Introduction

This report examines the development and use of scenarios in global climate change applications. It considers scenarios of various types – including but not limited to emissions scenarios – and reviews how they have been developed, what uses they have served, what consistent challenges they have faced, what controversies they have raised, and how their development and use might be made more effective. The report is Synthesis & Assessment Product 2.1b of the US Climate Change Science Program. By synthesizing available literature and critically reviewing past experience, the report seeks to assist those who may be conducting, using, or commissioning scenarios related to global climate change.

Scenarios are used to support planning and decision-making when issues have deep or poorly characterized uncertainty and high stakes, often accompanied by long time horizons. These conditions apply to the major decisions about how to respond to global climate change. As scientific research advances our knowledge of the climate's present state and trends, its patterns of variability, and its responses to external forcings, we are gaining an increasingly clear view of risks that may be realized late this century or beyond. These future risks are linked to near-term socio-economic trends and decisions in both public and private sectors. Some near-term decisions – such as investment in long-lived capital equipment, new resources, or new technologies in the energy sector – can influence long-term trends in the emissions contributing to climate change. Other near-term decisions – such as investment in water resources infrastructure or coastal development – can influence how adaptable and how vulnerable future society will be to the impacts of climate change.

Although such decisions are being made now, making them responsibly requires considering their potential consequences over the longer term, including associated uncertainties. This requires thinking about the future conditions that will shape their consequences, not just next month or next year but 10, 30, 50, or 100 years in the future – longer periods than the horizon of conventional methods of planning or analysis.[2] Attempting to describe potential future conditions over this long time horizon presents a seeming paradox. On the one hand, conditions this far in the future, and the factors and actors that may influence them, are deeply uncertain.[3] On the other hand, we have a great deal of knowledge that can help make informed assumptions about future conditions, even over such long horizons. This includes well-established scientific knowledge about physical, chemical, and biological processes; more weakly, relatively well-established causal mechanisms in economics, sociology, and politics; and more weakly still, certain seemingly robust empirical patterns of historical change in population, economics, and technology. All of these give some guidance to support judgments about future conditions that are more or less likely, virtually certain, or virtually impossible. In some ways we might be highly confident that the future will resemble the present, e.g., in the radiative properties of atmospheric trace gases. In others, we might judge it likely that future conditions will lie within some envelope extrapolated from present and past trends, e.g., in projecting rates of change in fertility, mortality, or labor productivity. Still other areas, such as the development and social consequences of major technological advances, or large-scale political events such as wars, political realignments, or epidemics, may hold more fundamental uncertainties. In some cases, such uncertainties may be adequately represented as wider distributions of recognized uncertain quantities. In others, they may represent events whose character or even possibility we have not yet imagined.

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Despite pervasive uncertainties, people must make near-term decisions related to climate change that have long-term consequences, including potential irreversibilities. Scenarios are tools to help inform these decisions by gathering and organizing relevant knowledge, organizing associated uncertainties, and structuring and disciplining associated speculation. This report assesses experience to date in developing and using scenarios for global climate change.

Early climate-change debates mainly concerned scientific questions such as whether and how the climate is changing, how much change is caused by human activities, and how sensitive the climate system is. Scenarios did not figure prominently in these debates. But as advancing climate science has increasingly shifted the debate from confirming and describing the climate-change problem toward deciding what to do about it, the need for long-term decision-support tools like scenarios has increased, as have the scrutiny and criticism these have attracted.[4] In a contentious public-policy area like climate change, controversy over scenarios is to be expected: scenarios are a method to structure and communicate the most important uncertainties, and conflicting judgments about uncertainties are a major source of disagreements over what to do. Consequently, we expect the trend of scenarios' increasing prominence and contentiousness to continue – particularly for emissions scenarios, since these are the relevant metric of human environmental burden and the point of most contested proposed intervention.

[2] Morgan et al. 1998.

[3] Lempert et al. 2006.

[4] See, e.g., Lomborg 2001; Michaels 2003b; Castles and Henderson 2003a, b; UK House of Lords 2005.

In this report, we try to cast some light on current and coming debates over climate-change scenarios. These debates presently exhibit basic confusion about the definition, purposes, and potential uses of scenarios. We aim to provide clarification and practical advice to two related audiences: those conducting assessments or analyses that develop or use scenarios; and those commissioning, using, and interpreting such assessments or analyses. For the first group, we seek to provide an organized summary of relevant experience in similar efforts, discussion and clarification of key choices and challenges, and – to the extent present knowledge allows – practical guidance about pitfalls, challenges, and opportunities in particular approaches. For the second group, we seek to provide guidance on what to ask for, how and how much to participate in its production, how to interpret the results, and what questions to ask.

Because the charge of this report is unlike those of other Synthesis and Assessment products, the approach we have taken to producing it is necessarily different as well. We were tasked with reviewing, interpreting, and evaluating experience with scenario methods in global climate change applications. This is not a narrowly focused question, and there is not a well-developed scientific literature on which we can draw for answers. While we have reviewed the existing literature on scenarios, most of it concerns scenarios in other decision domains than global climate change. In addition, we have examined several major scenario exercises in global-change applications. In this, we have drawn on published materials, both from the exercises themselves and from commentary and criticism, as well as documentary materials and records, interviews with participants and users, and the experience and judgments of team members.

Our review of this experience has not been entirely independent, since members of this writing team were involved as participants, reviewers, and critics in two of the scenario exercises we review, the IPCC SRES process and the US National Assessment. While we have drawn on the experience of these team members, we have attempted to limit the risk of idiosyncratic interpretations and bias by drawing on other sources as well and by engaging all team members in developing our summary and discussions of these exercises. Moreover, our purpose is not to either attack or defend these past exercises, but to seek to understand the decisions made in conducting them, the factors that influenced them, and the constraints under which they operated, in order to assess their experience, identify successes and pitfalls, and to the extent possible, provide guidance to advance scenario methods for climate change and other similar environmental issues. Because the experience we review does not provide a sufficiently large or random sample to support strong scientific inference, the diagnoses, interpretations, and recommendations we present rely on our collective judgment. We have endeavored to follow our own advice, and be as transparent as possible about the foundation and reasoning underlying our conclusions and recommendations.

The report is organized as follows. Drawing on the broader literature on scenarios – most of which concerns domains other than climate change – Section 1 introduces scenarios, sharpens their definition, and outlines a few major dimensions of variation and decisions that must be made in developing a scenario exercise. Section 2 focuses specifically on scenarios for global climate change, and outlines the types of decisions that could use scenarios and the main types of scenarios that have been developed for this issue. Section 3 reviews four major expe-

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riences in developing and using global-change scenarios. Section 4 discusses several issues that have posed key challenges in climate-change scenarios and that are likely to require particular attention in designing new scenario exercises. In addition to drawing on Section 3, this discussion also makes use of briefer discussions of eight other examples of global-change scenarios that illustrate particular issues or challenges; these examples are presented as short boxes in Section 4. Section 5 provides our conclusions and recommendations for future development and use of global climate-change scenarios.