temporal parameter values, modelling assumptions, timeframes and system boundaries[11,12]. Consequently, our analysis focused on quantifying uncertainty in one primary variable: net SOC loss to CO_2 from residue removal[1]. The 30-year time interval precedent set by Searchinger *et al.* is arbitrary and biases results in favour of biofuel producers[12,13]. Precedents used by the US Environmental Protection Agency may not favour near-term emissions reductions, and existing precedents will probably be revised. To accurately represent current climatic conditions and SOC dynamics, temperature measurements from 2001 to 2010 were used[1], because older data do not represent increased temperatures and future projections are more uncertain. The model[1], however, was also used to estimate SOC changes from 2010 to 2060 with estimated increases in crop yields and temperatures from the IPCC's Fifth Assessment Report climate simulations (representative concentration pathway 8.5 emissions scenario)[14]. When compared with no residue removal, removal of 3 Mg ha^{-1} yr^{-1} of residue from continuous corn was estimated to lose ~0.22 Mg C ha^{-1} yr^{-1} on average in the first 10 years in three counties in Nebraska and Iowa; for the first 30 years, this value was reduced by ~52% on average to ~0.11 Mg C ha^{-1} yr^{-1} (ref. 14).

Yet, to dilute SOC emissions over 30 years or more does not represent actual CO_2 emissions over the first 10 years, and presenting longer-term lower values can be deceptive. Sanchez *et al.* noted, "Policymakers may find it appropriate to focus on more certain, near-term climate impacts, in which case a short horizon for fuel warming potential is sufficient."[12] If residue is removed for biofuel, these systems could produce more CO_2 emissions than gasoline for more than 10 years (ref. 1) and then possibly reduce emissions in 20 to 30 years, after agricultural SOC stocks have significantly decreased and crop yields have probably declined. Alternatively, SOC loss from residue removal can be widely recognized, and appropriate management can be used to compensate for lost carbon and increased CO_2 emissions[1]. ❐

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CORRESPONDENCE:

Lessons learned from geoengineering freshwater systems

To the Editor — Our ecosystems and the services they provide are increasingly being degraded by multiple and interacting pressures. Humans are using geoengineering to mitigate their effects, even though it commonly addresses acute symptoms of single pressures. Barrett *et al.*[1] discuss the benefits, problems and geopolitical consequences of proposed geoengineering to alleviate the effects of climate change by injecting sulphate into the stratosphere. This is an untried, global measure, the efficacy of which is difficult to predict[2]. However, geoengineering is already being applied in fresh waters, at smaller scales, using additives to alleviate the effects of either local nutrient enrichment or regional acid deposition[3]. Lessons from these and other freshwater management experiences provide empirical evidence to reinforce the conclusions of Barrett *et al.* Here, we highlight the need to consider feedbacks between ecosystems and the pressures acting on them beyond the potential interactions in their Fig. 1.

Barrett *et al.*[1] discuss various environmental problems that stratospheric sulphate injection cannot solve, such as Antarctic ice loss and indirect effects on precipitation. Similarly, in fresh waters, phosphorus reduction using geoengineering will not alter the widespread effects of nitrogen enrichment[4]. Barrett *et al.*[1] point out that geoengineering will not return the climate to past conditions. The same is also true in lakes for phosphorus removal, and for natural or artificial recovery from acidification, where multiple pressures produce novel ecosystems[5]. Mitigation of climate change by sulphate injection could reduce the pressure on politicians to lessen carbon emissions. In fresh waters, there is a similar concern that geoengineering will reduce the pressure on regulators to manage nutrient loss from the catchment[3].

These limitations seem to be common across scales, but there are also positive and negative feedbacks of geoengineering that are difficult to predict. For example, a cooled climate may alleviate eutrophication symptoms in fresh waters, such as cyanobacterial blooms or the effects of rapid expansion of non-native species from warmer areas[6]. A decrease in phosphorus following rapid phosphorus control using geoengineering in fresh waters is likely to favour a decrease in methane ebullition from lakes to the atmosphere[7]. Altering weather may change catchment productivity, which is also linked to carbon dioxide losses to the atmosphere from lakes[8]. Both climate mitigation and phosphorus control are likely to reduce coastal fish stocks, compounding the negative socioeconomic effects of overfishing[9].

Management of climate systems may cause geopolitical problems that benefit some nations at the expense of others[1]. Similarly, in fresh waters, although the scale of effect is smaller, the projected financial burden of meeting the European Water Framework Directive through geoengineering is equally large (that is, about US$100 billion; ref. 3). The need to consider transboundary environmental and geopolitical conflicts across connected ecosystems has been acknowledged for both climate[1] and freshwater systems[10]. However, negotiations will be required, during which the financial burden of 'the polluters' may be balanced with the resultant financial gain of 'the polluted'. For fresh waters, the benefits of geoengineering to alleviate eutrophication symptoms are likely to be constrained to the region in which the managed system is situated, whereas the benefits of geoengineering to alleviate climate change symptoms may, arguably, be much wider in scale[2].

Geoengineering is mitigation, rather than adaptation, and continual and costly treatment of chronic symptoms will be required if the root causes of the problems (for example, nutrient loading and greenhouse-gas emissions) are not addressed[11]. We call for a more comprehensive long-term perspective when planning environmental management at this scale. ❐

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COMMENTARY:

Getting there from here

Keely B. Maxwell

Institutions need to adapt to ensure coequal social and biophysical global change science.

As a social scientist, I welcome the recent calls for better integration of the social sciences into global change research and transforming research into action[1,2]. It is encouraging that biophysical as well as social scientists recognize the need to reframe environmental change as a social problem, not merely a physical one[2]. Developing coequal intellectual partnerships and analysing linked biophysical and social systems[1] will be central to this process. How can this scientific parity be achieved? Creating new forms of science will require integrating the environmental social sciences into existing institutions. Insights from the social sciences should be used to facilitate this process. Here, I propose opportunities, challenges and strategies to integrate environmental social science into research by the federal agencies that are part of the US Global Change Research Program. I draw on my experiences as an environmental anthropologist hosted for two years by the US Environmental Protection Agency as an American Association for the Advancement of Science, Science and Technology Policy Fellow. Further insights come from the social science literature, reports and policies. While the scope of this Commentary is limited to federal agencies, its recommendations are applicable to other organizations, as well.

Science is not simply conducting experiments or testing hypotheses. It is also a social act[3]. Integrating environmental social science into global change research thus requires modifying the social networks and institutional practices of federal agency science. For the agencies involved, this translates into practical decisions about research planning, resource allocation and personnel. The social sciences need to inform these decisions.

The social sciences are integral to understanding environmental change in complex systems. Global change involves multiple stressors, feedbacks across scales, cascading consequences, shifting baselines and rates of change. It is also characterized by policy failures, power imbalances, competing values and socioeconomic inequalities in risk exposure. Social scientists illuminate the social, economic, cultural and political trends and conditions entwined with environmental change, the social impacts of global change policies, and the distribution and perception of environmental risks. Their research methods, sources of data, analytical strategies, and temporal and spatial scales of analysis complement those of biophysical scientists. Anthropologists, for example, provide unique insights into how people experience environmental change, climate change justice and the politics of climate change knowledge[4,5]. Social scientists can help agencies effect positive action on climate change by providing insights into environmental knowledge, values, behaviour and governance. By incorporating the social sciences, federal agencies can better formulate problems, evaluate policy alternatives, resolve conflicts, build trust, evaluate programmes, support participatory decision-making, communicate risk, improve community engagement, value ecosystem services and measure policy success.

Partnership

The paramount step that federal agencies need to take to integrate social and biophysical global change research is to hire more social scientists. Research partnerships will be an essential part of this endeavour[1], but they alone cannot sustain it. Without social scientists on staff, agencies will not even be able to