

Brave new world

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“O wonder!
How many goodly creatures are there here!
How beauteous mankind is! O brave new world,
That has such people in’t.”
—Miranda in Shakespeare’s *The Tempest*

“Great is truth, but still greater, from a practical
point of view, is silence about truth.”
—Aldous Huxley, *Brave New World*

Recent events in the U.S. have spurred us (the undersigned editors of *Biogeochemistry*) to make this statement in support of science and, in particular, environmental science. Media attention over “alternative facts” and “truthful hyperbole,” not to mention the tenor of the discussion over climate change, suggests that the very nature of science and its role in American society is under attack. We believe that

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well-established scientific consensus in these areas is being ignored in policy-making, and funding for scientific inquiry that runs counter to political interests is under threat. This political stance favoring ignorance over inquiry fundamentally would, if it is allowed to perpetuate, threaten not only our quality of life but also our future as a species.

As most readers of this journal are professional scientists, our jobs combine, in varying amounts, research, scholarship, teaching, service, and engagement. We might investigate applied topics such as pollution, invasive species, the effects of land-management or climate change, but our actions tend to be focused on testing hypotheses, conducting experiments, and writing papers, along with our immediate classroom demands. A number of us might be called to take action outside the bounds of our routine job responsibilities, perhaps in a courtroom or in a larger public discussion, but this is often not rewarded by our employers. Recent events have prompted many of us to ask whether this *status quo* is a good model for the profession of science.

Granted, public opinion and scientific consensus often have diverged, in the United States and elsewhere. For example, a Gallup poll that began in 1982 shows remarkably little change in the beliefs of US citizens about evolution (<http://www.gallup.com/poll/1708>). In 2006, a paper in *Science* reported that over the past 20 years, the percentage of U.S. adults accepting the theory of evolution has declined from 45 to 40% (Miller et al. 2006), showing a deep divide in acceptance of science that is the foundation of modern biology. This suggests that knowledge generated by scientists may not be easily accepted by teachers, school boards, politicians, or the American public.

Of immediate concern to readers of this journal is that environmental science as a discipline is under attack, and that results from decades of environmental and climate science research are in danger of being dismissed and dismantled by politicians, most prominently in the U.S. but also in some other countries. It was not always this way. When the Clean Air Act first became law in 1970, the Senate under a Republican president (Richard Nixon) passed it unanimously (<https://www.washingtonpost.com/news/the-fix/wp/2014>). All countries came together to ratify the original Montreal Protocol, and more recently, the Paris Agreement. Yet in 2017, a bill was proposed to eliminate the US EPA and environmental protection

was declared “a waste of all this money” (<http://www.nydailynews.com/news/politics/fla-lawmaker-pitches-bill-abolish-epa-article-1.2965>). Things have clearly changed.

Perhaps the need to vote for clean air was more obvious at a time when environmental damage and human health effects were directly visible. Residents of coal-dependent Pittsburgh were willing to pay more for heating in the 1940s if it meant that street lights did not need to be turned on at noon. After a few fires and an embarrassing cover on Time Magazine, Cleveland residents were willing to pass a \$100 million bond to fund the cleanup of the Cuyahoga River. The consequences of climate change are perhaps not as easy to see, but are, nonetheless, equally pernicious.

What is of concern is that while roughly half of Americans (48%) in the most recent Pew Research Center Poll (Pew Research Center, January 29 2015) say that they believe that climate is changing and that climate change is mostly due to human activity, far fewer (39%) have “a lot” of trust in information from climate scientists. Fortunately, about 2/3 of Americans say that climate scientists should have a major role in policy decisions about climate issues. Why is there so little trust in results from climate science?

Constant repetition of misinformation has shown to be a successful strategy in obscuring scientific analysis, as can be seen from the history of scientific knowledge of the cancer risks of tobacco versus tobacco industry propaganda. As late as 1960 only one-third of all US doctors believed that the case against cigarettes had been established in sharp contrast to findings of scientists studying the smoking-cancer link (Proctor 2012). We know that misinformation is easy to spread, and that even a few seeds of doubt can be sufficient to derail constructive change. This doubt is at times facilitated by society’s frequent misperception that the inherent uncertainty and incompleteness of the scientific process somehow devalue scientific insight.

We live in the Information Era—where Internet-based media, including Twitter, can send information, true or false, around the world in milliseconds. Debates over science increasingly and alarmingly are moving to the non-science, non peer-reviewed media, especially to media with specific non-science (or anti-science) agendas. A recent study examining news coverage of climate change in leading US

newspapers reported that *The Wall Street Journal* was least likely to discuss the impacts of and threat posed by climate change and most likely to include negative information and to use conflict and negative economic framing when discussing actions to address climate change (Feldman 2015).

What can be done? We can continue to focus on short-term goals: our own research, our papers, our students. Or we can acknowledge that current events are extraordinary and call for extraordinary measures. In these times, scientists must be called into action, to stand up for the role of science in understanding and documenting environmental effects and in policy analysis, to stand up to ensure that policy decisions are based on robust evidence, to stand up for climate science, to stand up for clean air and water, and to stand up to support the positive influence and activities of mission agencies like the U.S. EPA. We can't argue that policy isn't our job or our expertise. Our collective voice can be loud. In a world where facts, lamentably, no longer speak for themselves, science must be communicated effectively to counter the constant repetition of misinformation.

We also must change our approach to and involvement in science education, especially for non-science majors at our academic institutions. We must master language that makes sense, we must get better at outreach and effective science translation to the general public, and we must decide that teaching non-science majors and public outreach aren't "lesser," but instead a duty, and a privilege to share what we know. Advocacy for university and public education programs emphasizing environmental history and the scientific process is sorely needed. We need to write press releases, attend workshops on science communication, and accept invitations to speak to non-peer audiences (farmer groups, conservation groups, community organizations). We need to teach that when scientists use the term "error" this does not mean that we think that our results are wrong, and "uncertainty" does not mean that we think that our statements are false. And fundamentally, we must find ways to help the public regain trust in scientists as knowledge experts who can use their knowledge to help inform policy. We must help the public understand and accept the overwhelming evidence for climate change and other environmental threats, as well as the sometimes causative roles that humans play.

Biogeochemistry is an international journal created specifically to publish research on critical Earth system processes and the interaction of the human and natural world, and thus the Editorial Board felt a sense of duty to pen this editorial. The editors of *Biogeochemistry* have signed this editorial, with a few exceptions: we asked our colleagues in U.S. Federal positions (USGS, Forest Service) not to sign this editorial over concern for their positions and careers. This concern underscores the title of this editorial, "Brave New World." We offer our words in the spirit of Shakespeare, whose Miranda expressed wonder over the goodness of humankind and her future in the world, and not in the spirit of Huxley, whose narrative paints a more pessimistic vision of the future. International cooperation and collaboration in science are essential for global environmental understanding and management. Science is an act of dedication, which at times requires courage on the part of individual scientists, institutes, boards, and agencies. Addressing climate change through scientific research and engaging the public in mitigating it is an international duty that also requires bravery. With this editorial, we pledge our commitment to scientific excellence, to the publication of factual information, objective analysis, and rational interpretation, and to engagement of the public in discoveries of human influences on the natural world.

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