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Translating science for decision makers to help navigate the Anthropocene

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Abstract

Although scientists typically regard their work as finished with publication in an academic journal, in fact that is just the beginning if the goal is to help society solve problems. This is particularly true for the environmental sciences, in which a generation of scientists has documented that five interacting human impacts are causing undesirable planetary changes: climate change, extinctions, loss of ecosystems not dominated by humans, pollution, and over-population and consumption. Dealing with such issues requires active engagement of scientists with politicians and other leaders as well as the public-at-large. Here we report on the positive outcomes of one such engagement, *The Scientific Consensus on Maintaining Humanity's Life Support Systems in the 21st Century: Information for Policy Makers* (http://consensusforaction.stanford.edu/), which was published in a previous issue of *The Anthropocene Review*. We suggest that effective communication outside the academic sphere will be increasingly important in navigating environmental challenges in the Anthropocene.

Keywords

Anthropocene, climate change, ecosystem loss, extinctions, pollution, population growth, science communication

A defining reality of life in the Anthropocene is that humans exert an inordinate amount of influence on the biosphere. Numerous researchers have documented that as a result of people's activities climate is changing faster and reaching higher temperatures than species have experienced in millions of years (Diffenbaugh and Field, 2013; Intergovernmental Panel on Climate Change

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(IPCC), 2007, 2013); extinction rates are elevated far above background rates (Barnosky et al., 2011; Dirzo and Raven, 2003; GBO3, 2010; Pimm et al., 2006); nearly 40% of terrestrial ecosystems and much of the oceans have been transformed to service humanity at the expense of other species and often with the loss of critical ecosystem services (Cardinale et al., 2012; Daily et al., 2000; Ehrlich et al., 2012; Foley et al., 2005, 2011; Jackson, 2008; Tercek and Adams, 2013; Tyrrell, 2011; Vitousek et al., 1986, 1997); and environmental contamination is causing widespread health problems for people and other species (Diaz and Rosenberg, 2008; Hayes et al., 2003; Lim et al., 2012; Newbold et al., 2009; Staff, 2012). People have fundamentally changed such basic processes of the biosphere as the carbon cycle by adding CO_2 to the atmosphere about 200 times faster than was normal in pre-anthropogenic times (Archer et al., 2009; Berner, 2003; DePaolo et al., 2008), and increasing emissions of nitrogen five-fold, which leads to deposition up to an order of magnitude greater than prior to nitrogen production via the Haber-Bosch process (Erisman et al., 2008). In addition, humans have altered the amount and flow of energy and materials through the global ecosystem by co-opting for ourselves about one-third of the net primary productivity produced through photosynthesis (Grosso et al., 2008; Haberl et al., 2007; Running, 2012; Smith et al., 2012; Vitousek et al., 1986, 1997). At the same time, anthropogenic burning of fossil fuels releases huge amounts of 'fossil' energy into the biosphere (The Oil Drum, 2012; US Energy Information Administration (USEIA), 2013); the amount we add in this way is roughly equivalent to adding two-thirds as much energy as is produced by photosynthesis on land annually (Smith et al., 2012), all for use by a single species, *Homo sapiens*. All of the impacts are ultimately driven by ever-growing human populations, which in many parts of the globe also consume natural resources at a pace that some researchers suggest now requires about 1.5 Earths to sustain, and (assuming no changes) would require the equivalent of two Earths to sustain by the year 2030, and three Earths by 2050 (Rockström et al., 2009; World Wildlife Fund (WWF), 2012; Global Footprint Network (GFN), 2013).

These pressures mean that if society is going to continue to receive the basic services from the biosphere that it has come to take for granted – for example, clean air and water, adequate food, a climate that varies within expected limits – scientifically informed management and governance will be essential. Yet, bringing science to bear on policy decisions in both government and business is a difficult task, as illustrated all too well by such political and economically motivated controversies that surround climate science, environmental contamination, and even teaching such basics as evolution (Aviv, 2014; Oreskes and Conway, 2011).

In view of that, the question of how to effectively inject sound science into the decision-making process looms large in guiding the Anthropocene. Up to now, most scientists have not seen that as a key part of their job, nor has it been significantly rewarded in many academic institutions. In addition, tangible results of science communication efforts are often difficult to see. All of these considerations lead many scientists to the conclusion of 'Why bother?'. The answer is because when scientists are effective at communicating their discoveries outside academia, the science becomes an important component in determining the directions of global change. But, what leads to a successful science communication effort?

Here, we retrospectively examine one effort that, although still in early stages, has already been useful in engaging scientists and policy makers in a productive manner, with the goal of highlighting the ingredients that led to success. The vehicle for dialogue has been the *Scientific Consensus Statement on Maintaining Humanity's Life Support System in the 21st Century: Information for Policy Makers*. The full document was published in a previous issue of *The Anthropocene Review* (Barnosky and Hadly, 2014; Barnosky et al., 2014). Basically, it lays out the science-based consensus on the advisability of mitigating climate change, extinctions, ecosystem loss, widespread

pollution, and population growth and overconsumption, and as of this writing has been endorsed by more than 1400 practicing scientists and nearly 1800 people from other walks of life (business people, NGO representatives, graduate students, undergraduate and high school students, and other concerned citizens) (http://consensusforaction.stanford.edu/index.html).

We emphasize that there are numerous other such documents that have been exceptionally useful in developing dialogues between scientists and other constituencies (Crowder et al., 2012; GBO3, 2010; IPCC, 2007, 2013; IPCC-SREX, 2012; Molina et al., 2014; Society for Conservation Biology (SCB), 2013; Union of Concerned Scientists (UCS), 1992; United Nations Environment Programme (UNEP), 2012; WRI, 2005; World Science Academies, 1994), to name but a few. We focus on the *Scientific Consensus Statement* simply because we have been involved from the outset with creating it and using it to engage with policy makers, and thus are well versed in its development and in the process that led to its widespread use. Our hope is that the lessons we learned will be useful in stimulating other scientists to effectively engage with people outside academia who need to understand and use what science has to offer. We begin with a brief summary of what the Consensus Statement accomplished, then dissect what led to its widespread use, and conclude with our views on how consensus statements such as this one fit into the broader spectrum of making decisions in the Anthropoocene.

Background of the *Scientific Consensus Statement*

The effort began in 2010 as scientists from many research institutions located in the USA, Canada, Europe and South America met at a University of California-Berkeley Initiative for Global Change Biology workshop to identify major biological problems arising from the many ways people are now changing the Earth. The result was a publication in a peer-reviewed journal, produced after more than a year of follow-up work by 22 biologists from four countries (the USA, Chile, Finland and Spain) (Barnosky et al., 2012). The publication presented evidence that Earth had seen major 'state-changes', in its past; that such transitions are rapid on the scale of geological time and radically transform the biosphere with respect to the previous state; and that the magnitude of human impacts was now great enough to initiate another planetary state-change in the foreseeable future – not over geological time, but within human lifetimes. A key point of the paper was that such a rapid transition at the global level would be disruptive to present societal functions. This is because societal stability relies on the expectation that environmental fluctuations in the near future will not exceed those considered normal for the past couple of centuries and that any future changes will proceed linearly with ample warning for adaptation. In reality, biological systems (and complex systems in general) often change rapidly and in unanticipated directions as critical thresholds are crossed because of either gradual or sudden forcings.

The results presented in that publication were picked up widely in the popular media. California's Governor Jerry Brown also became aware of the study, and contacted the participating scientists to ask, in effect: 'If these are such big problems, why aren't you scientists shouting it from the rooftops? And why are you scientists only talking to each other? Why don't you give policy makers and the general public something we can use?'.

Following that, a group of 16 global change scientists from seven research and teaching institutions (UC Berkeley, Stanford University, University of Washington, University of New Mexico, University of Helsinki, University of Oslo, and Environmental Health Sciences) continued a dialogue with the governor and his staff about how to deliver scientifically accurate information in a form that world leaders could easily digest and use. The interaction led to the production by the scientists of the document: *Scientific Consensus on Maintaining Humanity's Life Support System*

in the 21st Century, Information for Policy Makers. The goals were to: (1) crystallize the science that documented that climate change, extinctions, ecosystem loss, pollution, and human population overgrowth and overconsumption were proceeding unusually fast with respect to the history of life on Earth; (2) point out scientifically grounded potential societal impacts; and (3) highlight broad-brush solutions to the problems. The scientists' role was to present accurate information. The role of the governor's office was to tell scientists what policy makers would find most useful to know, and what styles of communication were most effective.

Once the drafting scientists completed the document, it was e-mailed to researchers respected for their work in the global change community with the request to endorse it. Within less than month, 522 scientists from 41 countries throughout the world had signed the statement. At the same time, a multi-stakeholder collaborative organization, Sustainable Silicon Valley (SSV), invited the scientists coauthoring the statement and the governor to release it at SSV's annual summit, which SSV independently organized. This collaboration brought the business and NGO community into the communication effort. As a result of SSV's involvement, the Consensus Statement was jointly released by participating scientists and Governor Brown on 23 May 2013, at the 2013 SSV Water-Energy-Smart Technology Summit, held at the United States National Aeronautics and Space Administration Ames Research Center at Moffett Field, California.

Uses of the *Consensus Statement*

Upon its release, Governor Brown promptly started using the *Consensus Statement* and the information therein in policy discussions with political leaders nationally and internationally, as well as with US governors and California business people and local officials. Sustainable Silicon Valley began using the statement to engage business and technology leaders, and participating scientists continued to distribute it internationally, not only to academic leaders, but also to those in a variety of decision-making positions and the general public. The distribution included translating the statement into Chinese and Spanish (with the realization that translation into other languages is now needed – presently the Executive Summary is also available in French and Portuguese), and presenting the statement to summarize the issues in wide variety of venues, including policy meetings among high-level officials; direct contacts between scientists and decision makers; seminars and classes in academic settings in the USA, Canada, Mexico, Costa Rica, Finland, Norway, Austria, Germany, Switzerland and Kenya; and public lectures, op-eds and news stories, to name the chief ones. Recently a web-based effort also was launched (http://consensusforaction.stanford.edu/).

As a result, within a year the statement was delivered to many world leaders, among them: US President Barack Obama and many of his staff, including Secretary of State John Kerry; China's President Xi Jinping and Vice Chairman of the National Development and Reform Commission Xie Zhenhua; Japan's Governor Ichiro Matsui of Osaka Prefecture; the United Kingdom's Energy & Climate Change Minister Gregory Barker; Mexico's Governor Eruviel Avila, José Sarukhán (President of Mexico's National Commission on Biodiversity) and Julia Carabias (Mexico's former minister of the Environment); Malaysia's Right Honourable Datuk Seri Panglima Musa Haji Aman, Minister of the State of Sabah; the leader of the Othodox Christian Church His All Holiness Bartholomew I, Archbishop of Constantinople, New Rome, and Ecumenical Patriarch; a Wadaonai chief from the Yasuní region, Ecuador; governors of several states in the USA and ministers from Canadian provinces; selected congressional representatives in the USA; and mayors of several major cities in California and elsewhere. The nascent web-based distribution effort has also helped to bring the *Consensus Statement* to the general public, although much work remains to be done in that arena.

Did providing this information to policy makers make any difference? Only time will tell the full story, but already there are encouraging reports. Within the first six months of its release, the *Consensus Statement* helped inform policy discussions that led to two international agreements between California and other entities to cooperate on reducing greenhouse gas emissions and developing green technology. On 13 September 2013, California and China signed a Memorandum of Understanding that committed both parties to: 'Mitigating carbon emissions; strengthening performance standards to control greenhouse gasses; designing and implementing carbon emissions trading systems; sharing information on policies and programs to strengthen low-carbon development; exchanging personnel and jointly organizing workshops and training; and researching clean and efficient energy technologies' (http://gov.ca.gov/news.php?id=18205). The *Consensus Statement* was translated into Chinese and presented by Governor Brown to President Xi Jinping and National Reform and Development Commission Vice Chairman Xie Zhenhua (the signatory on behalf of China) in meetings that preceded the signing of the MOU (http://gov.ca.gov/news.php?id=18086).

The second international agreement came on 28 October 2013, with the signing of the Pacific Climate Pact by the governors of California, Oregon, Washington and British Columbia's Minister of the Environment (on behalf of the Premier of British Columbia). That agreement includes: 'accounting for the costs of carbon pollution in each jurisdiction; harmonizing 2050 targets for greenhouse gas reductions and developing mid-term targets needed to support long-term reduction goals; taking steps to expand the use of zero-emission vehicles, aiming for 10 percent of new public and private fleet vehicle purchases by 2016; enlisting support for research on ocean acidification and taking action to combat it; adopting and maintaining low-carbon fuel standards in each jurisdiction; and continuing deployment of high-speed rail across the region' (http://gov.ca.gov/news.php?id=18284). More broadly, the agreement commits the parties to:

> Cooperate with national and sub-national governments around the world to press for an international agreement on climate change in 2015. The governments of California, British Columbia, Oregon and Washington will join with other governments to build a coalition of support for national and international climate action, including securing an international agreement at the Conference of Parties in Paris in 2015. The governments of California, British Columbia, Oregon and Washington will coordinate the activities they undertake with other sub-national governments and combine these efforts where appropriate. (http://gov.ca.gov/news.php?id=18284)

And, relevant to scientists' efforts to communicate science such that it helps guide global change, the agreement includes the following language:

> Affirm the need to inform policy with findings from climate science.
>
> Leaders of California, British Columbia, Oregon and Washington affirm the scientific consensus on the human causes of climate change and its very real impacts, most recently documented by scientists around the world in the Intergovernmental Panel on Climate Change's Fifth Assessment Report released in September 2013, as well as other reports such as the Scientific Consensus on Maintaining Humanity's life Support Systems in the 21st Century. Governmental actions should be grounded in this scientific understanding of climate change. (http://gov.ca.gov/news.php?id=18284)

The California-China MOU and the Pacific Climate Pact are significant in three respects. First, they clearly incorporate the scientific realities into developing policies aimed at guiding the future, and benefited from dialogue between scientists and policy makers. Second, within the USA, they mark a watershed in how subnational entities can move forward with important international

cooperation, despite political gridlock in Washington, DC. Third, they have economic as well as scientific impacts on the world stage: China is the world's second largest economy, California the world's eighth largest, and the combination of California, Oregon, Washington and British Columbia would equate to the fifth largest in terms of Gross Domestic Product.

Ingredients of successful engagement

Despite having been in circulation only a year, and being forged and disseminated only through the grass roots efforts of scientists without funding by outside organizations, the *Consensus Statement* is now in the hands of political and other leaders in many nations, has led to direct dialogues between scientists and policy makers, and has proven useful in discussions that produced tangible international climate policies. To what can this high level of rapid engagement be attributed and are there general lessons for communicating science that can be extracted? In examining the process retrospectively, we identify the following key ingredients.

Sound science

The key ingredient, of course, is sound science, around which consensus actually exists. In the case of the *Consensus Statement*, the science conveyed about its five focal issues is the result of decades of research by hundreds of scientists, vetted and refined through the years in the form of thousands of peer-reviewed publications. Each of those publications, however, typically focused on just one of the five key environmental problems. An important trigger for developing the new dialogue with policy makers seemed to be a synthetic peer-reviewed study, coauthored by 22 investigators from seven countries and three continents representing a variety of related disciplines. That study treated the issues not as discrete, but as an interconnected set of problems that by interacting had the potential to cause abrupt, societally relevant changes that would likely manifest themselves within decades.

Media coverage and timing

There is no doubt that science reporters have an important role to play in translating the work reported in peer-reviewed scientific publications to wider audiences. Scientists can actively contribute to this process through working with their university press offices to prepare accurate press releases about their scientific work, as several of the authors of the synthetic paper noted above did, and by responding quickly, clearly and accurately to reporters when interviews are requested. If the issue is deemed newsworthy by the popular press, it can reach a broad audience rapidly through print, television and internet-based reporting.

Whether or not a scientific article will be picked up by the popular media depends in part on how it relates to current 'news hooks', that is, what people tend to be concerned with at the moment. In the case of the article that awakened interest in the issues that eventually were summarized in the *Consensus Statement*, the timing was fortuitous. The publication appeared just as the Rio +20 meetings were convening, so environmental issues were generally in the news. Whatever the reasons, considerable media attention ensued and brought the scientific issues covered in the paper to the attention of the general public, including the policy-making community.

Commitment from the policy-making community

Among those who saw reports about the peer-reviewed study was California Governor Jerry Brown. Recognizing the relevance of the study's conclusions to ongoing dialogues about climate

change and other environmental issues, he initiated conversation with the scientists about the key environmental issues that policy makers face. In the course of these conversations, it became apparent which information that is essentially taken for granted by the environmental science community had not effectively percolated outside academia, and that an important way to fill the information gap would be to develop a scientific consensus statement designed specifically to convey the issues to the policy-making community. After the *Consensus Statement* was released, Governor Brown integrated it into a wide variety of meetings with other high-level politicians to elevate the visibility of environmental issues that need to be addressed. The importance of such commitment by a politician to engage with scientists and advocate for including science into the decision-making process cannot be overemphasized, since it is in the political arena that policies are actually developed.

Ongoing dialogue

Communicating science to policy makers is not a one-off occurrence, and requires commitments by participating scientists to continually engage after the initial release of information. One of the lessons learned from our *Consensus Statement* experience is that successful communication requires an ongoing dialogue that involves not only telling the policy makers about the science, but learning from the policy makers what scientific information is most important to them in a given circumstance, and what constraints besides the science must also enter into the decision-making process. An important part of the engagement is the willingness of scientists to respond to immediate needs, which come up suddenly in the political arena.

Avoiding prescriptive advocacy

Elsewhere we have noted that efforts to communicate science generally fall into three basic categories: general interest communication, prescriptive advocacy and informative advocacy (Hadly and Barnosky, 2014). The first is simply communicating scientific discoveries that are likely to catch the public's interest but with no decision-making goal in mind (for example, the finding that crows can accomplish some tasks that require causal understanding similar to that of a 5- to 7-year-old child (Jelbert et al., 2014) (and see the Science Daily report at http://www.sciencedaily.com/releases/2014/03/140326182039.htm). The other two, as their names imply, involve advocating that the science be considered in making a policy decision. The difference between the two kinds of advocacy was the focus of a previous article, from which we extract the following relevant passages:

> Informative advocacy … uses scientific knowledge to foretell the environmental (in our case) changes of probable societal relevance that lie ahead. It differs from pure science communication, which is simply to inform, in having an important goal of injecting the scientific realities into the many different categories of information that decision makers must take into account when formulating policy. Informative advocacy also has a second goal that is critical: learning from decision makers about the kind of information they need. This back-and-forth dialog ultimately opens new doors for decision makers to formulate solutions to complex problems, and new doors for scientists to understand how their science is socially relevant.

> Prescriptive advocacy, in contrast, means using your position as a scientist to push for a particular policy action, which can do just the opposite of science communication or informative advocacy. We have found that prescriptive advocacy narrows choices for the decision makers, and often ignores harsh realities that especially elected officials face: a wide spectrum of societal views on what constitutes the most pressing needs, and economic and technological feasibility.

> In essence, communicating science involves boiling down the discoveries of the practicing scientific community to their accurate bullet points, and highlighting the societally relevant impacts. Informative advocacy involves taking that science to decision makers (and the general public), and pointing out scientifically sound paths to desired destinations. But it is left to the decision makers (often our elected officials) to decide which of the multiple pathways to solving a particular problem are the most practical to pursue, taking into account the layout of the entire constituency landscape.
>
> Communicating science and informative advocacy identifies destinations and available paths, but does not barricade some paths in favor of others.
>
> Prescriptive advocacy, on the other hand, is all about making arguments that your path is better than any other one. The problem with prescriptive advocacy is that you can tie the hands of decision makers, making it more difficult for them to find the best route through what is usually a complex maze of needs and opportunities.

While all three kinds of science communication can play a useful role in helping to guide the future, it is critical that scientists recognize which kind of communication they are using in a given instance. The Consensus Statement falls in the category of informative advocacy, in that while it specifies the needed destinations and their feasibility, it does not argue that policy makers should implement one specific solution over another. It makes clear that the science indicates that actions are needed to avoid certain future scenarios, but leaves it to policy makers to determine which future scenarios are most desirable, and exactly how to get there.

A challenge for scientists

Our engagement with policy makers in the context of developing and using the *Scientific Consensus on Maintaining Humanity's Life Support Systems in the 21st Century* has convinced us that such science communication efforts are both rewarding and productive. The experience has also demonstrated to us that, while communicating science to policy makers will be essential in helping to formulate a future in which society thrives, a reality is that effective engagement takes time. It adds yet another job to the other three that are usually expected of scientists in many institutions: doing cutting edge research that leads to new breakthroughs published in peer-reviewed journals; teaching; and the administrative duties essential to running both individual research programs and the employing institution. We suggest, however, that the task of making the science useful to those who need it most – political leaders, business leaders, and the public-at-large – is at least equally important as the basic research, teaching, and administration scientists are usually involved in. That means that no longer is a scientist's project finished when results are published in a peer-reviewed paper, especially with regards to critical global problems such as climate change, extinctions, ecosystem loss, pollution, and population overgrowth and overconsumption. The next step, communicating that knowledge to those who need it outside academia, will be what ultimately helps chart the course for navigating the Anthropocene. In our experience, taking that next step is well worth the effort.

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