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ORIGINAL RESEARCH REPORT

Chapter 9. Establishing Common Ground: Finding Better Ways to Communicate About Climate Disruption

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The key message of this chapter is that solving the climate problem will require motivating social and behavioral changes through effective communication. More and better communication about climate issues is needed so people will mobilize solutions. Currently most people in the world do not believe that climate change is worth doing anything about, if they have even heard of it at all. Despite the efforts of many journalists, scientists, educators, and politicians to convey the science behind and urgency of climate disruption, about a third of Americans still deny that climate is changing or that humans cause it, and nearly 60% feel that climate change is not a problem serious enough to affect them. What is more, in many parts of the world, at most 35% of adults have even heard of climate change.

This general lack of recognition about the magnitude of climate disruption and the urgency of dealing with it is slowing down the process of implementing solutions. Even if high-level decision makers want to put in place the policies, incentives, and ready-to-be-deployed technologies required to reduce greenhouse gas emissions, they are unable do so to the extent needed because they have to answer to their constituencies. Put another way, only if the majority of the global society sees the need to mitigate climate change, and the feasibility of doing so, will decision-makers be able to enact the policy changes needed to jumpstart a global energy transition. The good news, however, is that most people—for example, around 60% in the United States—have not yet made up their minds about the need to fix the climate problem. Reaching these individuals with the right information in the right way offers great opportunity to boost societal awareness and effect necessary change.

In this chapter we briefly review the information that supports these statements, and summarize the key pathways of communication about climate change that have prevailed so far, including where they have been successful and where they have fallen short. We focus on the United States, because of its high-emitter status and consequent influence on attitudes about climate mitigation worldwide. We then discuss findings from recent research on communication strategies that suggest an effective way forward—namely, that much remains to be done through appropriate framing of the issues for diverse constituencies that have not been effectively reached. We suggest that by targeting specific audiences with appropriately framed information, the societal balance can be tipped from the current condition of a majority who are apathetic to a majority who become receptive to the reality of harmful climate disruption and the need to avoid it. For example, strategies may include peer-to-peer interactions that communicate how climate change and associated impacts fit with existing value systems that define various religious, political, and economic spheres. To this end, we recognize four general communication strategies that will be useful.

- Develop coordinated local, state, national, and international informational campaigns to tell diverse constituencies about the need for and benefits of mitigating climate change. These must be framed appropriately for specific target audiences, much as advertising agencies do to promote products effectively, and evaluated rigorously to know how to improve subsequent campaigns.

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- Integrate education about climate change impacts and solutions into all levels of education, from K-12 through University curricula.
- Create venues for decision makers, business leaders, religious leaders, and academics, spanning the natural sciences, social sciences, humanities, and the arts, with the overall goal of developing recognition, dialog, and action on the intertwined behavioral, ethical, political, economic, social, health, and scientific dimensions of climate disruption.
- Communicate that actionable solutions to climate change problems exist and are feasible to implement. This should include embedding climate change information and action opportunities across a variety of venues, from print journalism, to traditional TV and radio, to digital and social media.

We also provide ten recommendations for how the University of California (and other universities in general) can implement communication programs to accelerate its own system-wide transition to carbon neutrality, while simultaneously contributing to the broader effort of motivating the societal shifts in perceptions and behavior needed to facilitate a global energy transition.

Introduction

In 1965, the newly inaugurated 36th president of the United States—Lyndon B. Johnson—gave a special message to Congress to announce his programs to curb recently identified pollution problems that were ravaging the country. When he got to air pollution, he said [1]:

> *"This generation has altered the composition of the atmosphere on a global scale through radioactive materials and a steady increase in carbon dioxide from the burning of fossil fuels."*

We know now that carbon dioxide (CO_2) is one of the key greenhouse gases giving the planet a fever. So did President Johnson, five decades ago. A few months after this special message to Congress, his Science Advisory Committee included, in a report on pollution problems [2], a chapter that discussed how warming and sea level rise could be triggered by the CO_2 increase. Fifty years later, though, our energy production is still pumping way too much CO_2 and other greenhouse gases into the atmosphere, at a much faster pace than when Johnson became the first president to acknowledge the problem. Back then, atmospheric CO_2 levels stood at about 320 parts per million (ppm), already some 14 per cent higher than was normal for Earth. Now, atmospheric CO_2 clocks in at just over 400 ppm, and as of 2014 we're adding about 2 ppm annually. In fact, greenhouse gas pollution increased every year between 1965 and 2014. This means that, despite great strides in the United States to improve air pollution and other environmental problems beginning with Johnson's leadership and continuing through subsequent administrations—both Republican and Democrat—reducing CO_2 and other greenhouse gas emissions stands out as a resounding failure.

So, where did we go wrong? And why do many people still believe that the goal of reducing greenhouse gases to the extent needed to keep climate change within reasonable bounds—for CO_2, a reduction of more than 6.2% per year for the next 85 years [3]—is unnecessary, unimportant, or unattainable? Some answers lie in the complexities of the science, economic and political interests, and the human tendency to focus on problems that are immediate, visible, local and personal, instead of problems that are temporally distal, largely invisible, global and social. Other answers, though, fall squarely in the realm of how climate-change issues are communicated. Helping the public to understand and take action to solve climate disruption was hard back in 1965, and it is still hard today. Despite the success of many communicators in bringing climate change to the forefront of public discourse, miscommunication, misperceptions, and misleading information persist on many levels and across many lines, including political, cultural, economic, and scientific.

Yet, communicating the realities of climate disruption in ways that connect rather than divide people will be crucial to generating the social change required to implement solutions. This is particularly true in high-emissions countries where there is still much disagreement about the reality and importance of climate change. Here we focus on how to better communicate climate change issues in the United States. As one of the predominant greenhouse gas emitters, the US contribution to the climate-change problem is disproportionately large, ranking only behind China in greenhouse gases emitted each year, but far above China on an average per capita (per person) basis. On average (as of 2014) each person in the United States emits about 17 tonnes of CO_2 per year (although of course some emit more, some emit less), compared to 7 tonnes per person in China, and less than 2 tonnes per person in India. Moreover, because of its high-emitter status, attitudes and decisions in the United States markedly influence those in other countries, making it an important crucible in which to stimulate widespread change in reasoning about dealing with climate change, especially among the "top billion" (the relatively wealthy sector of global society) whose emissions account for about 60% of the greenhouse gas problem.

Our goals here are to summarize the extent to which the United States public currently recognizes the need to minimize climate disruption, and to highlight five key pathways (listed below) intended to help move people who are currently in the "undecided" category into the "need-to-do-something" category. For each pathway, we point out what has worked, where some problems have become evident,

Communication involves knowing your audience and establishing common ground, no easy feat when it comes to working with diverse groups and different nations. An initial communication hurdle is basic awareness: Problems do not get solved if people do not know they exist. Even this basic hurdle has not been cleared in much of the world, and the extent of awareness differs markedly in developed versus developing countries. Recent research highlights some of the differences in perspectives pertinent to communication on the global stage [4].
· The vast majority of people in developed countries—90% in North America and Europe—are at least aware of climate change (but not necessarily accepting of it). However, this is not the case in developing countries. In Egypt, Bangladesh, and India, for instance, only 35% of adults have heard of climate change.
· Education level is strongly correlated with climate change awareness, regardless of country. Still, certain factors lead to interesting differences. In the United States, for instance, climate awareness is highest for groups engaged in civic awareness, and for those with easy access to communication tools, but In China, it correlates with household income and proximity to urban areas.
· People who are aware of climate change in developing countries often perceive associated risks as being much higher than do people in developed countries.
· In the United States, China, and nations in Latin America and Europe, people perceive greater risk when they understand that humans are causing climate change. In both developed and developing countries, perception of risk relates to local weather changes. In China, climate change is thought to be more dangerous among residents who are dissatisfied with local air quality.
· Communication about climate disruption must be tailored for different groups, taking into account differences related to culture, economy, education, and so on.

Table 1: Global Climate Change Awareness Differs Among Countries.*
*Adapted from [5].

and where improvements can be made. We then explain how proper framing of the issues targeted to particular audiences can increase the reach of climate communication, and give examples in the realm of religion and politics. Throughout, we offer examples of how the University of California is already involved in, and has the potential to be particularly effective at, delivering messages about climate change. Finally, we offer recommendations for how the UC system can contribute to information-transfer in ways that will help jumpstart the social change required to scale up carbon-neutral solutions.

While we aim this chapter primarily at better communication strategies for the United States, we recognize the importance of communicating on a global scale, and that different approaches are required in different nations. Many of the issues and challenges related to climate disruption, including how to communicate about it, differ considerably for the six billion people who contribute only 40% of greenhouse gases, particularly for the poorest three billion, who contribute only 5% of emissions. Some of the differences in perceptions between developed and developing countries are outlined in **Table 1**.

Acceptance of Climate Change

As of early 2015, about 63% of all Americans believed that global warming exists, and about half believed that it is human caused, according to a poll by the Yale Project on Climate Change Communication [5]. Awareness apparently increased after considerable media coverage of the 21st Conference of the Parties (COP21) climate meetings held in Paris in December 2015, where more than 190 countries agreed that climate change was a serious global problem and in principle agreed to address it. A Gallup poll in March 2016 revealed that 65% of Americans attributed rising temperatures to human activities rather than natural causes, 64% were concerned about the issue, and 41% thought climate change would eventually seriously threaten them or their way of life [6]. Such statistics mean that most Americans actually do recognize the reality of climate change, and a growing number (but still a minority) regard it as a serious problem that will affect their lives.

However, accepting that climate change is occurring does not necessarily translate into feeling it is an actionable issue. A 2012 Yale Project on Climate Change Communication, the so-called Six Americas study, sheds light on why, by identifying six distinct audience groups based on their beliefs about global warming: Alarmed (16%), Concerned (29%), Cautious (25%), Disengaged (9%), Doubtful (13%), and Dismissive (8%) [7]. Those in the Alarmed category are generally supportive of efforts to combat climate change, and are unlikely to have their opinions swayed. Those in the Dismissive category are relatively sure that climate change is not a problem, and are also unlikely to change their minds, no matter how much more information they receive. The same applies to the Doubtful category, although they are somewhat less dogmatic than the Dismissives.

The remaining categories, comprising about 63% of the population (the Concerned, Cautious, and Disengaged), represent the people who are likely to be swayed by effective communication. That roughly 60% of the population is open to being convinced one way or the other apparently reflects attitudes about social change in general. For example, in analyses of proportions of people willing to take action for the common good, about 20% were found to be "altruists", who are ready to act for the good of the group; about 20% were "free riders", who mainly look out for themselves; and about 60% were "conditional co-operators", who had not formed a strong opinion one way or another and could be swayed by persuasive discourse [8].

The lesson here is that some 63% of the American public probably has a more-or-less open mind about the need to do something about climate change, a large enough percentage to effect significant social change. Therefore, targeted communication directed to these subgroups has great potential to make a difference.

The flip side, of course, is that the Six Americas study and the afore-mentioned surveys reveal that at least a third of the American public fail to recognize that humans cause climate change, and less than half feel that climate change is serious enough to warrant fast action. This reflects a stark disconnect between public perception and reality, and reveals that the need for better communication is very real. For example, many "climate myths" have achieved widespread acceptance (**Table 2**), despite facts that show the contrary. The challenge is to correct such misperceptions while also communicating the new knowledge that is constantly emerging about climate disruption and its solutions.

Communication can be a tangled web, especially when there is risk and uncertainty. Still, five communication pathways have been useful to communicating information about climate disruption in the past: traditional journalism (including broadcast media like TV and radio), digital communication including social media, education, communication by scientists, and communication by special interest groups. Because the confluence of these will continue to be the primary means of informing the general public about climate communication, it is useful and informative to look at each of the pathways, especially where they have been effective and where improvements are needed, and how they inter-relate.

Key Communication Pathways

Journalism

Much effort has gone into trying to understand journalism's role in educating the general public about climate change, mitigating climate change, and adapting to climate change. A critical piece of information in this regard is how often messages about climate change actually reach Americans through journalism-based media. In 2015, the Yale Project on Climate Communication reported that there is much room for improvement. A recent study led by that institute found that approximately two-thirds of Americans say that they are at least "a little interested" in hearing about global warming through the media or some other means. Yet only 19% say that they hear about it weekly (i.e., at least once a week), and only 40% say they hear about it monthly (i.e., at least once a month). The perception that news is not reaching them may reflect a lack of interest in news or a paucity of reporting about climate change (although at times there is considerable coverage of high-profile, momentous meetings and concerted efforts that target climate change, for instance, Climate Week, held in New York in September, 2015, and the COP21 climate meetings, held in Paris in December, 2015).

Increasing the general public's interest in news about events and situations that involve uncertainty is never easy. Still, universities and other educational institutions can play an active role in incorporating learning activities about current events, especially climate change, into diverse parts of their curricula. From the perspective of the media, increasing the frequency of climate-change reporting, including climate change messages into programming, and framing messages appropriately (see the Framing section below) can also help. Given the myriad news stories that compete for print space and airtime, there are real barriers to the former. Such competition can result in pressure on editors to bump stories about climate disruption to make room for other news. A further problem is that more and more news media are cutting back on investigative and science journalism. Because of these realities, the need to properly frame and accurately report what climate-change coverage does make it into the media is doubly important.

While media coverage has been instrumental in raising public awareness of climate disruption, it has not motivated coordinated action (nor has anything else). This could be due to many factors, which have the net effect of sending mixed messages to the general public. For instance, journalists sometimes present factual information about climate change in a superficial or imprecise manner because they lack expertise about the more nuanced details. Also, given that climate change involves probability, risk, and uncertainty about the future, generating clear, coherent messages can be challenging. There is also the problem of how to boil down complex messages about high-risk outcomes, while still conveying that potential catastrophes can be avoided by taking appropriate steps. Journalism depends on its readers, and trying to draw in a large readership can lead to an overemphasis of doom and gloom, especially with more threatening messages. This in turn can also lead to what is known as "reactance," a hardening of positions rather than the learning and change needed to deal with climate change. In other cases, there is pressure from editors to emphasize information related to novelty or controversy around the issues, rather than the issues themselves. Sometimes this invites skepticism, for instance, by opening the door to a "he said, she said" interpretation, even when there is overwhelming scientific evidence to support only one side of the purported controversy [12]. Most these problems can be helped by fostering ongoing dialogs between journalists and the scientists, provided, of course, that the scientists are willing to and skilled at communicating their discoveries (see the section below on Science Communication).

Once the facts of a story are well understood, what is needed is communication that lets people effectively incorporate the information into their own worldviews in a way that builds consensus and yields collective action (see Framing section below). In this context, there is a tradeoff between emphasizing solutions versus problems. People may be more receptive to positive messages, but it is also necessary to convey information that includes urgency, potential losses, and bleak realities. In fact, the value of dystopian—or even apocalyptic—visions can focus minds on bad future outcomes and how to avoid them, if we act soon. For example, to mobilize public and policy actions, California's Governor Jerry Brown has effectively

Myth: *"Even scientists disagree when it comes to whether unusual climate change is happening and how it is caused."* ***Myth-busting Fact:*** About 97% of the scientists who study climate change agree that we are witnessing it and that it is caused by humans. They also concur that it is happening fast and requires serious attention [9].
Myth: *"Many climate changes have occurred in the past. So, what's the big deal about an increase of a degree or two in recent years?"* ***Myth-busting Fact:*** If we continue business-as-usual greenhouse gas emissions, the Earth will become hotter than it has ever been for humans, and hotter than the planet has been in million of years, within many of our lifetimes. If we don't limit emissions dramatically, by 2100 we will drown coastal cities, diminish food production, dry up water supplies for billions of people, and cause extinctions of many animals and plants.
Myth: *"God controls climate. It's not our job to worry about such things."* ***Myth-busting Fact:*** The leaders of all the world's major religions, including Muslims, Catholics, Buddhists, and Jews, have issued proclamations that humans are causing dangerous climate change, and that we have to stop it for the good of humanity and the planet.
Myth: *"So fossil fuels are the problem? There's no way we can get off of them."* ***Myth-busting Fact:*** There is good evidence that fossil fuels can be replaced by carbon neutral energy sources by 2050, even though this will require a huge effort in emplacing new infrastructure and energy policies. The changeover can be accomplished mostly by scaling up existing renewable-energy technology—solar, wind, wave, sustainable biofuels and so on.
Myth: *"It's too costly to fix climate change."* ***Myth-busting Fact:*** While the aggregate numbers for transitioning to new energy sources sound enormous, the up-front costs for the consumer are very small, and the longer-term economic and personal benefits are very big. Up-front costs can be minimized with intelligent and flexible policies, and the energy transition already is creating new valuable new industries and jobs; over the past few years, growth of new jobs in the renewable energy industry has far outpaced job growth in the fossil fuel industry.
Myth: *"OK, so climate is changing, but that doesn't really affect me personally."* ***Myth-busting Fact:*** Climate disruption is already creating huge problems for everyone. In developed countries, wildfires are increasing, flood and fire insurance costs are skyrocketing, coastlines are losing land, and lethal heat waves are more common. The impacts are even more disastrous for poor people in the world's most fragile nations, where food, water, and energy shortages already are occurring from climate change. When such disasters hit, such as drought-induced food shortages that have already contributed to conflict in places like the Sudan, Somalia, Syria, and Egypt, they also affect people in developed countries. For example, millions and millions of refugees who are fleeing such conditions are flooding Europe, and the United States generally is among the first to provide humanitarian aid and military support, which costs American dollars and American lives.
Myth: *"Climate change is a planet-sized problem. Nothing I can do will help enough."* ***Myth-busting Fact:*** Ultimately, our climate is changing because of emissions of greenhouse gases that trace back to each of us, especially in developed countries. A million people here, a million there, and pretty soon you're talking real emissions. In the same way, reduction in individual carbon footprints of people—with those emitting at the high end of the scale needing to reduce most—contributes to solving the problem. Major social change in the past has always been made through collective action—i.e. ordinary people coming together to act collectively. Particularly crucial in developed countries are individual behaviors that help stimulate changes in the marketplace and political arena that will be needed to make renewable energy cheaper than fossil energy; such behaviors include voting, consumer choices, and peer-to-peer communication about the importance of minimizing climate disruption.
Myth: *"Lowering my own carbon footprint will mean that China and India will raise theirs. Why should I bother?"* ***Myth-busting Fact:*** It is possible for developing countries to leapfrog over fossil fuel energy production and instead build their energy sectors with renewables, much as they have leapfrogged over using land-line telephones to rely on more convenient, cheaper mobile phones, although that will require rapid policy shifts and technology transfer. Leap-frogging is already taking place for lighting and electricity in rural parts of Africa, India [10] and Nepal, for instance: the state-of-the-art Lukla Hospital at the base of Mount Everest is entirely powered by off-grid microhydro and solar [11]. Developed countries, where venture capitalists are investing in requisite technology, and where industries are already producing off-the-shelf renewable energy components, can play a key role in this technology transfer.

Table 2: Ten Common Climate Myths versus Facts. See other papers in this volume for information that underpins the myth-busting statements.

used dire, even apocalyptic future scenarios—all scientifically sound—about what our world will face if we fail to reduce climate disruption. Examples include statements that appropriately link the California drought and wildfires to climate change, while emphasizing the need for pragmatic response at all levels, starting with the individual [13, 14]. Such messaging appears to be working: Californians have indeed stepped up to support his vision, for instance, by dramatically reducing water use during the current drought [15]. The key is to honestly communicate both the bleak outlook if no action is taken, and what solution(s) will avert dire consequences.

Digital Media

Online media are becoming more important to disseminating news and fostering the creation of user content. More and more people are going to social media outlets such as Facebook, blogs, Twitter, Reddit, and YouTube to access or comment on current news about climate change [16]. By late 2016, well over 2.5 million YouTube videos had been tagged with "climate change" (October, 2016). And an analysis of 1.3 million blog posts found one large interconnected set of climate-science denier blogs, compared to many more science-based communities, covering a plethora of topics about climate change science and climate change politics [17].

An important aspect of digital media is that they provide novel opportunities for rating, recommending and linking to other materials, especially new ways to mobilize and engage people online [18]. For example, after 20 months of Greenpeace International's Unfriend Coal Facebook campaign to "green" the very platform it was using (Facebook), Facebook itself changed its energy policy, announcing a new goal to run on clean, renewable energy. Digital media also provides new ways to communicate: climate change institutions, centers and advocates embed multiple digital media approaches into their websites and other communications. Climate change researchers also provide and maintain awareness of the most recent issues, tools, conference, funding, and results through social media and research websites. Smartphones allow downloadable applications for climate change stories and videos, measurement of local conditions, and sponsorship or donation opportunities.

Particularly significant for targeted communication is the demographics associated with digital media use. While young adults maintain almost as much interest in following the news as older people do (93% of Americans over 60 say they keep up with the news compared to 83% of those age 18–29), there are significant differences in where different age groups get their news, with the under-30 groups more likely to use digital media, especially mobile devices. About 76% of adults 18–29 rely on cell phones for news, compared to 59% of adults age 40–59, and 37% age 60 and over [19]. The under-30 group is also more likely to follow breaking news through social media than the over-30 group, who rely more on television. Print media still is used by all age groups, but by fewer of the under-30 group. About 75% of the over-60 group commonly read print news, compared to 61% of those aged 40–59; 55% of those aged 30–39; and 47% of those aged 18–29.

Such trends show how digital media are becoming increasingly important to transmitting information to young people, our future leaders. Thus, training the next generation of communicators—including journalists, scientists, and educators—to create and use digital content will be imperative in the years to come. The University of California can be very helpful here. The system has many programs that promote research on environmental communication, including those listed in **Table 3**.

Scientists

While the general public depends on news and other media for information about climate change, they usually trust scientists as the ultimate sources of the information, even somewhat more than they trust family and friends. That insight comes from the 2015 poll by the Yale Project on Climate Communication, mentioned above, which revealed only a few major sources of climate information are commonly trusted by more than half of Americans. The trusted sources are: climate scientists (71%), family and friends (67%), other scientists (64%), TV weather reporters (60%), and primary care doctors (57%). This trust imbued by the public means that scientists play a crucial role in communicating climate change.

It is challenging for scientists to communicate their discoveries accurately yet clearly. On the one hand, the sum of scientific information about climate change tells us the future holds more certainty than ever before in human history: Decades of data and models converge, with high confidence, to verify that global temperature has risen and will continue to rise due to past and current human activities that are changing atmospheric composition. The same body of information yields high confidence—virtual certainty—that the impacts of the resulting climatic disruption will cause expensive and socially disruptive problems for the global society, including rising seas that drown parts of highly-populous cities, increased frequency of extreme weather events and wildfires that cause loss of life and property, and shortages of such essentials as food and water. On the other hand, there is uncertainty inherent in forecasting specific climate impacts in specific places because the climate system is very complex, and the future greatly depends on how humans will act to limit future greenhouse gas emissions, growth rates, technology trajectories, and spatial patterns of industrialization and consumption, among other choices.

This sets up a very real tension between knowledge and uncertainty. However, when scientists stress what they do know—while still acknowledging the uncertainty—it can be remarkably effective, as demonstrated by efforts that have taken that approach in connecting scientists directly with policy makers, religious leaders, and the general public. Examples include international communication efforts such as the Intergovernmental Panel on Climate Change [21], the Pontifical Academy of Sciences [22], the Scientific Consensus on Maintaining Humanity's Life Support Systems in the 21st Century [23] and regional programs such as The California Nevada Climate Applications Program (CNAP; see **Table 3**). Such efforts have been useful in helping to base policy positions and decisions—such as international climate negotiations exemplified by the Conference of the Parties (COP) meetings, subnational agreements such as the Under2MOU [24], and local and regional initiatives such as the Pacific Coast Climate Pact [25]—on sound science because they acknowledge scientific consensus on major points, rather than quibbling over details that do not change the overall picture, and they convey accurate scientific information stripped of jargon, in terms their target audiences can relate to. Successful scientific communication to policy makers also tends to involve *informative advocacy*, a communication style that clearly lays out the facts and general targets needed to achieve a result, rather than *prescriptive advocacy*, which specifies

The UC system is well known for promoting and supporting teaching of and research on environmental issues, including communication. Three UC campuses were listed in the Sierra Club's [20] top 10 (out of 153) "cool schools", universities committed to environmentalism, climate action, and sustainability, UC Irvine was ranked 1st, UC Davis 2nd, and UC San Diego was ranked 7th.

- The new ***Center for Climate Communication at UC Merced*** conducts and promotes interdisciplinary research on climate communication, and hosts outreach events, such as theme-based workshops aimed to connect climate researchers with the local community (for instance, workshops on the challenges of communicating drought issues with farmers, water district managers, and community leaders) and an on-going talk series that brings in experts to discuss climate communication. http://ccc.ucmerced.edu/
- The ***California-Nevada Climate Applications Program*** includes UC scientists and works collaboratively with stakeholders to support decision-making on climate-related issues. A representative program is the *National Integrated Drought Information System*, which includes meetings with farmers, water managers, and policy makers to identify how climate information can be tailored to inform and motivate management decisions. http://meteora.ucsd.edu/cap/
- ***The Institute of the Environment and Sustainability at UCLA*** offers a journalism and media fellowship for journalists, editors, and producers to spend time at UCLA working collaboratively on a stories with researchers. The journalists have an opportunity to produce deeper, better informed, nuanced work, in collaboration with researchers, while retaining editorial control of their work.
- ***The Environmental Media Initiative of the Carsey-Wolf Center at UCSB*** offers a 9-week summer program, ***Blue Horizons***, which brings together environmental researchers and media creators to produce ocean-related documentary films and to learn from each. After examining critical issues of our region's oceans and seashores, student groups produce documentaries, which are premiered at the Pollock Theater each August (http://www.carseywolf.ucsb.edu/emi/blue-horizons). Several have gone on to win film festival awards. Other programs of the CWC's EMI include ***GreenScreen***, a hands-on, project-based environmental media production program where students work in teams to leverage collective production skills and environmental knowledge (http://www.carseywolf.ucsb.edu/emi/greenscreen).
- Based upon the success of the ***Blue Horizons Program***, the Bren School of Environmental Science & Management, working with the Carsey-Wolf Center, developed the ***Strategic Environmental Communication and Media Focus***, in which students learn to use media (http://www.bren.ucsb.edu/academics/secm_focus.htm) to communicate effectively and strategically around environmental issues, culminating in a capstone project.
- The new ***Center for Environmental Communication and Education (CECE) at UCSB*** fosters environmental awareness and stewardship through research on, development of, testing, and promoting best practices in environmental communication, designed to improve scientific literacy and foster a greater sense of stewardship across all segments of the population.
- Web-based climate-change resources are delivered to the K-12 through university-level teaching communities through the ***UC Museum of Paleontology at Berkeley***. ***Understanding Global Change*** will launch in 2016, and is modeled after the highly successful ***Understanding Evolution*** (http://evolution.berkeley.edu/evolibrary/home.php) and ***Understanding Science*** (http://undsci.berkeley.edu/) web sites, which receive more than 2 million unique hits each month. Materials associated with these sites include data resources, lesson plans, and teaching tools that will fit into the Next Generation Science Standards framework.
- The UC system has a tremendous opportunity for obtaining and distributing programming about science communication, climate change, and carbon neutrality through ***UCTV*** (http://www.uctv.ucsb.edu/). UCTV reaches millions through satellite and cable channels, with scheduled programs, online viewing, and downloading of content produced from the 10 campuses (see, for example, recent videos of a conference on sustainable science communication, at http://www.uctv.tv/shows/29770).

Table 3: Representative Communication Programs in the UC System.

particular paths a policy maker should take [26]. An example of informative advocacy is the statement "It is necessary to reduce greenhouse gas emissions on average xx% per year for xx years in order to minimize societal disruption from global warming." This gives policy makers latitude to mix and match actions to achieve needed targets in order satisfy a variety of stakeholders—in the case of reducing emissions, they can refer to a menu of all methods that help in achieving carbon neutrality. In contrast, prescriptive advocacy would be a statement like: "Reducing greenhouse gas emissions the necessary amount requires increased reliance on nuclear power." Prescriptive advocacy not only limits a policy maker's effectiveness in satisfying multiple stakeholders, but can impede success if the prescription is unpopular among the policy makers' constituents, at least in a democracy. Prescriptive advocacy can also compromise the very reason that the public tends to trust scientists: a reputation for objectivity.

Given that scientists form an important link in the chain of communication about climate change, communication efforts will benefit from offering science communication as part of the training of scientists, where scientists are trained, that is, within universities. This can be achieved by increasing opportunities to link scientists with journalists and other communication experts in meaningful, lasting collaborations, and by creating a reward system for graduate students and faculty that

bridge the science-communication divide, both for the scientists and the communication specialists involved in the collaborations.

Education

Upon entering the university, some students are skeptical about climate change. Others are indifferent to it. Many have a fractured understanding of how climate change works, including its causes and consequences. This is often because they have received little or no formal instruction in climate-change science as children. The result is that few are able to identify key problems, and few have acquired appropriate language to talk about it.

This situation now has the potential to change rapidly. The emergence of the Next Generation Science Standards (NGSS) in K-12 instruction and guiding framework developed by the National Research Council offers an ideal way to integrate climate science into pre-university curricula, because the new framework presents the practices of science, disciplinary core ideas, and cross-cutting concepts across all domains of science. California has adopted the NGSS and school districts statewide are expected to develop resources, strategies, and activities to teach to the core ideas. Climate change and climate systems figure prominently in the Earth and space sciences domain of NGSS, and the importance and the applications of climate science to society are implied throughout [27] (Wysession 2012).

Because K-12 teachers often lack the resources or even the expertise needed to effectively teach climate science, mergers of university resources with the K-12 community are critically needed, and the UC System is well-positioned to provide the needed help through its teacher-training and educational outreach programs. As one example of an effective approach, the UC Museum of Paleontology (UCMP) is developing instructional support and resources for teaching about climate change at the K-12 through university levels via web-based programs, as it already has successfully for teaching evolution and understanding science (**Table 3**).

The UC System can also educate the public about climate change through its numerous venues for the arts, theater, interactive and static museum exhibits, and film programs. These venues reach sectors of society that often are typically turned off by science and technology, and touch people at an emotional level, where the biggest changes can happen. After all, emotions are known to drive the way people reason and make decisions [28, 29]. Art may be more able to convey the remoteness of "climate" in time, scale, location and unpredictability, and our complex relationships with nature and climate, thus engaging society personally, emotionally, and experientially [30], and through representation, performance, and mitigation [31]. Grant et al. [32] and Merrick [33] argue that both traditional and participatory artistic practices and processes can help overcome some of the many personal, social and cultural barriers to engagement with climate change issues. Duxbury, Ginnarchi, and Merrick describe various projects [30, 31, 33], including visual arts, performance, and new media, designed to communicate climate change. Images and visual displays have been central to the development, representation, and communication of science and technology [34, 35]. More and more, popular media are presenting information about climate change, and doing so in a variety of entertaining ways. For example, each day more than half a million viewers watch TED talks [36]. Also popular are comics ("graphic novels") that express nuanced, accurate scientific information in the form of images, myths, magic, and legends [37].

Special Interest Groups

Many climate myths (**Table 2**) have become popularized through well-organized disinformation campaigns funded by constituencies motivated by ideologies or economic interests at odds with the science on climate disruption [38, 39, 40]. Ironically, these disinformation campaigns illustrate just how important effective communication can be in swaying public opinion. They include working with lobbyists to influence policy at the highest governmental levels; well-crafted press releases (for a recent example, see [41]) that get reported widely because of their clear language, easily-understood assertions, and fuel for the "he-said she-said" controversies that increase readership; cherry-picking facts out of context to make a false "scientific" case against the compelling conclusions that emerge when the whole body of evidence is examined; hiring or funding people with some kind of science credentials (though usually not climate-science credentials) as "experts" to contradict the mainstream science; and attacking both the scientific and personal credibility of individual, well-known scientists who have been influential in discovering or communicating the reality of climate change.

The critical lessons of talking directly to top policy makers and the power of clear, compelling press releases and good media relations need to be taken to heart and replicated in efforts to communicate the reality of human-caused climate change and its impacts. The climate-denier campaigns have also shown that lying, cherry-picking facts, and personal attacks are effective in swaying public opinion. Obviously, such communication tools have no place in the fact-based communication necessary for informing the public about the reality of climate change. However, climate communicators can do much better and much more to counter unfounded claims of the "merchants of doubt" [39] through such venues as clear, fact-based op-eds, blogs, social media, and popular writing and speaking. At the institutional level, the University of California can be effective by implementing courses and communication programs designed to provide awareness of ongoing disinformation campaigns, to monitor climate myths, and to "bust" them with clear fact-based information distributed through press releases, reporting, and social media. This will involve collaboration across disciplines, including stronger linkages between those in the sciences who intimately know the scientific facts, those in communication fields who can find effective ways to

target the same audiences the disinformation is swaying, and students who can provide an untapped source of discovering disinformation, and who will benefit by pedagogy that teaches them hands-on ways to counter it.

The Importance of Framing

All the communication pathways discussed above can be improved by developing better ways to frame messages for given target audiences, and by using general communication techniques summarized in **Table 4**. Framing is an effective communication tool for drawing attention to, legitimizing, and providing an interpretive context for abstract, complex, or unfamiliar information. It involves selecting and positioning messages, including words, text, and images, to influence people's attitudes toward certain situations and states [42]. Framing can powerfully influence people's perceptions, opinions, and actions, by foregrounding or backgrounding certain information [43]. Even small shifts in wording or grammatical form can lead to significant differences in how people reason about situations and events, including likelihood of occurrence [44].

Framing is pervasive in public discourse about social issues. Frames in the context of environmental issues often concern public engagement [49, 50], such as national and global security, morality and social justice, social progress, economic development, scientific and technical uncertainty, public accountability and governance, national security, polar bears, money, catastrophe, justice and equity, and collective action. When it comes to attitudes about climate change, health frames can have robust effects [51]. Frames related to economic gains versus losses are also robust in this domain, and so are those pertaining to local versus distant impacts [52].

Image frames—familiar ones include polar bears, refineries, and climate change refugees—can also be important. A recent study of climate change news stories in United States newspapers [53] identified common frames such as government and politics, science and the people who do it, keeping track of human impacts—mostly undesirable impacts—to the environment, and the Earth heating up, among others. Scientists, journalist, and advocates need to carefully consider and evaluate which frames they use in both text and visual components of climate change communication. Different frames can dispose audiences to "read" or remember different dimensions of the story, or to ignore the story altogether.

Effectively framing of information requires understanding an audience and anticipating reactions to positive and negative messages. When negative messaging is effective, it tends to be so in the context of verifying that a bad outcome is inevitable without action, while at the same time providing a practical and effective solution, and a sense of personal efficacy. In this context, it is critical to communicate that there are already feasible solutions at hand, and that practical steps can in fact be taken.

Past communications about climate change often emphasized the problems more than the solutions. So, indeed, many sectors have misconceptions about some of the more feasible solutions, including the extent to which technology is already available to mitigate climate disruption, the feasibility of transitioning off of fossil fuels, and the ability of society at large to deal with such large-scale

· ***Establish Common Ground.*** For effective communication to take place, there has to be common ground, even when there are differences of opinions. Pay attention to differences in context, including cultural context, and pay attention to what others have to say, even when there is little overt agreement. Effectively connecting to another person requires working toward a common understanding, even if there is not full alignment in the end [45].
· ***Keep the Message Simple.*** Use concrete language when discussing issues around climate disruption. People are more likely to attend to and trust findings that are reported in a clear, accessible manner [46]. One good way to make a message simple is to rely on metaphor. Metaphors are useful for conveying scientific information because they provide a way to structure complex information in terms of more basic, everyday knowledge and experience [47, 48]. Images, such as graphs, are also useful alongside messages, especially when they appear with meaningful captions.
· ***Be Inclusive.*** Seek opportunities to engage with the all members of the community. Hold outreach events that make possible constructive interactions in a neutral environment. Universities are ideal venues for these activities: UC Merced holds such events, and they are met with great success, even from groups known to doubt climate change. Other neutral venues include churches and community centers. Community talks often draw community leaders, religious leaders, K-12 teachers, children, local journalists, and farmers. Seek funding to create and foster these events.
· ***Tell a Story.*** Effective literature and commercial media involve telling stories. Presenting information within a narrative structure engages audiences, and provides a structure for linking information, people, actions, and consequences. It also provides a larger frame through which to tell others about the message (http://www.worldsciencefestival.com/programs/science_storytelling/)
· ***De-politicize climate messages.*** With a heavy political frame, especially when there is negative information or risk of loss, people tend to polarize—it is their default. This is where framing can be especially helpful. Getting the message right and acknowledging human behavior may help curtail political polarization [49], for example, by framing such as: "You may think that believing climate change is a problem amounts to admitting the need for government oversight, but some of the most attractive policies are entirely market-based, depending on price signals to find the least-cost solutions."

Table 4: Effective Communication Techniques.

problems. As demonstrated in other papers in this volume, the requisite technological, policy, and economic solutions are at hand and ready to be implemented. Communicating such solutions more widely and more explicitly is urgently needed. Taking an even broader perspective, it is also important to communicate that the global society has shown its ability to solve problems equally as complex and widespread as the current climate-change crisis, including emplacing new infrastructure and technology to the extent that will be required to shift the world's energy systems to become greenhouse-gas neutral. Some examples are listed in **Table 5** (these and others are discussed in more detail in [23, 54, 55, 56, 57, 58, 59, 60]).

Challenges related to framing come in many different forms. One problem relates to the perception of risk. Messages about climate change typically include some degree of uncertainty. It is difficult or even not possible to pinpoint exactly when a particular event will occur, and exactly what effect it will have on a particular individual or group. This makes it difficult to perceive how much risk can be inferred, and how or even whether it should influence activities. Statements such as "There is a 66% chance that the airplane you are set to board is going to crash" may cause people to make inferences about a high risk of death and destruction, an immediate risk to avoid. Yet statements such as "There is a 66% chance that global temperature will rise above 4°C within the next human lifetime" may bring on a more diffuse, lower sense of risk. Linguistic details can also pose challenges for framing messages for the general public. In the area of political language, for instance, it is known that minor wording changes in messages about political candidates can lead to different perceptions of past actions and whether or not they will be elected. In one study, when people read about a hypothetical politician who "was accepting hush money" instead of "accepted hush money", it caused them to believe that more dollars were accepted and to feel more confidence that he would not be elected [61].

Effective framing requires knowing the target audience and knowing how to tailor messages for that particular group. This becomes challenging when there is significant cultural diversity. We see this in California, the most

- ***The Green Revolution:*** In the 1960s it became clear that a billion people would starve within two decades if business-as-usual agriculture continued. Through a global effort that incorporated very much the same components that are now required to mitigate climate disruption—acceptance of the problem, followed by dedicated efforts of individuals (such as biologist Norman Borlaug); collaborations between people rooted in different disciplines; cooperation between nations, industry, business, and non-governmental organizations; and communication that helped stimulate behavorial changes at the grass-roots level—nascent technology was scaled up and improved, new practices became commonplace, and the looming food crisis was averted. By 1985, within thirty years of the world's decision to fix the problem, global production of key food crops such as cereals was doubled.
- ***The Montreal Protocol:*** In the early 1970s, scientists Mario Molina and F. Sherwood Rowland, then at UC Irvine, discovered that chlorofluorocarbon (CFCs), a common constituent in many consumer goods at the time, would accumulate in the atmosphere and break down in a way that would cause dangerous changes in the ozone layer, which in turn would propagate impacts that were harmful to humanity. After initial contesting by the chemical industry, empirical information confirmed the reality of the problem, and the world decided to fix it: by 1989, an international treaty was in force—the Montreal Protocol on Substances that Deplete the Ozone Layer—that limited CFC use and production and had the net effect of phasing out the use of CFCs. Now the "ozone hole" is shrinking. It was only 20 years from discovering the problem to fixing it. The parallels with what we now face with fixing climate disruption are striking: Scientists discovering an "invisible" problem, verifying it with empirical data, holding congressional hearings, overcoming opposition by industry, stimulating acceptance by the international community with appropriate communication efforts, forging solutions through international agreements that involve governments and industry leaders, and shifting from older, harmful technologies to newer, safer ones.
- ***Building New Infrastructure:*** Converting the present fossil fuel based energy infrastructure to one that utilizes primarily renewables by 2050 sounds like huge task, and it is. But similarly enormous infrastructure emplacements demonstrate humanity's ability to accomplish such feats when they decide to do so. For example, in the second half of the 20th century, the global society dammed more than 60% of the world's large rivers—amounting to building some 25,000 large dams, plus auxiliary infrastructure such as power plants and irrigation networks. Over the same period of time, in the United States alone, enough paved roads were built to encircle Earth's equator twice.
- ***The Communication Revolution:*** In about 30 years beginning in the 1970s, the world's communication infrastructure, and communication itself, was completely transformed: from letters with postage stamps, telegraph lines, and about 310 million telephones connected by landlines, to more than 6 billion people now connected through mobile phones, handheld computers, and the internet. Notably, the emplacement of this new communication infrastructure to empower people in developing countries leap-frogged over the more expensive, less-efficient landline systems that had grown up in developed countries.
- ***Abolishing Slavery:*** The United States has already demonstrated that ultimately, economics does not trump ethics. In 1865, the thirteenth amendment went into effect, freeing all slaves, a move that was economically disadvantageous to the white people who "owned" them, but incontrovertibly essential on ethical grounds. This example also illustrates that people are willing to take extreme measures to ensure basic ethical principles are upheld: The issue was a key trigger of the Civil War, and slavery was abolished only after five years of brutal fighting.

Table 5: Evidence that people work together to quickly solve problems as complex as the current climate-change crisis when they decide solutions are needed.

populous and diverse state in the nation. Its complex social and cultural fabric requires a resilient approach to framing climate change messages, especially given that different cultures hold different views about public engagement in societal issues and what counts as urgent. California is also linguistically diverse, with about 44% of its population speaking a language other than English in the home, most often Spanish. Different language backgrounds mean different ways of talking about and reasoning about uncertainty, and risk. For people who speak English as a second language, elements of their first language tacitly carry over into their own systems of communicating and reasoning. In the end, a "one-size-fits-all" framing is not always effective.

In addition, people in different regions of California or the nation may care much more about one set of issues than another. For instance, people in the inland areas of California, where water rights and the impact of drought on agriculture are burning issues, may not be receptive to messages that emphasize rising sea levels. Such individuals may be more responsive to framing that emphasizes the need to scale back water use. In this same vein, grape growers in Napa Valley may be more open to messages that emphasize solutions for climate disruption than almond growers in the Central Valley.

Framing Examples

Religion

There are, in round numbers, two billion Christians in the world, a billion and a half Muslims, a billion Hindus, half a billion Buddhists, and hundreds of millions practicing other religions. By some estimates, religion contributes to motivating actions of 80% people on Earth [62]. As such, it offers a powerful avenue of communication on climate change issues, including to those living in both developed and developing countries. People have not generally connected climate change messages with their religious beliefs, even though many of the world's religions recognize environmental stewardship as a key responsibility of humans. Indeed, the leaders of nearly all of the world's major religions have now spoken out about the responsibility that humans have to prevent continued climate change as part of a broader responsibility to care for the natural world. Major recent proclamations have been issued from Pope Francis [22], Patriarch Bartholomew I (Eastern Orthodox), and the Dalai Lama. Leaders within most of the world's major religions, including Islam, have made comparable statements [63]. A recurring theme in these proclamations is the detrimental impacts on humanity as a whole, on fellow human beings, and on other animals, plants, and nature that continued climate disruption will cause, and the ethical and moral responsibility that we have to protect the planet that nurtures us. Many of these declarations are very recent—within the last year or two—so the jury remains out as to their efficacy in shifting societal opinion. However, given the emotional and moral links many people have with their religion, as well as the relative independence of religious leaders from market and electorate pressures, this may be one of the most powerful ways to communicate key messages about climate change.

With this recognition, religious scholars have been actively exploring how engagement with religion can enhance communication about climate change and motivate action. Between 1998 and 2003, Harvard University Press published a nine-volume series, "Religions of the World and Ecology," under the general direction of Mary Evelyn Tucker, who now directs the ongoing Forum on Religion and Ecology at Yale University. This series included *Buddhism and Ecology* [64], *Confucianism and Ecology* [65], *Christianity and Ecology* [66], *Hinduism and Ecology* [67], *Daoism and Ecology* [68], *Indigenous Religions and Ecology* [69], *Jainism and Ecology* [70], *Judaism and Ecology* [71], and *Islam and Ecology* [72]. Earlier (1989), Holmes Rolston III, a philosopher of science and theologian at Colorado State University who would later win the Templeton Prize for his work, published *Environmental Ethics: Duties to and Values in the Natural World,* his first sustained attempt to ground a moral obligation to preserve the environment in compatibility with the evolutionary story of its origins [73]. Brian Swimme, a philosopher working in cooperation with Tucker, published *The Journey of the Universe* with a companion DVD in 2011 [74], aiming to present the scientific story of the universe in a way that might motivate action by inspiring awe and devotion [75].

What scholars of religion, as distinct from religious leaders proper, typically do when addressing the topic of religious environmentalism is observe, report, and reflect upon the different intra-religious paths or conceptual frames taken by religiously different groups as they converge upon cognate environmental action. One example of this is Roger C. Gottlieb's *A Greener Faith: Religion, Environmentalism, and Our Planet's Future* [76]. Gottlieb tracked down a set of American groups who had dared to take concrete action addressing different environmental issues in different venues, each time proceeding from the principles of a different religion. Recently, he has assembled a conceptually richer set of potential starting points or frames in *The Oxford Handbook of Religion and Ecology* [77]. Other studies have shown that connections between climate change and religion in the developing world can be particularly strong, as illustrated in Elizabeth Allison's work on the spiritual significance of losing mountain glaciers as rising temperatures shrink them worldwide [62].

At the same time, the direct engagement of scientists with religious leaders has proven extremely effective in disseminating information in the climate change crisis. Such efforts bear fruit, as is seen with Pope Francis' May 2015 encyclical letter on "Care for Our Common Home" [22], a compelling call for the people of the world to recognize and deal with human-caused climate change, incorporated information from papal-level dialogues with many scientists (**Figure 1**).

Politics

Climate change is one of several issues for which a person's beliefs do not rely on objective observations, but instead align with partisan loyalties. Almost half of the people who identify as Republican remain skeptical about climate change, while only slightly more than 10% of Democrats do. It is tempting to attribute this stark political divide to

Figure 1: Dialogues between scientists and religious leaders, such as this one taking place at a meeting of the Pontifical Academy of Sciences at the Vatican, preceded the formulation of Pope Francis' encyclical "Care for Our Common Home" [22]. Pictured left to right are Prof. Veerabhadran Ramanathan (UC San Diego), Prof. Partha Dasgupta (Cambridge University), Archbishop Roland Minnerath (Dijon, France), Monsignor Sánchez Sorondo (Vatican), and Pope Francis. To the left and behind Monsignor Sorondo is Prof. Werner Arber, a Nobel Laureate and President of the Pontifical Academy of Science.

unequal provision of and access to information, especially since multiple studies show that Americans increasingly live in homogenous communities that can become echo chambers that reinforce pre-existing biases.

Yet, years of research on public misperceptions about other issues on which there is a scientific consensus shows that the problem is not information. It is known that simply providing people with factual information is not an effective way to correct misperceptions about science or policy [78, 79, 80]. The problem is not that people do not know the facts or the scientific consensus; rather, they hold personal or group identities that make them unwilling to acknowledge certain beliefs [81]. Because of this, Nyhan [82] suggests that a potentially effective communication approach is to "try to break the association between identity and factual beliefs."

In that context, ameliorating the partisan divide requires building social relationships that model different linkages between information and group identities. One way this can come about is through receiving information from a trusted source within a particular identity group. For example, it may be important in changing some Republican views that the United States military leaders and national security advisors are now more vociferously and strongly acknowledging climate change as a chief threat to national security, in no uncertain terms. A case in point is the efforts of high-ranking officers who have commanded the armed forces, including the Navy, Air Force, Army, and Marines, and who comprise the Military Advisory Board of the CNA Corporation, an influential national security think tank. These military leaders have authored two recent reports that mince no words. Their 2007 report stated: "The nature and pace of climate changes being observed today and the consequences projected by the consensus scientific opinion are grave and pose equally grave implications for our national security" and, with regard to taking into account risk and uncertainty in climate projections, "We never have 100% certainty. We never have it. If you wait until you have 100% certainty, something bad is going to happen on the battlefield" [83]. In 2014, the language became even stronger: "We are dismayed that discussions of climate change have become so polarizing and have receded from the arena of informed public discourse and debate. Political posturing and budgetary woes cannot be allowed to inhibit discussion and debate over what so many believe to be a salient national security concern for our nation . . . We remain steadfast in our concern over the connection between climate change and national security . . . Strengthening resilience to climate impacts already locked into the

system is critical, but this will reduce long-term risk only if improvements in resilience are accompanied by actionable agreements on ways to stabilize climate change" [84]. The Pentagon [85] and Department of Defense [86] also have recently issued reports that convey similar themes. More directly, CNA's Military Advisory Board reaches out to conservative communities through talks and visits that present the as-yet little realized military view of the seriousness of climate change. Such direct communications from trusted sources (the military) can be much more effective in swaying opinions of the undecided sector of the Republican community than hearing the same message from someone whose political identity is different.

A second way to communicate climate change issues in traditionally unaccepting political communities is through the everyday relationships people form in their personal and social lives [87]. In her study of evangelical Christianity, for instance, sociologist Lydia Bean finds that the linking of religious and political views comes not through sermons delivered by the clergy. Instead, people learn to link their religious and political identities through Bible study leaders, PTA leaders, or bake sale organizers who become role models of how to live a Christian life, and have particular ways of processing and understanding things like climate science [88]. Bean calls these Bible study leaders the "captains of the culture war" because they are the ones who propagate particular beliefs and identities. The challenge in communicating climate science, then, is to find ways to reach different captains (or, in more common social science terms, "opinion leaders"), who can then enter into the same kind of transformative relationships with ordinary people.

Economics and Business

Given that about 19% of greenhouse gas emissions come from the production of goods and services, and that there are substantial financial interests at stake in transitioning from fossil fuels to near zero-emissions energy production, framing messages about climate change in terms that realistically express potentials for economic profit and loss is crucial. In this context, collaborations between communicators, economists, and the business community are becoming increasingly important. One role of communicators here is to evaluate and accurately convey the facts that underpin or reject commonly held perceptions about the impacts of climate mitigation on the average consumer. For example, a popular argument against climate mitigation is that it will cost jobs. But recent trends and projections suggest the opposite is true. In California, jobs in the clean energy sector grew by 109% from 1995 to 2010, compared to only 12% job growth in the general economy [89]. At the national level, job growth in the renewable industry is outpacing job growth in the fossil fuel industry as well. In 2013, the solar industry created more new jobs than coal mining, oil and gas drilling, pipeline construction, and conventional power generation together [90]. And analyses that project job growth under scenarios of replacing 20% of energy generation by renewables by 2020, versus job growth that would accrue from continuing to use fossil fuels to generate that same 20% of energy, found that the shift to renewables would create up to 240,000 jobs by 2020, in contrast to no more than 75,000 jobs that would result from sticking with fossil fuels. That same study found that shifting to renewable energy creates more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment, than producing energy from fossil fuels [91]. Yet other research has focused on the total cost of meeting the world's growing energy needs by emplacing renewable-energy power plants rather than building new fossil fuel plants. While the total yearly cost of meeting new energy needs with renewables sounds enormous—about half a trillion dollars per year as of 2012—it could in fact be entirely covered by a tiny addition to present electricity charges, an increment of only 1 cent per kilowatt-hour in industrialized countries like the United States and many in Europe, and about 2 to 5 cents per kilowatt-hour in other places [92]. For a typical California family of four, this tiny monthly expense would amount to about $8.00. Such information is eye-opening for many people who hold the belief that energy transition costs would be prohibitively high. This framing is effective because it presents the issues in terms of what is familiar and viable.

At the corporate level, there are also important communication opportunities. More and more business leaders now recognize the value of substantially reducing their greenhouse gas emissions to stem climate change, both for their own bottom line and out of moral and ethical considerations (or corporate social responsibility efforts) [93]. For example, CEOs of many of the most profitable corporations—including those in the energy, mining, auto, airline, electronic, food, and digital information industries—have collaborated on developing the Vision 2050 Plan and its follow-up, Action 2020, which set out the pathways, with decade-by-decade benchmarks, that lead to "a global population of some 9 billion people living well, within the resource limits of the planet by 2050." Among the benchmarks are those that contribute substantially to carbon-neutrality, including: "incorporating the costs of externalities, starting with carbon, ecosystem services and water, into the structure of the marketplace; halting deforestation and increasing yields from planted forests: halving carbon emissions worldwide (based on 2005 levels) by 2050 through a shift to low-carbon energy systems and improved demand-side energy efficiency, and providing universal access to low-carbon mobility" [94, 95]. Major corporations are also increasingly joining efforts led by Non-Governmental Organizations to combat climate change. For instance, The Climate Group / Carbon Disclosure Project RE100 initiative, which requires companies to pledge to source 100% of their electricity from renewable sources, now includes 36 major corporations, including such well-known brands as Goldman Sachs, IKEA, Johnson & Johnson, Nestlé, Proctor & Gamble, Starbucks, and Unilever [96]. Such commitments send a powerful message to the general public about the reality of climate disruption, the need to guard against the risks it poses for continued prosperity, and the commitment of leaders in the private sector to take action.

Motivating Behavioral Change

Decades of research highlight the big gap between people's opinions and what they actually do [97], which means that, even if effective framing of issues changes an individual's opinions about dealing with climate change, motivating them to take action still presents an additional challenge. Motivating action requires finding ways to make people feel like what they do matters, in the context of their particular ideology and personal agency. (In this context, "personal agency" or "efficacy" refers the feeling that one is controlling their actions and choices.) That is no easy task—a short conversation with a canvasser at the doorstep or a phone call from a call center is unlikely to transform someone's sense of personal agency. Instead, research shows that the transformative work of developing agency happens when people are in relationship with each other. Social relationships are powerful because of their potential to transform the motivations, interests, and capacities that people need for political action [98, 99, 100, 101].

The social interactions that form the basis of these relationships do not have to be happenstance; instead, civic and political organizations and other institutions of democracy can strategize ways to intentionally cultivate them. [102, 103, 104, 105]. For example, it is possible to create digital and physical spaces, and to employ organizing strategies, that are designed to bring people into relationship with each other, and structure those relationships in ways that help them scale their work [101].

Such approaches are most successful when institutional support is adequate. Too often, schools, civic organizations, churches, and other such institutions find themselves struggling to devote resources to the patient work of building the space through which people can develop capacities for democratic action. Universities and other institutions that bring together people can serve a valuable role in this regard. Given its mission and existing infrastructure, the University of California and many other universities are ideally situated to create and maintain the spaces and opportunities needed for people to develop relationships across political and cultural divides.

Conclusions

Effective communication about climate change and its impacts is essential to fostering the social changes needed to attain carbon neutrality. The American public is currently split on its opinions about the importance of climate change, but approximately 60% have not really made up their minds definitively one way or the other. That represents an enormous opportunity for communicators to accelerate the societal shift that has to occur in order to hold global temperature rise to less than 2°C. The communication challenge is to frame the issues appropriately, and use a variety of traditional and digital media, to reach diverse target audiences, and to enable more interactions between communicators who use different approaches. All are critically important. If messages are framed inappropriately, people close their ears. And if the ties between journalists, scientists, digital media experts, and educators are not strong, mixed or confusing messages can emerge, as has happened to varying degrees in the past when the different communication sectors have not taken full advantage of the expertise available in complementary sectors. However, when proper framing and strong interactions between the different communication pathways occur, the results have been encouraging.

For example, coverage in mainstream journalism has been shifting toward clearer reporting of the scientific consensus on climate change, and toward making connections between local events the public cares about (like Hurricane Sandy, or drought conditions and extreme wildfires in the West) and the global problem of climate disruption caused by elevated greenhouse gas emissions. Such journalism has the potential to change the debate through well-researched, accurate reporting, which can be facilitated by close interactions with scientists who are willing to reach across their disciplinary boundaries. At the same time, climate scientists are increasingly recognizing the value of reaching out to communicate more broadly, and it is becoming more common for them to take lessons from successful journalistic approaches, employ social media, and hone personal interaction skills to become more effective at doing so [23, 38, 58, 106, 107]. Coinciding with the increasingly better communication by media professionals and on scientific fronts, some policy makers at the highest levels have recently begun to embrace the message that climate change is among this generation's greatest challenges—perhaps *the* greatest challenge—and using their platforms to spread that word. This includes the presidents (as of 2016) of the two highest-emission countries, the USA's President Obama and China's President Xi, and also politicians who have found ways to do end-runs around the political gridlock of Washington DC. California's Governor Jerry Brown, for example, has used both direct information from scientists and the power of the news media to help forge successful agreements at the state level and internationally between California and such diverse entities as China, Mexico, British Columbia, Washington, Oregon, and several subnational governments worldwide [24, 25]. And outside the political arena, new constituencies are also embracing the messages that it is time to acknowledge and deal with climate change, including segments of society that used to be associated with not taking climate change seriously: the United States military [83, 84, 86], the Catholic Church [22], and some of the world's wealthiest corporations [94, 95].

Moreover, a new generation of communicators can now take advantage of the billions of connected mobile devices—there are more than 6 billion unique mobile phone connections in the world, not to mention computers and other internet-enabled devices—to reach billions of people through social media. Importantly, this also opens up a new way to frame messages specifically for a diverse set of target audiences (called "personalization" or "tailoring"), something that previously was not possible through print and television media alone. And climate science is now being seen as an integral teaching tool in the Next Generation Science Standards, opening many avenues for

integration of climate-change issues into the curricula across science, technology, humanities, and the arts. Still lagging is a coordinated effort to counter disinformation campaigns, probably in view of the fact that these have only recently become widely recognized. However, with recognition of the problem, efforts at the institutional level can provide an effective counterbalance.

Encouraging as these success stories are, we are still faced with the problem of extreme polarization about climate change in the American public, and this will not change without concerted efforts to effectively communicate the issues to a broader spectrum of society than is currently being targeted. In that task, the University of California is well positioned to make substantive, long-lasting contributions. Indeed, the Carbon Neutral pledge itself is a clear demonstration of a high level of commitment from a major research university to take serious steps to confront climate disruption through telling a new, empowering story.

Recommendations

Based on the information discussed above, we see clear ways that the University of California can accelerate its communication efforts to drive social change toward carbon neutrality. To accomplish that goal, we recommend taking the following actions to build and enhance the University's communication programs, at a pace that will make them fully operational within five years. While these recommendations center on the UC system, they are applicable to many other universities as well.

1. ***Create closer connections between UC climate-science researchers and media practitioners, including those in journalism, film, and social media.*** Stronger, more structured interactions between faculty and students in these separate disciplines can forge new territory for communicating climate change issues. This will be essential to reaching and communicating to a diverse range of audiences whose beliefs and actions will ultimately make or break the success of achieving carbon neutrality.
2. ***Create a climate messaging hub for diverse communities.*** The diversity of the state's people provides an ideal testing ground for effective framing of climate messages to a broad spectrum of society. Lessons learned can be scaled up nationally.
3. ***Increase the opportunities for scientists and educators in general to learn how to communicate effectively to non-scientific audiences.*** UC is well positioned to offer training in this area, on all campuses, through in-person coursework and online modules.
4. ***Create a reward system that values science communication along with publishing in specialty journals.*** The current reward system in the sciences and other disciplines discounts outreach efforts compared to publishing in discipline-focused venues.
5. ***Facilitate dialogs between scientists, scholars, policy-makers, business leaders, and religious leaders.*** Such one-on-one interactions can lead to messaging billions of people about climate change.
6. ***Establish a Washington DC presence.*** Through UCOP and UCDC, present a yearly UC Summit on Climate Change, and update information annually. Work directly through California Representatives and Senators with the House and Senate Caucuses focused on topics germane to Climate Change.
7. ***Create a coordination point for faculty spokespersons, and qualify/train the spokespersons to effectively convey the consensus messages developed through this initiative.*** Facilitate the faculty spokespersons to work with the cadre of faculty colleagues in order to (1) inform the spokesperson, and (2) ensure ownership and concurrence of faculty colleagues in support of the effort.
8. ***Identify existing communication programs and courses, or if necessary create new ones that can respond rapidly to ongoing disinformation campaigns***. Countering inaccurate claims with clear, fact-based information distributed through press releases, reporting, and social media remains a challenge in climate communication. UC can play a key role in countering disinformation campaigns on issues specific to California climate policy. On a broader stage, there are existing programs already devoted to this task outside UC, such as such as Climate Central, the Yale Project on Climate Communication, the George Mason University Center for Climate Change Communication, and others, and we suggest that UC's niche is to use its growing expertise in environmental communication and framing messages for diverse audiences to complement and strengthen effectiveness of these existing efforts.
9. ***Incentivize teaching about climate change and how to communicate it across all disciplines in the UC system***—not only in science and technology, but also across the social sciences, arts and humanities.
10. ***Enhance the teaching of climate-related curricula in California K-12 schools.*** This can be done through outreach programs in place, and new ones that include bringing pre-university students and teachers in contact with UC students and faculty, and developing web-based information and lesson plans for the K-12 community.

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The authors have no competing interests to declare.

References

1. Johnson, L. B. 1965, February 8. President Lyndon B. Johnson's Special Message to the Congress on Conservation and Restoration of Natural Beauty. Retrieved from: http://www.lbjlib.utexas.edu/johnson/archives.hom/speeches.hom/650208.asp.
2. The White House. 1965. Report of the Environmental Pollution Panel of the President's Science Advisory Council, Restoring the Quality of Our Environment, Washington, DC, 1–. Retrieved from: http://dge.stanford.edu/labs/caldeiralab/Caldeira%20downloads/PSAC,%201965,%20Restoring%20the%20Quality%20of%20Our%20Environment.pdf.
3. PWC. 2014. Two degrees of separation: Ambition and reality/ Low Carbon Economy Index 2014. Retrieved from: http://www.pwc.co.uk/assets/pdf/low-carbon-economy-index-2014.pdf.
4. Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C.-Y., and Leiserowitz, A. A. 2015. Predictors of public climate change awareness and risk perception around the world. Nature Climate Change. DOI: http://dx.doi.org/10.1038/nclimate2728
5. Leiserowicz, et al. 2015. Climate Change in the American Mind (Yale University and George Mason University.) New Haven, CT: Yale Project on Climate Change Communication. Retrieved from: http://environment.yale.edu/climatecommunication/article/Global-Warming-CCAM-March-2015.pdf.
6. Saad, L., and Jones, J. M. 2016, March 16. U.S. concern about global warming at eight-year high. Gallup Politics. Retrieved from: http://www.gallup.com/poll/190010/concern-global-warming-eight-year-high.aspx.
7. Roser-Renouf, E., Maibach, A., Leiserowitz, G. F., Rosenthal, S., and Kreslake, J. 2014. Global Warming's Six Americas: Perceptions of the Health Consequences of Global Warming and Update on Key Beliefs. Yale University and George Mason University. New Haven, CT: Yale Project on Climate Change Communication. Retrieved from: http://environment.yale.edu/climate-communication/files/Six-Americas-October-2014.pdf.
8. Lambin, E. 2012. The Ecology of Happiness. University of Chicago Press, 174 pp. DOI: http://dx.doi.org/10.7208/chicago/9780226466699.001.0001
9. Cook, J., Nuccitelli, C., Green, S. A., Richardson, M., Winkler, B., Painting, R., Way R., Jacobs, P., and Skuce, A. 2013, June. Quantifying the consensus on anthropogenic global warming in the scientific literature. Environmental Research Letters, 8(2). Retrieved from: http://iopscience.iop.org/1748-9326/8/2/024024/article. DOI: http://dx.doi.org/10.1088/1748-9326/8/2/024024
10. d.light. 2015. d.light reaches 50 million lives empowered. Press release, d.light Solar, Retrieved from: http://www.dlight.com/files/2614/3172/1502/50_Million_PDF_for_Website.pdf, and also see http://www.dlight.com/.
11. Das Shrestha, K. 2013, March 22. Solar power and arable winters in the gateway to Everest. Sustainable Nepal. Retrieved from: http://sustainablenepal.org/solar-power-and-arable-winters-in-the-gateway-to-everest/#.VhghZRNVhBc.
12. Boykoff, et al. 2004. Bias as balance: global warming and the US prestige press. Global Environmental Change, 14, 125–136. DOI: http://dx.doi.org/10.1016/j.gloenvcha.2003.10.001
13. Sacramento Bee. 2015, 20–21 July. California's sensible evangelism needs to be heard. Retrieved from: http://www.sacbee.com/opinion/editorials/article27966166.html.
14. Siders, J. 2015, 21 July. Jerry Brown's climate warning: 'We are talking about extinction.' Sacramento Bee. Retrieved from: http://www.sacbee.com/news/politics-government/capitol-alert/article27998554.html.
15. Associated Press. 2015, 27 August. Official: Californians Conserving Water in Drought. Retrieved from: http://www.capradio.org/articles/2015/08/27/official-californians-conserving-water-in-drought/.
16. Boykoff, M. T. 2011. Who Speaks for the Climate? Making Sense of Media Reporting on Climate Change. Cambridge, MA: Cambridge University Press. DOI: http://dx.doi.org/10.1017/CBO9780511978586
17. Elgesem, D., Steskal, L., and Diakopoulos, N. 2015. Structure and content of the discourse on climate change in the blogosphere: The big picture. Environmental Commnication, 9(2): 169–188. DOI: http://dx.doi.org/10.1080/17524032.2014.983536
18. Newell, R., and Dale, A. 2015. Meeting the climate change challenge (MC3): The role of the internet in climate change research dissemination and knowledge mobilization. Environmental Commnication, 9(2): 208–227. DOI: http://dx.doi.org/10.1080/17524032.2014.993412
19. American Press Institute. 2014. Social and demographic differences in news habits and attitudes. Retrieved from: http://www.americanpressinstitute.org/publications/reports/survey-research/social-demographic-differences-news-habits-attitudes/.
20. Sierra Club. 2015. America's greenest universities, the top 10. Retrieved from: http://www.sierraclub.org/interactive/sierra/cool-schools-2015.
21. IPCC. 2013. Summary for Policymakers. In Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Xia, Y., Bex, V., and Midgley P. M. (Eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press Cambridge, United Kingdom and New York, NY, USA. Retrieved from: http://www.climatechange2013.org/images/report/WG2011AR2015_SPM_FINAL.pdf.

22. Vatican. 2015. Encyclical Letter Laudato Si of the Holy Father Francies on Care for Our Common Home. Vatican City, Rome, pp. 1–82. Retrieved from: http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html.
23. Barnosky, A. D., Brown, J. H., Daily, G. C., Dirzo, R., Ehrlich, A. H., Ehrlich, P. R., Eronen, J. T., Fortelius, M., Hadly, E. A., Leopold, E. B., Mooney, H. A., Myers, J. P., Naylor, R. L., Palumbi, S., Chr Stenseth, N., and Wake, M. H. 2014. Introducing the scientific consensus on maintaining humanity's life support systems in the 21st century: Information for policy makers. The Anthropocene Review, 1(1): 78–109 (originally published as Scientific Consensus on Maintaining Humanity's Life Support Systems in the 21st Century: Information for Policy Makers, and hosted on the website http://consensusforaction.stanford.edu/).
24. Under2MOU. Sustainable Global Climate Leadership Memorandum of Understanding, Retrieved from: http://under2mou.org/.
25. Pacific Coast Climate Pact. 2015. Pacific Coast Action Plan on Climate and Energy. Retrieved from: http://www.pacificcoastcollaborative.org/Documents/Pacific%20Coast%20Climate%20Action%20Plan.pdf.
26. Hadly, E. A., and Barnosky, A. D. 2014. Beyond science communication: informative versus prescriptive advocacy. ConsensusForAction Blog. Retrieved from: http://consensusforaction.stanford.edu/blog/beyond-science-communicatio.html.
27. Wysession, M. E. 2012. Implications for Earth and space in new K–12 science standards. Eos, Transactions American Geophysical Union, 93(46): 465–466. DOI: https:/doi.org/10.1029/2012EO460001
28. Ariely, D. 2008. Predictably Irrational: The Hidden Forces That Shape Our Decisions. Harper Collins.
29. De Martino, B., Kumaran, D., Seymour, B., and Dolan, R. J. 2006. Frames, biases, and rational decision-marking in the human brain. Science, 313(5787): 684–687. DOI: http://dx.doi.org/10.1126/science.1128356
30. Duxbury, L. 2010. A change in the climate: New interpretations and perceptions of climate change through artistic interventions and representations. Weather, Climate, and Society, 2: 294–299. DOI: http://dx.doi.org/10.1175/2010WCAS1053.1
31. Giannarchi, G. 2012. Representing, performing and mitigating climate change in contemporary art practice. Leonardo, 45(2): 124–131. DOI: http://dx.doi.org/10.1162/LEON_a_00278
32. Grant, B., Baldwin, C., Lieske, S. N., and Matin, K. 2015. Using participatory visual methods for information exchange about climate risk in canal estate communities. Australian Journal of Maritime & Ocean Affairs, 7(1): 23–37. DOI: http://dx.doi.org/10.1080/18366503.2015.1014012
33. Merrick, K. 2012. The power of art to engage the public on the impacts of climate change on the coast. Curtin University Sustainability Policy Institute. Western Australia: Curtin University. Retrieved from: www.Coastalcluster.curtin.edu.au/local/pdf/Kath_Merrick_DiscussionPaper.pdf.
34. Lefèvre, W., Renn, J., and Schoepflin, U. (Eds.). 2003. The Power of Images in Early Modern Science. NY: Springer Sciences-Business Media.
35. Pauwels, L. 2006. Visual cultures of science: rethinking representational practices in knowledge building and science communication. UPNE.
36. Sugimoto, C. R., and Thelwal, M. 2013. Scholars on soap boxes: Science communication and dissemination in TED videos. Journal of the American Society for Information Science and Technology, 64(4): 663–674. DOI: http://dx.doi.org/10.1002/asi.22764
37. Tatalovic, M. 2009. Science comics as tools for science education and communication: A brief, exploratory study. Journal of Science Communication, 8(4): A02, 1–17.
38. Mann, M. E. 2013. The Hockey Stick and the Climate Wars: Dispatches from the Front Lines. Columbia University Press, 448 pp.
39. Oreskes, N., and Conway, E. M. 2011. Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming. Bloomsbury Press, 368 pp.
40. Schneider, S. H. 2009. Science as a Contact Sport: Inside the Battle to Save Earth's Climate. National Geographic, 304 pp.
41. Heartland Institute. 2015. Heartland Institute Joins Coalition Challenging Pope Francis's Views on Global Warming, Capitalism. Retrieved from: http://www.wtrf.com/story/30035102/media-advisory-heartland-institute-joins-coalition-challenging-pope-franciss-views-on-global-warming-capitalism.
42. Entman, R. M. 1993. Framing: Towards clarification of a fractured paradigm. Journal of Communication, 43(4): 51–58. DOI: http://dx.doi.org/10.1111/j.1460-2466.1993.tb01304.x
43. Chong, D., and Druckman, J. N. 2007. Framing theory. Annual Review of Political Science, 10: 103–126. DOI: https:/doi.org/10.1146/annurev.polisci.10.072805.103054
44. Matlock, T. 2012. Framing political messages with grammar and metaphor. American Scientist, 100: 478–483. DOI: http://dx.doi.org/10.1511/2012.99.478
45. Clark, H. H. 1996. Using Language. Cambridge University Press. DOI: http://dx.doi.org/10.1017/CBO9780511620539
46. Oppenheimer, D. M. 2006. Consequences of erudite vernacular utilized irrespective of necessity: Problems with using long words needlessly. Applied Cognitive Psychology, 20(2): 139–156. DOI: https:/doi.org/10.1002/acp.1178
47. Gibbs. R. W. 1994. The Poetics of Mind: Figurative Thought, Language, and Understanding. Cambridge University Press, New York.

48. Lakoff, G., and Johnson, M. 1980. Metaphors we live by. Chicago: U of Chicago Press.
49. Nisbet, M. C. 2009. Framing science: A new paradigm in public engagement. In Kahlor, L., and Stout, P. (Eds.), Understanding science: New agendas in science communication. New York: Taylor & Francis, pp. 40–67.
50. Lakoff, G. 2010. Why it matters how we frame the environment. Environmental Communication, 4(1): 70–81. DOI: http://dx.doi.org/10.1080/17524030903529749
51. Myers, T. A., Nisbet, M. C., Maibach, E. W., and Leiserowitz, A. A. 2012, June 28. A public health frame arouses hopeful emotions about climate change. Climatic Change, 113(3–4): 1105–1112. DOI: http://dx.doi.org/10.1007/s10584-012-0513-6
52. Spence, A., and Pidgeon, N. 2010. Framing and communicating climate change: The effects of distance and outcome frame manipulations. Global Environmental Change, 20(4): 656–667. DOI: http://dx.doi.org/10.1016/j.gloenvcha.2010.07.002
53. Rebich-Hespanha, S., Rice, R. E., Montello, D. R., Retzloff, S., Tien, A., and Hespanha, J. P. 2015. Image themes and frames in U.S. print news stories about climate change. Environmental Communication (in press). Retrieved from: http://www.tandfonline.com/eprint/Un6YQeeKNVwpI6PJUgdK/full.
54. Jacobson, M. Z., and Delucchi, M. A. 2009, November. A path to sustainable energy by 2030. Scientific American: 58–65. DOI: http://dx.doi.org/10.1038/scientificamerican1109-58
55. Jacobson, M. Z., and Delucchi, M. A. 2011. Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials. Energy Policy, 29: 1154–1169. DOI: http://dx.doi.org/10.1016/j.enpol.2010.11.040
56. Delucchi, M. A., and Jacobson, M. Z. 2011. Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies. Energy Policy, 29: 1170–1190. DOI: http://dx.doi.org/10.1016/j.enpol.2010.11.045
57. Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O., and Ludwig, C. 2015. The trajectory of the Anthropocene: The great acceleration. The Anthropocene Review, 2(1): 81–98. DOI: http://dx.doi.org/10.1177/2053019614564785
58. Barnosky, A. D., Ehrlich, P. R., and Hadly, E. A. 2016. Avoiding collapse: Grand challenges for science and society to solve by 2050. DOI: http://dx.doi.org/10.12952/journal.elementa.000094; https://elementascience.org/articles/94.
59. Barnosky, A. D. 2014. Dodging Extinction: Power, Food, Money, and the Future of Life on Earth University of California Press, Berkeley, California.
60. Barnosky, A. D., and Hadly, E. A. 2015. End Game: Tipping Point for Planet Earth? HarperCollins UK, London, p. 264.
61. Fausey, C. M., and Matlock, T. 2011. Can grammar win elections? Political Psychology, 32: 563–574. DOI: http://dx.doi.org/10.1111/j.1467-9221.2010.00802.x
62. Allison, E. A. 2015. The spiritual significance of glaciers in an age of climate change. WIREs Clim Change 2015, 6: 493–508. DOI: http://dx.doi.org/10.1002/wcc.354
63. Yale Forum on Religion and Ecology. 2015. Climate change statements from world religions. Retrieved from: http://fore.yale.edu/climate-change/statements-from-world-religions/.
64. Tucker, M. E., and Williams, D. R. (eds.). 1998. Buddhism and Ecology: The Interconnection of Dharma and Deeds. Cambridge: Harvard University Press.
65. Tucker, M. E., and Berthrong, J. (eds.). 1998. Confucianism and Ecology, The Interrlation of Heaven, Earth, and Humans. Cambridge: Harvard University Press.
66. Hessel, D. T., and Ruether, R. R. (eds.). 2000. Christianity and Ecology Seeking the Well-Being of Earth and Humans. Cambridge: Harvard University Press.
67. Chapple, C. K., and Tucker, M. E. 2000. Hinduism and Ecology. The Intersection of Earth, Sky, and Water. Cambridge: Harvard University Press.
68. Girardot, N. J., Miller, J., and Xiaogan, L. (eds.). 2001. Daoism and Ecology, Ways within a Cosmic Landscape. Cambridge: Harvard University Press.
69. Grim, J. A. (ed.). 2001. Indigenous Traditions and Ecology, The Interbeing of Cosmology and Community. Cambridge: Harvard University Press.
70. Chapple, C. K. (ed.). 2002. Jainism and Ecology, Nonviolence in the Web of Life. Cambridge: Harvard University Press.
71. Tirosh-Samuelson, H. (ed.). Judaism and Ecology, Created World and Revealed World. Cambridge: Harvard University Press.
72. Foltz, R. C., Denny, F. M., and Baharuddin, A. (eds.). 2003. Islam and Ecology, A Bestowed Trust. Cambridge: Harvard University Press.
73. Rolston, H. 1989. Environmental Ethics: Duties to and Values in the Natural World, Temple University Press.
74. Swimme, B., and Tucker, M. E. 2011. The Journey of the Universe. Yale University Press.
75. Swimme, B., and Tucker, M. E. 2016. The Journey of the Universe, Film Website, http://www.journeyoftheuniverse.org/.
76. Gottlieb, R. S. 2006. A Greener Faith: Religion, Environmentalism, and Our Planet's Future. Oxford University Press. DOI: http://dx.doi.org/10.1093/acprof:oso/9780195176483.001.0001
77. Gottlieb, R. S. 2010. The Oxford Handbook of Religion and Ecology. Oxford University Press.
78. Nyhan, B., and Refler, J. 2010. When corrections fail: The persistence of political misconceptions. Political Behavior, 32: 303–330. DOI: http://dx.doi.org/10.1007/s11109-010-9112-2
79. Nyhan, B., and Refler, J., 2013. The hazards of correcting myths about health care reform. Medical Care, 51(2): 127–132. DOI: http://dx.doi.org/10.1097/MLR.0b013e318279486b

80. Nyhan, B., Reifler, J., Richey, S., and Freed, G. L. 2014. Effective messages in vaccine promotion: A randomized trial. pediatrics. DOI: http://dx.doi.org/10.1542/peds.2013-2365
81. Kahan, D. M. 2014. Climate-Science Communication and the Measurement Problem. Advances in Political Psychology, 36: 1–43 DOI: http://dx.doi.org/10.1111/pops.12244
82. Nyhan, B. 2014. When beliefs and facts collide. New York Times (July 5, 2014). Retrieved from: http://www.nytimes.com/2014/07/06/upshot/when-beliefs-and-facts-collide.html?rref=upshot&_r=1.
83. CNA Corporation. 2007. National Security and the Threat of Climate Change. Published by the CNA Corporation, Alexandria, Virginia, pp. 1–35. Retrieved from: https://www.cna.org/cna_files/pdf/National%20Security%20and%20the%20Threat%20of%20Climate%20Change.pdf.
84. CNA Military Advisory Board. 2014. I. (Alexandria, VA: CNA Corporation, 2014). Retrieved from: https://www.cna.org/cna_files/pdf/MAB_5-8-14.pdf.
85. Lamothe, D. 2014. Climate Change Threatens National Security, Pentagon Says. Washington Post (October 13). Retrieved from: https://www.washingtonpost.com/news/checkpoint/wp/2014/10/13/climate-change-threatens-national-security-pentagon-says/.
86. Department of Defense. 2015. DoD Releases Report on Security Implications of Climate Change, U. S. Department of Defense, DoD News, Defense Media Activity. Retrieved from: http://www.defense.gov/News-Article-View/Article/612710.
87. Munson, Z. 2009. The Making of Pro-life Activists: How Social Movement Mobilization Works. Chicago, University of Chicago Press.
88. Bean, L. 2014. The Politics of Evangelical Identity: Local Churches and Partisan Divides in the United States and Canada Hardcover. Princeton and Oxford: Princeton University Press. DOI: http://dx.doi.org/10.1515/9781400852611
89. Melville, J., Brown, C., Harutyunan, A., and Held, K. 2012. Seven growth sectors driving California's clean and efficient economy. Environmental Defense Fund (New York), 13 pp. Retrieved from: http://www.edf.org/sites/default/files/EDFSevenSectors-5.24.2012pdf.pdf.
90. Hering, G. 2015. Solar adds more US jobs than fossil fuel extraction. PV Magazine (January 15, 2015). Retrieved from: http://www.pv-magazine.com/news/details/beitrag/solar-adds-more-us-jobs-than-fossil-fuel-extraction_100017786/#axzz3o2g53Yi4.
91. Kammen, D. M., Kapadia, K., and Fripp, M. 2004. Putting renewables to work: How many jobs can the clean energy industry generate? Report of the Renewable and Appropriate Energy Laboratory, Energy and Resources Group, Goldman School of Public Policy, Berkeley, CA. Retrieved from: http://rael.berkeley.edu/old_drupal/sites/default/files/very-old-site/renewables.jobs.2006.pdf.
92. Faiman, D. 2014. Concerning the global-scale introduction of renewable energies: Technical and economic challenges. MRS Energy & Sustainability 1: 1–9. DOI: http://dx.doi.org/10.1557/mre.2014.8
93. Kleiner, K. 2007. The corporate race to cut carbon. Nature Climate Change, 3: 40–43. DOI: http://dx.doi.org/10.1038/climate.2007.31
94. WBSCD. 2013a. Vision 2050, World Business Council for Sustainable Development. Retrieved from: http://www.wbcsd.org/vision2050.aspx.
95. WBSCD. 2013b. From Vision 2050 to Action 2020. World Business Council for Sustainable Development. Retrieved from: http://www.wbcsd.org/action2020.aspx.
96. Furlong, H. 2015. Climate Week: Climate Neutral Now, RE100 Initiatives Recruit Fortune 500 Companies. Sustainable Brands, the Bridge to Better Brands. Retrieved from: http://www.sustainablebrands.com/news_and_views/cleantech/hannah_furlong/climate_week_climate_neutral_now_re100_initiatives_recruit_f.
97. Campbell, A., Converse, P. E., Miller, W. E., and Stokes, D. E. 1960. The American Voter. New York, Wiley.
98. Sinclair, B. 2012. The Social Citizen: Peer Networks and Political Behavior. Chicago: University of Chicago Press. DOI: http://dx.doi.org/10.7208/chicago/9780226922836.001.0001
99. Rolfe, M. 2012. Voter Turnout: A Social Theory of Political Participation. Cambridge, UK: Cambridge University Press. DOI: http://dx.doi.org/10.1017/CBO9781139058513
100. Rogers, T., Gerber, A. S., and Fox, C. R. 2012. Rethinking why people vote:V as dynamic social expression. In Shafir, E. (Ed.), Behavioral Foundations of Policy, Princeton: Princeton University Press. pp. 91–107.
101. McKenna, E., and Han, H. 2014. Groundbreakers: How Obama's 2.2 Million Volunteers Transformed Campaigns in America. New York: Oxford University Press.
102. Han, H. 2016. The organizational roots of political activism: Field experiments on creating a relational context. American Political Science Review, 110(2): 296. DOI: http://dx.doi.org/10.1017/s000305541600006x
103. Han, H. 2014. How Organizations Develop Activists: Civic Associations and Leadership in the 21st Century. New York: Oxford University Press. DOI: http://dx.doi.org/10.1093/acprof:oso/9780199336760.001.0001
104. Warren, M. 2001. Dry Bones Rattling: Community Building to Revitalize American Democracy, Princeton Studies in American Politics. Princeton, NJ: Princeton University Press. DOI: http://dx.doi.org/10.1515/9781400832040
105. Ganz, M. 2009. Why David Sometimes Wins. New York: Oxford University Press.
106. White, J. W. C. (Chair.), Alley, R. B., Archer, D. E., Barnosky, A. D., Foley, J., Fu, R., Holland, M. M., Lozier, M. S., Schmitt, J., Smith, L. C., Sugihara, G., Thompson, D. W. J., Weaver, A. J., Wofsy, S. C.,

Dunlea, E., Mengelt, C., Purcell, A., Gaskins, R., and Greenway, R. 2013. Abrupt Impacts of Climate Change, Anticipating Surprises. National Academies Press, 201 pp.

107. Jordan, R. 2014. Stanford students create interactive tool that tells the story of global change (http://news.stanford.edu/news/2014/october/cal-stories-map-101714.html), reporting on Geographic Impacts of Global Change: Mapping the Stories of Californians (http://stanford.maps.arcgis.com/apps/StorytellingTextLegend/index.html?appid=dafe2393fd2e4acc8b0a4e6e71d0b6d5).

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