead Author for the controversial chapter on "Assessing Key Vulnerabilities and the Risks from Climate Change," in short, defining "dangerous" climate change, the topic of his PNAS Inaugural Article.

Regarding the controversy his research seems to attract, Schneider expresses no regrets. "I should write a book one day called 'Science as a Contact Sport.' I'm not religious, but I just figure that, in my value system, we're on the planet to make it better than we found it," he says. "You can do that behind the scenes, or you can get out in front and point people in the direction you think we need to go. And I'm much more in the latter style than the former."

Regina Nuzzo, *Science Writer*

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