Corridors of Clarity: Four Principles to Overcome Uncertainty Paralysis in the Anthropocene

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Global environmental change challenges humanity because of its broad scale, long-lasting, and potentially irreversible consequences. Key to an effective response is to use an appropriate scientific lens to peer through the mist of uncertainty that threatens timely and appropriate decisions surrounding these complex issues. Identifying such corridors of clarity could help understanding critical phenomena or causal pathways sufficiently well to justify taking policy action. To this end, we suggest four principles: Follow the strongest and most direct path between policy decisions on outcomes, focus on finding sufficient evidence for policy purpose, prioritize no-regrets policies by avoiding options with controversial, uncertain, or immeasurable benefits, aim for getting the big picture roughly right rather than focusing on details.

Keywords: global environmental change, science–policy interface, sufficient evidence, uncertainty

Global environmental change poses unprecedented challenges to humanity because of its broad-scale, long-lasting, and potentially irreversible consequences. Many aspects of the Anthropocene, in which humans are the dominant driver of earth system dynamics (Crutzen and Stoermer 2000, Waters et al. 2016), are novel. This novelty reduces our ability to use the past to forecast the future (Brondizio et al. 2016). In addition, technological and social innovations, along with feedbacks among environmental, socioeconomic, and political spheres, lead to complex system dynamics that confound our ability to accurately anticipate the future (Polasky et al. 2011, Homer-Dixon et al. 2015, Keys et al. 2019).

Despite the potentially large consequences for current and future human well-being, human institutions have largely failed to develop effective responses to global environmental change (Walker et al. 2009, Galaz 2014). Climate change, loss of biodiversity, and pandemic responses are examples in which the global community has not taken sufficient action to address threats (IPCC 2014, 2018, IPBES 2019, Osterholm and Olshaker 2020). A wide range of factors can explain inaction in the policy sphere including the lack of effective or charismatic leadership, the lack of engaged stakeholders to generate political will, the lack of resources, and disagreements over values and priorities. In the present article, we focus on the role that uncertainty and complexity play in impeding progress on global environmental change, and the role that science could play in overcoming these impediments.

Uncertainty obscures the links from actions to outcomes, making it hard to discern whether taking an action will lead to a desirable or undesirable outcome. Uncertainty can also make it hard to know which alternative is likely to be a better choice. Fear that a choice could lead to a bad outcome, or is not as good as another choice, can result in paralyzing uncertainty (Markus and Schwartz 2010), which we define as uncertainty leading to a failure to act even in the face of looming threats. Uncertainty can cause reluctance to adopt policy changes, even when such reforms are likely to generate positive net benefits (Fernandez and Rodrik 1991). Uncertainty may be real (it is beyond the ability of current science to predict the outcome) or perceived (decision-makers believe there is uncertainty). Mixing together groups with conflicting values and the potential for creating perceived uncertainty is particularly problematic. Different policy options may create distinct groups of winners and

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losers. Groups that feel they will probably lose with policy reforms may adopt deliberate strategies to create doubts about scientific findings (Oreskes and Conway 2010), or issue calls for further research as a means of delaying or discouraging action. For example, industry groups who oppose climate regulations have invested in organizations that question or deny the results of mainstream climate science (Oreskes and Conway 2010, Dunlap and McCright 2011, 2015). Uncertainty and political polarization can lead groups who favor different policies to draw different conclusions from outcomes, which can further entrench the political polarization (Dixit and Weibull 2007).

What can science and an associated science–policy interface do to help overcome paralyzing uncertainty? Telling decision-makers that the world is complex and that science cannot provide all the answers, although accurate, does not lead to a fruitful science–policy interface. In the present article, we argue that an important component of the answer is to use the right scientific lens to peer through the mist of uncertainty surrounding complex issues. The complex web of causality that typically links policy actions to outcome in social–ecological systems may have corridors of clarity, which we define as evidence-based scientific understanding of critical phenomena or causal pathways that are sufficient to justify taking policy action. The most constructive science–policy interfaces occurs when scientific information makes clear links between policy choices and outcome, and this can be clearly communicated and readily understood by decision-makers in a timely manner (sensemaking; Weick 1988). Corridors of clarity strip away aspects of complexity and uncertainties that are largely irrelevant for decision-making while retaining conceptual clarity and scientific rigor. The idea of a corridor of clarity is similar to the notion of requisite simplicity (Stirzaker et al. 2010), or Einstein's quote about science that "Everything should be made as simple as possible but no simpler." Clearly communicating results that emerge from analysis of a corridor of clarity can counteract the potentially paralyzing effect of uncertainty in complex environmental issues.

Finding corridors of clarity: General principles and illustrative examples

Science can contribute to effective governance of global environmental change by clearly articulating and quantifying important causal pathways from policy decisions to their likely outcomes. Although science thrives by gaining ever more nuanced and detailed description of reality, such details may not be that useful to decision-makers. In the present article, we outline four general principles for finding corridors of clarity.

Follow the strongest and most direct path between policy decisions and outcomes. The most important scientific information for decision-making connects policy decisions to likely outcomes of interest in a clear and direct manner. By focusing on the most direct and well-established causal pathways, corridors of clarity can provide sufficient relevant information, while not focusing on uncertainty of little relevance for policy.

Consider the case of climate change and land-use change, which are two fundamental and pervasive aspects of global environmental change. Although there are many causal pathways linking climate and land-use change to outcomes of interest, some pathways have fewer steps in the causal chain as well as a greater degree of certainty for each link in the chain. For example, one relatively direct pathway from climate and land-use change to outcomes affecting human well-being involves the probability of flooding. Changes in precipitation or storm intensity, influenced by climate change, and changes in runoff, retention, or protection from storm surge, influenced by land-use change, can affect the probability of flooding and its consequent impacts on lives lost and property damage (figure 1). Das and Vincent (2009) showed that mangroves protected coastal villages from a super cyclone that struck Orissa, India in 1999. Even though conserving mangrove may have other societal benefits, they found that flood mitigation benefits alone justified mangrove conservation. Watson and colleagues (2016) estimated that preserving wetlands in a watershed in Vermont reduced property damage downstream by 54%–78%, with estimated benefits from $3 million to $30 million for one downstream town (Middlebury), making "a compelling case for the role of green infrastructure in building resilience to climate change" (Watson et al. 2016: 16). There is a rapidly expanding body of work on ecosystem services that quantifies many links between land-use change and human well-being (IPBES 2019) and highlights cases in which conservation more than pays for itself through increased value of ecosystem services (e.g., Balmford et al. 2002, Nelson et al. 2009, Bateman et al. 2013). The effects of climate change on ecosystem services are also becoming clearer, although many of these links still have considerable uncertainty (Runting et al. 2017).

Other pathways also link climate and land-cover change to changes in human well-being, but these pathways are typically more complex, more uncertain, or less important in terms of the magnitude of change on human well-being. For example, altered land-cover affects biodiversity (e.g., Newbold et al. 2015), with consequent changes in ecological processes that modify the provision of various ecosystem services (e.g., Díaz et al. 2006, Cardinale et al. 2012) that affect human well-being (figure 1). However, the relationship between biodiversity, ecological processes, and their subsequent impacts on the provision of ecosystem services is complex with large uncertainties (Loreau et al. 2002, Tilman et al. 2014).

Environmental topics such as plastic debris in the oceans and extinction of charismatic species receive much public attention. Research funding has followed. However, this research often focuses on unravelling effects that are complex as well as uncertain and possibly weak (figure 2). Examples include the effect of plastic on organisms and ecosystem functioning (Koelmans et al. 2017, Burns and Boxall 2018, Besseling et al. 2019). A self-propelling feedback between interest and funding promotes a continued focus

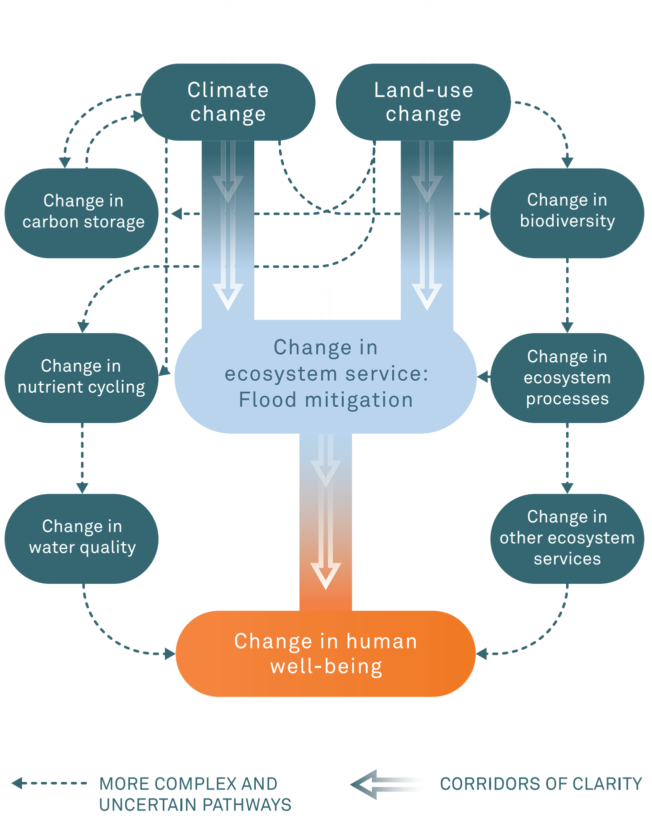

Figure 1. The ecosystem service of flood mitigation links climate and land-cover change to changes in human well-being. The large arrows indicate this corridor of clarity. Climate and land-use change affect the probability of flooding (upper large arrows). Floods can cause injuries and deaths along with extensive property damage (lower large arrow). Numerous other pathways also link climate and land-cover change to changes in well-being, including links through changes in biodiversity, carbon cycling, and nutrient cycling. Each of these other pathways contains weak links (the dashed arrows), involving greater complexity and larger uncertainty, or having small impact on human well-being. Image by Ruby Creative.

on complex effects. This is a problem both because of the diversion of funding and scientific brainpower from more important topics and because a focus on uncertain causal links may ultimately undermine support for managing the problem. There are good reasons to reduce plastic debris that have nothing to do with these complex causal links. A more direct reason to control plastic pollution is the broad concern of the public about plastic debris and its impact on the subjective experience of unspoiled nature (Koelmans et al. 2017).

Finding sufficient evidence. Corridors of clarity can help focus on what scientific information is sufficient for policy purposes. In some cases, focusing on more readily measurable links, without getting to complex or difficult to measure links, is sufficient. For example, reducing emissions of air pollutants may have a wide range of benefits to society, but focusing on human health benefits alone can be sufficient to show that the benefits of emission reductions is worth the cost. An analysis by the US Environmental Protection Agency of the Clean Air Act Amendments of 1990 projected that benefits of emissions reductions in 2020 would be nearly $2 trillion, of which over 90% were related to reductions in premature mortality, versus $65 billion in costs ($2006; USEPA 2011).

Similarly, the benefits of providing clean drinking water provide sufficient information to justify protection of watershed in the Catskill Mountains near New York City. The estimated cost of conserving the watersheds was $1billion to $1.5 billion, but the cost of not doing so was far higher: Building and operating a water filtration plant was estimated to cost $6 billion to 8 billion (Ashendorff et al. 1997, Chichilnisky and Heal 1998). Conserving the watersheds also enhanced the provision of other ecosystem services, but the choice of whether to conserve watershed could be justified solely on the basis of protecting the water supply (NRC 2005). The example of New York City inspired new science and policies aiming to protect watersheds to secure safe drinking water and generate other benefits (Goldman-Benner et al. 2012, Brauman et al. 2019).

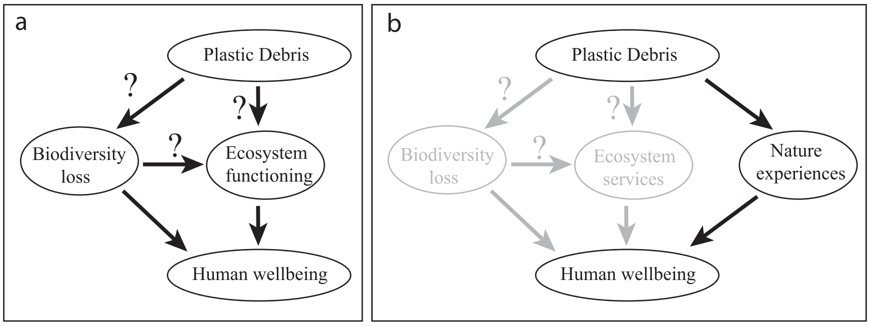

Figure 2. Plastic debris effects on human wellbeing. a) Effects of plastic on biodiversity and ecosystem functioning are complex and overall possibly minor. b) The more direct pathway for which there is stronger evidence is the negative view of the public about plastic debris and its impact on the subjective experience of unspoiled nature.

No-regrets policies. Similar to focusing on sufficient information, no-regrets policies are ones in which a policy action is justified by taking account of clear benefits, even without factoring in more controversial, uncertain, or hard to quantity benefits. For example, although there are numerous uncertainties in the links between greenhouse gas (GHG) emissions and human well-being, many actions that reduce GHG emissions generate sufficient additional benefits to justify taking action even without reference to climate change. Many investments in energy efficiency, such as improved

Figure 3. Gray Weather, Grande Jatte, ca 1886–1888, by Georges Seurat, The Metropolitan Museum of Art. Zooming in on details only reveals bundles of small dots of different colors. The full picture only appears when observing from a distance. Image: Peter Barritt / Alamy Stock Photo, modified by the authors.

insulation, lighting, appliances, and building design, generate cost savings from lower energy bills and make sense strictly from a private financial perspective independent of climate or other environmental benefits. In the United States, investments in energy efficiency of about $520 billion have been estimated to generate savings of $1.2 trillion (Granade et al. 2009: vii), more than paying for themselves, even without consideration of environmental benefits. In addition, reducing energy use would also improve air quality, generating large public health benefits. For example, the National Research Council estimated that air pollution damages from coal-fired electricity production in 2005 was $62 billion (NRC 2010). Rather than trying to resolve the many uncertainties we face, we can instead focus on identifying key policy relevant issues that could change the policy choice.

Seeing the forest for the trees. The painter Georges Seurat (figure 3) constructed his paintings using small dots of paint. Standing close to his paintings one can see the dots. Only by stepping back from the painting can one see what the painting actually represents. Scientists facing an issue as complex as global environmental change in the Anthropocene often feel the temptation to retreat to safe science by focusing on smaller problems, or insisting on collecting ever more data and building ever more sophisticated models, in an attempt to more accurately and rigorously capture reality (i.e., getting each dot right). However, more complicated models do not necessarily predict future outcomes better than simpler models (Burnham and Anderson 2002), and an overload of information can lead to cherry picking facts, greater polarization, and confirmation bias (Sharot 2018).

Experiments at the scale of the policy issue are more relevant to policy choice and therefore more persuasive to policymakers. Studies of whole ecosystems, which is the scale of relevant impacts, have contributed valuable information about the effect of acid precipitation in watersheds (Likens 1992), eutrophication of lakes (Schindler 2012), and biomanipulation of lakes that can be employed to improve water quality (Bernes et al. 2015). In each case, narrower studies of parts of the problem did not clearly predict ecosystem response. The effects of phosphorus, nitrogen, and inorganic carbon on algae in small enclosures, for example, gave conflicting results about causes of eutrophication, but whole-lake experiments showed clearly that phosphorus input was the primary driver. Experiments in small enclosures commonly fail to predict results of experiments on whole lakes (Schindler et al. 1987, Levine and Schindler 1992, Carpenter and Kitchell 1993, Gonzalez and Frost 1994). Whole-lake experiments seem realistic to the general public, managers, and policymakers and are therefore considered in real-world decisions (Carpenter 1998, Schindler 1998).

Conclusions

The complexities and uncertainties of global environmental change should not be an excuse for inaction. Science produces compelling evidence relevant for policy purposes when we conduct research at the relevant scales (Carpenter 1998), use models and statistics that embrace uncertainty (Biggs et al. 2009), and seek corridors of clarity. Finding corridors of clarity that focus on direct, well-supported, and understandable links between policy decisions and outcomes that affect human well-being is one pragmatic approach to better link science with policy. Pursuing corridors of clarity can also be a useful defense against paralyzing uncertainty and the efforts of vested interests to magnify uncertainty in order to block progress on global environmental change issues. Taking immediate action following a corridor of clarity may also buy time to learn how to address the less well understood or more complex causal links.

Of course, the corridors of clarity approach will not help in all situations, either because there are no clear pathways between policy choices and human well-being, or because other considerations block effective action on global environmental change. For example, even though there are relatively clear links between overfishing, declines in fish stocks, and reduced incomes for fishermen, overfishing in the oceans continues because of a lack of effective institutions to deal with the tragedy of the commons (e.g., Dietz et al. 2003, Walker et al. 2009).

Promoting any particular corridor of clarity requires careful thought about unintended consequences that might occur through indirect pathways that turn out to be important (Mace et al. 2012). But if every pathway is important, then nothing is important; policymakers must choose the path that is most likely to have desired outcomes. The seeming simplicity of corridors of clarity should rest on a state-of-the-art understanding of the full web of causality in a complex social–ecological system and may therefore only emerge after careful study of the dynamics of such systems. This entails taking a holistic view rather than acquiring detailed knowledge of each part of a system.

In view of the fundamental difficulties of communicating the implications of the uncertainties associated with various actions, highlighting corridors of clarity may be a powerful way to visualize relevant scientific insight in complex environmental situations and help crystallize the will to act.

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