# A Review of the Draft 2013 National Climate Assessment

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Panel to Review the National Climate Assessment

Board on Atmospheric Studies and Climate
Division of Earth and Life Studies

Board on Environmental Change and Society
Division of Behavioral and Social Sciences and Education

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

**Stephen Carpenter,** University of Wisconsin, Madison
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**Claudia Tebaldi,** Climate Central, Princeton, NJ
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Although the reviewers listed above have provided constructive comments and suggestions, they were not asked to endorse the views of the committee, nor did they see the final draft of the report before its release. The review of this report was overseen by Lynn R. Goldman, George Washington University, and George M. Hornberger, Vanderbilt University, appointed by the NRC Report Review Committee, who were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring panel and the institution.

We also thank the members of the "parent" Boards to this panel (the Board on Atmospheric Sciences and Climate and the Board on Environmental Change and Society) who provided input to this activity.

# Contents

# Executive Summary

As mandated by the Global Change Research Act (GCRA), the U.S. Global Change Research Program is currently producing a "National Climate Assessment" (NCA). The NCA is a report to inform the President, the Congress, and the American people about the current state of scientific knowledge regarding climate change effects on U.S. regions and key sectors, now and in the coming decades. This document contains an evaluation of the draft NCA report, presented through consensus responses to the Panel's Task Statement questions (listed in the Introduction), and through a large collection of individual Panel member comments and suggestions for specific chapters, statements, figures, etc. (see Appendix A). While focusing primarily on practical suggestions for immediately improving the current draft, the Panel also raises some broader considerations about fundamental approaches used in certain parts of the NCA report, and about the scope of USGCRP research that underlies the NCA findings. Some suggestions can be viewed as longer-term advice for future versions of NCA work.

This NCA has been a significantly more ambitious effort than previous assessments, in terms of the scope of topics addressed and the breadth of public engagement processes involved. Some of the important new areas include the use of "traceable accounts," the articulation of needs for future research and a vision for an ongoing assessment process, the outreach efforts to help various stakeholders define their climate-related information needs, and the initial (though incomplete) effort to assess the current state of climate change response activities around the nation. Given the current state of the science and the scope of resources available, we believe the NCA did a reasonable job of fulfilling its charge overall. Although more needs to be done to fully meet the nation's needs for information and guidance, such needs cannot be met without an expanded research effort on the part of the USGCRP and future assessments.

The Panel suggests that the NCA report would be improved by addressing the numerous specific problems and concerns raised in the Appendix A comments and the more cross-cutting issues raised in the consensus answers to the Task Statement questions—which include, for instance, the need to:

- provide a clear overarching framework for the report that (i) helps readers understand climate change as part of a complex system with interacting physical, biological, and human social/economic dimensions, and (ii) offers practical guidance on using iterative risk management strategies to make decisions in the face of large uncertainties;

- clearly acknowledge how climate change affects and is affected by other types of major global environmental changes and other societal developments;
- offer an explicit discussion about the uncertainties associated with the regional model projections presented in the NCA draft;
- take full advantage of the e-book format planned for this document through strategic use of hyperlinks among different parts of the report and other innovative approaches that help guide the experience of the NCA's diverse audiences.

As the nation continues to engage with the threats, opportunities, and surprises of climate change in its many manifestations, the 2013 NCA should prove to be a valuable resource, as a summary of the state of knowledge about climate change and its implications for the American people.

# Introduction

The Global Change Research Act (GCRA) mandates that a National Climate Assessment (NCA) be produced every four years, as a report to the President and the Congress. Carried out under the auspices of the U.S. Global Change Research Program (USGCRP), the NCA is an important effort to periodically inform the American people about the effects of climate change across U.S. regions and key sectors, to project major trends for the subsequent 25 to 100 years, to evaluate the current state of mitigation and adaptation activities, and to highlight key gaps in our knowledge. NCA reports were produced in 2000 and 2009; and a 2013 report is now in development. This document contains an evaluation of the draft 2013 report.

The National Research Council (NRC) has a long history of convening expert groups to provide independent advice and review for the USGCRP and its main program elements, including the NCA. A new committee to advise the USGCRP was convened in mid-2011, and from that committee a subsidiary panel was created with the specific charge of reviewing the draft 2013 NCA report. This panel is composed largely of members of the parent committee, but augmented in areas of key relevance to the NCA.

This Panel to Review the National Climate Assessment was specifically asked to consider the following questions:

1. Does the report meet the requirements of Section 106 of the GCRA[1]?
2. Is the report responsive to the nation's needs for information on climate variability and change in a global change context, their potential implications, and the potential effects of different response options?
3. Are the key messages and graphics clear and appropriate from a communications perspective?

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[1] SEC.106. SCIENTIFIC ASSESSMENT: *On a periodic basis (not less frequently than every 4 years), the Council, through the Committee, shall prepare and submit to the President and the Congress an assessment which*

- *integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings;*
- *analyzes the effects of global change on the natural environment, agriculture, energy production and use, land and water resources, transportation, human health and welfare, human social systems, and biological diversity; and*
- *analyzes current trends in global change, both human- induced and natural, and projects major trends for the subsequent 25 to 100 years.*

4. Are there any critical content areas missing from the report?
5. Are the findings documented in a consistent, transparent and credible way?
6. Does the research needs chapter address the most important gaps in existing knowledge?
7. Does the sustained assessment chapter provide an appropriate path to support the development of a sustained assessment process within USGCRP that engages regional and sectoral communities of interest?

The Panel conducted this evaluation during the same 12-week period that the draft NCA report was undergoing public review. To carry out this work, the Panel members held one in-person meeting and had a variety of additional exchanges via email, webinar, and phone—to share and debate their views on the NCA report and develop consensus answers to the Task Statement questions. Given the very short time allowed for this review, the considerable length of the draft report, and the great breadth of topics covered, it was not feasible for each Panel member to carefully review the entire document. Rather, the Panel relied on the expertise of just a few members to provide the primary review of specific chapters. The Panel then considered the chapter-specific comments collectively, to help develop their evaluation of the report as a whole.

This document provides the Panel's consensus responses to the Task Statement questions listed above. With a report as large and diverse as this one, the answers to these questions were naturally a complex mix of positive reactions for some parts of the report and less positive reactions for other parts. Appendix A of this document presents a large collection of comments and suggestions focused on specific chapters, statements, figures, etc.. Because the Panel did not have time to collectively discuss each of these individual comments, they are not presented as true consensus findings or recommendations.

The Panel focused primarily on offering practical suggestions that could feasibly be addressed in the short time that the NCA authors will have to revise the document. But this inevitably spills over into more broad-based considerations about the fundamental approaches used in certain parts of the draft report, about the way the NCA enterprise is framed and designed, and about the nature and scope of USGCRP research that underlies the NCA findings. Thus some suggestions will likely need to be viewed as longer-term advice that may be applied in future NCA assessments.

We wish to acknowledge the tremendous amount of work that has gone into the preparation of the NCA report, and likewise to acknowledge that this NCA has been a significantly more ambitious effort than previous National Climate Assessments, in terms of the scope of topics addressed and the breadth of outreach/engagement processes involved. We offer our congratulations to the NCA leadership and authoring teams for their accomplishments thus far, and our sincere hope that the suggestions offered herein will aid their efforts.

# Answers to Task Statement Questions

**QUESTION 1: Does the report meet the requirements of Section 106 of the GCRA?**

We find that the NCA draft report does generally meet the requirements of the legislative mandate in terms of timeliness, in summarizing key findings from USGCRP research, in analyzing effects on the various sectors/systems specified in the GCRA, and in projecting important trends for the coming decades. In addition, the draft report has gone beyond the explicit GCRA mandate in a few ways, which we find to be worthwhile and constructive additions to the report. For instance:

- it identifies research needs and knowledge gaps;
- it provides a vision for an ongoing assessment process;
- it examines mitigation and adaptation responses.

As defined in the NRC report *Analysis of Global Change Assessments* (2007, p.5), "assessments are collective, deliberative processes by which experts review, analyze, and synthesize scientific knowledge in response to users' information needs relevant to key questions, uncertainties, or decisions." This definition points to some key constraints affecting how the NCA must approach its work:

- The NCA must build on existing science, primarily research supported by the USGCRP. To the extent that the available body of research does not adequately meet users' information needs, the NCA in turn is not fully able to meet those information needs. By identifying important gaps in knowledge and data, this NCA can help develop the research goals for improving future assessments.

- The NCA must build on users' information needs, yet some decision makers are only just beginning to become aware of the implications of climate change for their sector or region, and have not yet fully identified their climate-related information needs. The NCA's broad participatory process is, in large measure, an attempt to help users identify those needs. Offering a vision for an ongoing assessment process that can link scientific analysis with decision maker deliberation is a useful advance, because an ongoing process is essential for the exchange of information, both to inform decision makers and to inform the scientific community about the needs of decision makers.

- The NCA must consider mitigation and adaption activities as essential to an assessment of this scope. However, this points to an ambiguity in the GCRA mandate, which is not fully clarified in the NCA draft. The assessment definition above, with its focus on scientific knowledge, can comfortably encompass information about climate change, its impacts, and the social vulnerabilities implied in those impacts. But when discussing mitigation and adaptation response options, there is a gray area between describing the current state of scientific knowledge and offering guidance on what actions to take. Some would argue that the effort should be limited to only assessing knowledge (including knowledge about the current status and outcomes of mitigation and adaptation efforts), while others would argue that actual guidance on future action is a necessary part of being responsive to the nation's information needs. It would be helpful for the intent and the goals of the NCA to be clarified, regarding this balance between assessing knowledge and providing guidance.

Because the NCA must examine climate change impacts on such a diverse array of regions and sectors, as well as a diverse array of response efforts, this leads to a very broad mandate for the assessment—much broader than that of many other high-profile assessments (e.g., the UNEP Stratospheric Ozone Assessment). The breadth of what must be done and the lack of clearly articulated needs by some decision makers create a very challenging task for the NCA authors. Given this, inevitably some parts of the NCA draft report are stronger than others. This review does raise a variety of concerns about, and suggestions for improving, specific parts of the draft NCA report. But these detailed suggestions should not cloud the Panel's overall assessment—that the NCA draft is a useful synthesis of a large body of knowledge, much of which did not exist when the Global Change Research Act was enacted. As the nation continues to engage with the threats, opportunities, and surprises of climate change in its many manifestations, the 2013 NCA provides a valuable summary of the state of knowledge about climate change and its implications for the American people.

Below are three particular areas where the Panel feels more attention is needed in order for the report to fully meet the GCRA mandate.

**I** A part of the GCRA mandate is to "integrate" the USGCRP's research findings. The Panel suggests that this integrative effort would be enhanced if the report provided a clear overarching framework that helps people think about the complex problem of climate change within the broader context of global change. Although the current draft offers some framing concepts in later chapters of the report, this framing needs to be presented clearly from the outset to give the reader much-needed context for the sector- and region-specific information that follows. These framing concepts likewise need to be reinforced throughout the document, in part because many readers may only view a few select chapters. Building upon the ideas that are already touched upon in the NCA draft, this framing would include at least two important dimensions:

***Climate change as part of a complex, coupled human/natural system.*** While this NCA draft has made progress in looking at linkages among different biophysical systems, the overall framing also needs to convey how human systems are intrinsically linked with the biophysical systems. Climate change is not a phenomenon happening in isolation, but rather it is embedded in a complex set of interacting global changes. The influence of human activities has grown over time to become a dominant driver of global environmental change, such that it is no longer possible to understand the earth's ecological and physical systems without a concomitant understanding of how human activities influence these systems. Many NCA authors are likely familiar with the growing body of research that demonstrates the nature of these coupled human/natural systems.

***Dealing with uncertainty through iterative risk management***. A wide range of decisions made by societies (e.g., regarding the location of settlements, planting of crops, planning for epidemics, management of fisheries) rely on an assumption that climate is stable—that any given place will have the same kinds of weather fluctuations in the future that prevailed in the past. But climate change undermines this premise of a "stationary" system by changing the future probabilities of weather norms and extremes. Even with continued advances in climate science, significant uncertainties about these changes will remain. As discussed in the NRC's *America's Climate Choices* reports, the soundest approach for dealing with this uncertain future is iterative risk management. This involves moving away from a traditional "predict-then-act" paradigm, in which one identifies an optimal outcome and then takes the action most likely to realize that outcome, towards an "explore-then-test" paradigm, in which one considers multiple plausible outcomes and then pursues/tests response strategies that are adaptable and likely to prove resilient across a broad range of outcomes. Risk management decisions made by government leaders, businesses, and individuals are guided by many factors other than science (e.g., personal values, economic considerations, social norms); thus while scientific knowledge is critical, it is just one of many factors that will inform and help us build a resilient society. Advancing these risk management strategies thus requires sustained dialog between scientists and the broader community—a goal that the NCA process itself can (and has already begun to) help advance.

The NCA authors have several options for where these framing ideas can be raised within the draft. The ideas might be presented as a stand-alone opening chapter; and they might be reinforced in the short synthesis pieces presented at the beginning of the sectoral chapters, regional chapters, and "response strategies" chapters. The Panel's view is that the introductory "Letter to the American People" offers the best opportunity to initially raise these framing ideas. More suggestions for how "the Letter" can be best used are given in the response to Question 3.

**II** As the title implies, the National Climate Assessment is focused primarily on climate change, whereas the GCRA refers to an assessment of *global* change more broadly[2]. The NCA draft needs to clearly define how it is interpreting the concept of global change used by the GCRA. This distinction between climate and global change was discussed at length in the recent NRC review of the USGCRP Strategic Plan, and many of the same concerns raised in that review apply here.

It is appropriate to have climate change be the central focus of the assessment effort; and it is understandable that practical constraints (in time and resources available, in document length, etc.) make this focus necessary to some degree. Further, the overwhelming majority of work funded by the USGCRP has been on climate change, and that work must be the basis of the assessment. We are concerned, however, that the current draft sometimes portrays climate change as an isolated problem, without sufficient consideration of other important global environmental changes and societal developments (both positive and negative) that will interact with climate change, affecting both our vulnerability and our strategies for responding.

In most settings, decision makers have to deal with a broad set of interacting issues and priorities, not just climate change in isolation. An overly narrow focus can encourage one-sided solutions, for instance by giving an impression that reducing greenhouse gas emissions alone will solve all of the major environmental concerns discussed in this report. Of course it is not feasible for the assessment to provide detailed analysis of all the relevant interacting global change forces, but the report could note, with greater frequency and clarity, that climate change will unfold in a broader and very complex context. This would help the NCA report to ultimately be more responsive to the nation's information needs.

There are a number of ways that the current NCA draft could be feasibly augmented to give readers a better understanding of this broader framework. For instance, Chapter 2 could have an additional section that describes some of the other global changes that interact with climate change. Perhaps the chapter title could even be revised from *"Our Changing Climate"* to something such as *"A Changing Climate in a Changing World."* The report could also reinforce this idea within each of the sectoral chapters by pointing to examples of how climate change impacts and response needs will interact with other key developments and priorities in that sector. This broader perspective may point to some "win-win" actions that help address multiple priorities simultaneously.

**III** The GCRA mandate to discuss scientific uncertainties appears to be adequately addressed in the NCA draft on some fronts. However, the Panel is concerned about the lack of explicit discussion about the uncertainties associated with the regional model projections presented in the NCA draft. The report presents model projections for changes in key climate variables (temperature, precipitation, etc.) at regional spatial scales and decadal timescales. At these scales, variations of results among the models for any given scenario can be as large as or larger than (for some

[2] The definition of "global change" given in the GCRA itself and used in the recent USGCRP Strategic Plan is: "changes in the global environment (including alterations in climate, land productivity, oceans, or other water resources, atmospheric composition and/or chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life."

variables) the variation of results between scenarios (see comment #25 for further discussion). Decision makers need a clear understanding of these uncertainties in order to fairly evaluate the actual utility of using these projections as a basis for planning decisions. The NCA report can help provide that understanding.

As discussed further in the Appendix A comments, some possible strategies for improving the presentation of the model projections include evaluating how the statistics of critical processes such as extreme precipitation (e.g., frequency, persistence, intensity) might change under climate change scenarios and presenting the statistics of the projections themselves, as well as the statistics of the particular process being modeled. The assessment would also benefit from employing more rigorous methods for using historical observational data to calibrate and validate the regional-scale models (see comment #23 for details).

**QUESTION 2: Is the report responsive to the nation's needs for information on climate variability and change in a global change context, their potential implications, and the potential effects of different response options?**

This is a difficult question to answer because (a) the nation comprises a diverse array of communities and stakeholders with widely varying needs, (b) the Panel cannot define *a priori* what the nation's needs actually are for all of these broad realms, and (c) some decision makers are only beginning to understand climate change as a serious risk and thus be able to articulate information needs to which the NCA could respond. Given the current state of the science and the scope of time and resources available, we believe this draft report does a reasonable job of fulfilling its charge. The Panel suggests, however, that the information provided in the current draft, with its heavy focus on impacts, is necessary but not sufficient as a foundation to fully meet the nation's needs for information and guidance. As discussed later, many such needs cannot be met without expanded research efforts on the part of the USGCRP agencies or others.

**With regard to information on climate variability and change:** The report does offer substantial information about current trends and future projections of key climate variables. For some purposes, decision makers would like to use projections of greater certainty and finer spatial resolution than are currently possible, which thus inherently limits the degree to which the NCA can be responsive. But for many purposes, regional-scale information on climate trends (as provided in the draft) can be a valuable starting point for helping decision makers understand potential risks and for understanding why it is necessary to move away from the "stationary climate" assumptions that implicitly inform so many decisions today

**With regard to information on potential implications**: The report offers a wealth of information about the potential impacts of climate change on specific regions and for important social and economic sectors, and in general this is one of the strongest aspects of the report. However, the

Panel does have numerous suggestions for ways in which specific elements of this information could be augmented or changed to be more useful to readers (discussed further in the Question 4 response and in the Appendix A comments). Some general concerns that arose include the following:

- The report would be more balanced if it explicitly acknowledged some of the possible beneficial impacts that may result from climate change (along with the wide array of negative impacts that are identified), and acknowledged that some predicted adverse impacts might be lessened through other developments that are expected in the coming decades (for instance, the idea that historical trends of rising agricultural productivity are expected to continue, and adverse climate change impacts may only slow this increase).
- In several chapters, the discussion of current and future impacts comes across as a litany of disconnected facts with no sense of prioritization of major versus minor concerns. While assigning relative importance to different impacts is largely a subjective exercise, greater use of tabular presentations and approximate rank ordering of scale of impacts would be helpful.
- As discussed earlier, the draft tends to look at the regional and sectoral climate change impacts in isolation from other processes of change; and as a result, climate change is sometimes portrayed as a key driving force behind trends that are in fact driven by numerous causal factors. For example, the decline of some tribal and indigenous cultures has been ongoing for many decades and may be accelerated by (but not primarily driven by) climate change.

**With regard to information on the effects of response options:** This is the first NCA report to explicitly evaluate the state of the nation's response efforts, and the Panel acknowledges that this sort of evaluation is a challenging undertaking and an important positive step. But the evaluation efforts fall short in some important ways, discussed below in the context of the three "response options" chapters.

*Chapter 26 (Decision Support):* While this chapter contains a useful summary of the basic concepts and frameworks for decision support, there were also several concerns about the chapter, summarized below and with further details in the Appendix A comments.

- This chapter suffers from an overly academic orientation, as demonstrated in part by the "insider" jargon used throughout the chapter. In addition, there is a heavy focus on idealized models of decision-making, and an apparent view that knowledge production is the final goal of decision support efforts. There is little discussion of the real-world situations in which valuable knowledge and support tools are often not used by the intended audiences—a reality that is especially relevant for an issue as complex and politicized as climate change. When the chapter does offer real life examples, it engages and informs; it would thus be helpful to see more of these examples of current climate-related decision support efforts, coupled with practical guidance for advancing such efforts.

- The chapter makes several claims regarding the effectiveness of decision-support tools, but does not support these claims with any evaluation of existing climate-related decision support efforts. For instance, while the draft chapter discusses the value of participatory processes to link scientists and stakeholders, there is no discussion of existing efforts to do this sort of work, such as the Regional Integrated Science and Assessments (RISAs). Because the chapter is so heavily focused on the *process* of decision support, it gives little sense of the *outcomes* that can ultimately be achieved (or that have been achieved thus far) through successful decision support efforts. It would be useful to explore what has worked and not worked in these real-world examples. (See comment #584 for references on the RISAs and related activities).
- Unless the chapter itself can be substantially re-drafted, it might need to be re-titled to better reflect the actual content. For instance, it could be called "Informing Decisions" or "Decision Support Tools and Processes,," or include a subheading such as "Models for bridging the gap between scientific understanding and decision making."

*Chapter 27 (Mitigation):* This chapter does go farther than the adaptation or decision support chapters in terms of actually assessing the adequacy of current response efforts (concluding that current mitigation efforts are "not close to sufficient"). But much of the relevant information about what particular mitigation options might do to actually bend the curve of greenhouse gas emissions nationally or in particular sectors is scattered among other chapters of the report (e.g., chapters 3, 10, 13, 16). It would be helpful to see better linkages among these different chapters, perhaps using hyperlinks to avoid repetition of text. The Panel members identified some specific issues that they feel merit more in-depth consideration within this chapter. These include, for instance,

- greater acknowledgement (and at least one key message?) about the international context—i.e., how U.S. emission reductions fit into the larger picture of needed global emission reductions;
- an acknowledgment that not only pricing and technology changes affect emissions, but also population growth and shifting demographics, institutional arrangements, consumption patterns, and culture (see comment #595);
- additional consideration of the opportunities that exist to close the "energy efficiency gap" as part of the nation's mitigation strategy (see comment #597);
- consideration of a greater range of possible emission scenarios (see comment #601);
- discussion of the possible distributional impacts of mitigation policies on different parts of the population (see comment #602); and
- a more complete understanding of the state of the science related to the major energy sources discussed in this chapter, including additional discussion of how the recent dramatic expansion of natural gas production affects emission trajectories.

*Chapter 28 (Adaptation):* This chapter is based largely on presenting lists of adaptation planning efforts underway by various actors across the country, which may serve as useful inspiration for some readers. But these unstructured lists of planning activities do not offer the readers much of a systematic understanding of what is needed to advance effective adaptation efforts, nor a vision for how research could help develop the knowledge base to inform coherent adaption policy. The goal of adaptation is to handle change resiliently and to cope with some unavoidable or unpredictable conditions. As the NRC *America's Climate Choices* reports pointed out, decision-making in this context requires a risk management strategy. It would be helpful for the chapter to directly describe how iterative risk management can be used to aid adaptation efforts and to suggest what kinds of data (e.g., on vulnerability) most need to be collected to support such efforts. Some related suggestions and areas of concern highlighted by the Panel include the following:

- This Chapter did not try to assess how much past adaptation actions have reduced, and future ones might reduce, vulnerability to climate-related events. This omission is understandable, given the lack of necessary information base and robust indicators needed to support such an assessment, but at a minimum this could be an important knowledge gap.
- In addition to all of the examples of adaptation *planning* efforts, it would be helpful to see some examples of actual *activities underway* to build adaptive capacity and resilience (recognizing that in some cases, planning itself can contribute to increased resilience—e.g., having an emergency plan in place may be sufficient, as long as the plan is actually enacted when needed).
- The discussion needs a more complete and realistic examination of the barriers that can prevent further progress in adaptation (see comments #635-637 for details).
- The chapter needs a fuller consideration of how adaptation planning connects to disaster management planning (see comments #640, 641 for details).
- There is a heavy focus on steps to be taken by large governmental or private sector institutions, but little consideration of how to downscale these efforts and engage small businesses, households, etc.
- Some of the most useful discussion and examples relating to adaptation are found in the sector-specific chapters (e.g., on agriculture). It would be good to at least refer the reader to those discussions through the use of hyperlinks or some other means.

An issue that reaches across the different response chapters in the NCA report (decision support, mitigation, adaptation) is the need to draw upon fields such as anthropology, decision sciences, and psychology to gain important insights on the cognitive and social processes that affect how people may respond to the expectation of climate change and its impacts. Such insights are needed, for instance, to assess the uncertainties in human responses to climate change and to effectively pursue iterative risk management strategies. The IPCC Fifth Assessment report, currently under development, is taking some important steps towards applying this sort of perspective.

**QUESTION 3: Are the key messages and graphics clear and appropriate from a communications perspective?**

The draft contains numerous figures that are likely to be clear and compelling to readers, but the Panel does also have numerous suggestions for improving the clarity of specific graphs and figures. Some of the more general concerns include:

- There are many instances where the figures are not referenced in the text. It is left to the readers to determine how the figure relates to the discussion.
- The time periods illustrated by the different figures vary a great deal, with little apparent rationale for these differences. This may leave the NCA vulnerable to accusation of cherry-picking data to prove certain points. The report needs a statement affirming that the time periods used for all figures were based on the reliable data available in each case. To the extent possible, it would be best to use just a few standard time scales, even if this means that for some figures, the time scale begins somewhat before data is available. And at a minimum, all figures need to have their time frame clearly indicated in the figure title.
- A few of the images and figures seem misleading. For instance, the "shrinking clam" photo (Figure 24.3) is at odds with the report's message about having "low confidence" in predictions of ecosystem change. The tick distribution map (Figure 9.8) suggests a significant spread of Lyme disease risk, whereas the reference that figure is based on actually concludes the opposite.

The report's use of Key Messages is a good way to distill the massive collection of information into a digestible set of ideas, which many readers will surely appreciate. But the Panel members offer a number of suggestions for strengthening specific Key Messages, as discussed in the Appendix A comments. General concerns are that some of the Key Messages are so vague or hedged in nature that they lack real meaning (e.g., see comments #7, 589); and that some Key Messages seem inconsistent in tone with or unsubstantiated by the underlying chapter text (e.g., see comments #19, 454, 529, 531, 552, 607). Some other communication-related concerns about the draft report include the following:

- Parts of the report are written at a level of discussion that may be suitable for certain specialist audiences (such as scientific researchers and federal agency managers) but inaccessible to the average lay reader. The use of technical and scientific jargon and undefined acronyms needs to be minimized, if not entirely removed, throughout the report. A few terms are defined at various places in the report, but we urge consideration of a more comprehensive glossary, as well as an acronym list (both of which could be hyperlinked from the main text).
- Some chapters read like a complex collection of facts, with no sense of a narrative or roadmap to help the reader to make sense of all the information or follow the train of

evidence to the conclusions. We suggest working with the science communication specialists on the NCA team to improve the report's readability in this regard.

- Looking across the NCA report chapters, one finds inconsistencies in terms of verb tenses and imperial versus metric units. There is also inconsistent usage of some key terms (e.g., vulnerability, impacts, risks). A thorough editorial scrubbing of the report is needed to address such problems.
- There are unavoidable repetitions of content across the report, e.g., between regional and sectoral chapters, and between both of these and the last several cross-cutting chapters. This may be necessary because many readers will only look at specific chapters of interest to them. But the authors should check for repetitious areas and make sure what is said in the multiple places is consistent.

Some of these concerns could be partially addressed by taking full advantage of the e-book format planned for the final publication. The NCA can effectively exploit this electronic platform by using hyperlinks among multiple instances of similar or related concepts used in different places throughout the report. The jargon problems can be partially addressed by using hyperlinks between the text and a glossary and acronym list. One could even exploit the non-linear nature of this platform by doing away with chapter numbers and presenting a "network" rather than a line of chapters. The non-linear structure also opens up new opportunities to help guide the experience of the diverse audiences that will be reading this complex assessment. In thinking over these communication challenges, the Panel thought of a fanciful (though hopefully helpful) analogy, described below.

**A Museum Analogy**

Imagine the NCA reader as a first-time visitor to a large museum containing a wealth of knowledge. Some of the information presented in the museum will be of immediate passing interest; some may engage the visitor more deeply and lead to significant learning; and some will be the province of specialists (though available to a curious and persistent visitor).

Down one corridor lies the American Wing, where the landscapes of North America may be found, each in a separate glass-walled diorama. Here a citizen can see what her or his homeland might look like as the climate changes over the coming decades. Another corridor leads to the Natural History and Commerce Collection, where large sectors of the economy (cities, farming, energy) and of the environment (water, land) can be examined. Much of this may draw the interest of specific stakeholders more than the casual visitors. For the civic-minded, there is the Hall of Public Choice, where the questions of mitigation, adaptation, research, and decision support are presented, in a way that stands back from political controversy while informing public debate. Overall, visitors will see a portrait of a changing world, at once familiar and strange.

Given the great breadth and complexity of the information contained in this museum, there is a need for an "entry hall" of sorts, which helps to introduce visitors to the museum's many

sights, and to efficiently direct them to the galleries that offer the information of greatest interest. In the current NCA draft, the *Letter to the American People* serves as this entry hall. We suggest this purpose be pursued more explicitly, with the Letter recast as a "guide to the reader" aimed at helping readers navigate the document, and providing an initial sense of the overarching frameworks that shape the document as a whole. The Letter could be posted on the first page readers encounter when they come to the website containing the report; it could then point readers with different interests to chapters containing the most relevant content. By providing readers with links to specific content, the entry page could help readers negotiate the vast body of material contained in the report.

**QUESTION 4: Are there any critical content areas missing from the report?**

We approach this question with an acknowledgement that the NCA draft already covers a huge array of topics, and that there are always more topics one could add to an assessment as broad this one. And it is probably fair to say that everyone would like to keep the report from expanding beyond its already considerable length. We have thus tried to refrain from suggesting a long list of all possible topics that could potentially be appropriate to add to the report. But there are some topics that do seem to be truly "missing," in that their absence undermines the usefulness of the assessment. The comments in Appendix A point to an array of specific issues that the NCA authors may wish to consider. Some of these omissions were noted in the earlier discussion about the response efforts (decision support, mitigation, adaptation) chapters. Here we highlight some additional examples:

- As noted earlier, it would be helpful to see more explicit discussion of the uncertainties that are inherent in the report's projections of future climatic changes (given that these uncertainties can be quite large for regional spatial scales and for decadal timescales).
- The Chapter 2 discussion of the climate system needs to look beyond just atmospheric system variables—for instance, to acknowledge the profound role of the oceans in the climate system and to highlight biological indicators of a changing climate.
- There is a clear need for more international context in the discussion of energy use and mitigation efforts, and in understanding U.S. vulnerabilities that stem from impacts occurring elsewhere in the world.
- Many readers will be looking for guidance on how climate change response efforts relate to other key priorities within particular sectors as well as for opportunities to advance adaptation and mitigation together with these other priorities.
- The urban cross-cut chapter lacks information about how urban areas contribute to emissions and can reduce emissions (especially considering the role of land use and transportation planning); about climate change impacts on cities (beyond just storm surge and sea level rise); and about the unique context of suburban and ex-urban environments. This chapter also lacks explicit consideration of the complex processes involved in applying

scientific and engineering knowledge to mitigation and adaptation in urban areas—i.e., through development of new standards, and in some cases new engineering codes, regulations, and enforcement, as well as the resulting requirements for reaching consensus among many stakeholders and for training for those who must implement new standards and regulations.

- The land-use discussion would be enhanced by consideration of the biophysical consequences (not only the biogeochemical consequences) of land use change, how land use changes affect vulnerability (e.g., flood risk), and how land use strategies can contribute to climate change mitigation.
- The discussion of human health issues needs to explore potential health threats caused by climate-related changes in infectious agents and to acknowledge the very limited understanding of the links between climate change, ecosystem change and disease vectors (discussion and example references in comment #324).

**QUESTION 5: Are the findings documented in a consistent, transparent and credible way?**

The traceable accounts analyses presented at the end chapter are a valuable innovation over past NCA reports and will prove especially valuable if the NCA's e-book format allows readers to link back directly to the primary references and datasets. In most places, the draft does a good job of documenting the support for key findings. But the Panel's Appendix A comments point to a number of places where the execution of the traceable accounts needs improvement (e.g., where the traceable accounts are not truly consistent with, or supportive of, the main chapter text).

Also it is worth noting that the confidence levels assigned in some traceable accounts seem to contrast with findings in recent and forthcoming reports of the Intergovernmental Panel on Climate Change (IPCC), particularly on the topic of attribution of extreme events. (See comments #17, 195, 727-9, 736-8 for details and references). The credibility of the NCA report would be enhanced if these apparent differences are explained.

**QUESTION 6: Does the research needs chapter address the most important gaps in existing knowledge?**

Chapter 29 ("Research Agenda for Climate Change Science") starts with the following disclaimer: "*Since the focus of this chapter is on research needs identified through the national assessment process, it is not intended to cover the full range of goals of the USGCRP. There are many additional USGCRP priorities for climate change and global change science more broadly that are not reflected here."* While this disclaimer helps clarify that the goal is not to articulate a "full" research agenda, the Chapter title implies otherwise and might need to be changed to avoid confusion. More generally, there seems to be lingering confusion about the actual purpose of the chapter. Is the goal

to identify research needs for supporting the assessment process itself? Or research needs for directly informing decision makers? Or something else? This goal should be articulated as clearly as possible, as it affects what one identifies as the most important gaps in existing knowledge.

The Appendix A comments point to a variety of research needs that the Panel feels merit more consideration by the NCA authors. This includes some biophysical research topics, for instance, topics related to climate change impacts on ocean and coastal resources, characterization of the future frequencies and intensities of extreme events, and climate-driven infectious disease threats. It also includes many knowledge gaps in the social sciences, for instance, the need for research related to identifying and quantifying vulnerabilities, public understanding of risk, methodologies for valuation and for evaluating tradeoffs, understanding what motivates people to change practices and behaviors, and understanding of uncertainties in emission scenarios coming from demographic and lifestyle changes. Social science research is included by inference in some of the topics mentioned in Ch.29, but given how the USGCRP agencies have long struggled to expand research in this realm, we suggest more explicitly pointing to the need for a serious commitment to address these critical knowledge gaps.

Other general suggestions related to this chapter:

- The NCA is a process embedded within the USGCRP, and the USGCRP Strategic Plan commits to use the assessment process to identify research needs to meet the priorities of decision makers and stakeholders. It would thus make sense for the NCA report to offer some discussion about how the research needs identified in the NCA draft relate to the research goals in the USGCRP Strategic Plan (e.g.: Which goals in the Plan does the NCA see as a priority? What goals might be missing from the Plan that are critical to support an ongoing assessment?). It would likewise be helpful to provide some analysis of whether the topics identified in the NCA draft are addressed in existing research programs of the USGCRP agencies. And finally it would be useful for the USGCRP implementation process to explicitly draw upon the NCA in setting research priorities.
- It would be helpful to see some prioritization among the many topics that are listed. Setting research priorities is always a difficult endeavor, but at least within key realms (e.g. adaptation, vulnerability, resilience) it seems the NCA authors would be as well poised as anyone to say what is *most* needed in order to strengthen the assessment process in the future.
- Some NCA chapters already conclude with listing research needs (e.g., Ch.27). It might be helpful to do this more consistently across the report, with each chapter concluding with a list of (what the authors see as) glaring knowledge or information gaps that most need to be filled in order to assess that chapter topic more robustly and completely in future assessment reports. If this was indeed the approach used to compile the summary list in Ch.29, it does not come across very clearly.

**QUESTION 7: Does the sustained assessment chapter provide an appropriate path to support the development of a sustained assessment process within USGCRP that engages regional and sectoral communities of interest?**

Chapter 30 presents a detailed vision for a sustained process, argues for why the envisioned process would be desirable, and identifies the key elements of an ongoing effort (e.g., data sources, information management systems, an indicator system, research and observations, assessment reports, capacity building, identification of knowledge gaps and uncertainties). This chapter does not offer any details on how to actually implement the articulated vision, but the Panel was informed that the NCA authors did not actually attempt to present any such implementation plans, and that a separate report on that subject is now being produced by the NCA Development and Advisory Committee (NCADAC). While the Panel thus cannot comment on whether an appropriate path forward has been provided, we do offer a few general thoughts about the vision that has been offered.

This chapter describes an ambitious suite of activities that could enable effective use, through broad-based communication and outreach, of the USGCRP's research findings. But these activities do have costs, and it is important to consider how the assessment activities can draw upon existing federal agency data collection, research, and evaluation efforts. Precise budget estimates for a sustained assessment process may be difficult to determine at this point, but it would be helpful to at least see order-of-magnitude estimates for the incremental costs of the sustained assessment as envisioned and for the underlying full cost of the monitoring and analysis infrastructure needed for its support.

It would be helpful for this chapter to more clearly explain the rationale for *why* the nation should have a sustained assessment process (beyond just the fact that it is mandated by law), for instance, by discussing how these types of assessments can actually help stakeholders incorporate climate change information into important decisions and build much-needed trust between producers and users of climate information. Is it possible to provide some evidence for the chapter's claims that "*this sustained assessment process will lead to better outcomes for the people of the United States by providing more relevant, comprehensible, and usable knowledge to guide decisions…*" (p.1048)? The chapter discussion has such a heavy focus on process alone that it is hard to actually see the "better outcomes" that will ultimately result from this process.

Chapter 30 suggests that the sustained assessment effort would aim to "evaluate the nation's vulnerabilities to climate variability and change and its capacity to respond." This implies a different type of assessment than what has been presented in the 2013 NCA draft report. Yet the chapter also suggests that the sustained assessment effort would largely continue the same basic approaches being used in the 2013 NCA report. We suggest that attaining the stated new aim requires exploring a broader range of possibilities for what a sustained assessment process might look like.

For instance, a more direct focus on the aim articulated above would entail assessing numerous factors beyond just climate science. It may include assessing the state of: technological

innovation (*are we making sufficient progress in advancing clean energy technologies?*), technical readiness (*do we have adequate observational capabilities*?), human resource capacity (*are we training a new generation of scientists able to address broad interdisciplinary issues?*), public education and engagement efforts (*are we reaching the right audiences with opportunities for productive dialogue?*), and current and proposed policy options (*is a particular policy helping or hurting our vulnerability?).*

An assessment of this broader range of questions would, of course, require a broader foundation of research findings to draw upon, and thus it would be necessary to explore how this broader range of issues could be addressed, either within the scope of the USGCRP's research program or elsewhere. It might, for instance, require expanded involvement of programmatic agencies not typically involved with the USGCRP (e.g., the Department of Housing and Urban Development, the General Services Administration, Navy Facilities Engineering Command, Federal Highway Administration) to conduct pilot projects for mitigation and adaptation.

The Panel offers a few suggestions about alternative ideas (and practical strategies) that could perhaps be considered in planning the ongoing assessment process:

- The NCA could launch an effort to identify leading innovators, who are taking important exploratory steps in mitigation or adaptation and thus learning by doing. This effort to identify leading and best practices might initially be done as a stand-alone NCADAC report, but would ideally take the form of an ongoing system for tracking leading practices. It would be valuable to the sustained assessment process to ask these leading innovators to identify specific information and decision support tools they feel they need in order to do a better job in the future.
- The considerable length of the current NCA draft points to a need to consider a series of topically-focused reports, which could be of a more readable length yet would allow greater depth on any given subject. We are not recommending the approach used for the *Synthesis and Assessment Product* (SAP) reports produced in 2006-2008, which were very focused on physical science topics and didn't use the transparent, user-driven model envisioned for the sustained assessment process. We consider the current assessment vision to be a considerable improvement over the SAP approach. But there are other possible models for a distributed assessment that could build upon the NCA's current move from a traditional hardcopy report to more adaptive, web-based publishing approaches (as discussed under question 3).
- Relating back to the concerns expressed earlier about climate change versus global change, future NCA efforts could potentially expand the scope of issues addressed and look at other critically important elements of global environmental change. One approach to starting this expansion is with a special NCADAC report that identifies what particular topics could most feasibly be integrated into future assessments.
- The Panel did find the draft document to contain a variety of factual errors and editorial-type problems (that in some cases might be construed as biases), which are detailed in the

Appendix A comments. This is to be expected in a large, complex draft document developed by numerous authors on a very short timeframe. The public comment period and this NRC review were designed precisely to help catch such problems and thus allow the NCA authors an opportunity to make needed corrections for the final report. However, the public comment draft is, by definition, a public document, and in this case it was widely reported on by the media (even if this media coverage was not actively sought by the NCA). That reality entails some obligation on the part of the NCA leadership to ensure that errors are minimized *before* the public comment draft is released. To help assure scientific rigor, we thus suggest that in future assessments, the report production timeline be staged to allow an additional round of careful internal peer review before a draft is released for comment by the public (and the NRC).

- Executing the sustained assessment process as envisioned may require a more formal support structure that does not have to rely so heavily on volunteer experts. The problem of "assessment fatigue" may make it harder over time for the NCA to engage the necessary pool of volunteers on an ongoing basis. However, a larger core of dedicated staff points to a need for greater financial support, which is not a simple suggestion in today's budget environment. But finding a way to assure financial support at levels commensurate with the magnitude of the task is a critical part of making the sustained assessment process actually sustainable. The NRC report *Analysis of Global Change Assessments: Lessons Learned* (2007) offers further useful discussion of these practical management challenges.

# Appendix A
# Compilation of Chapter-Specific Comments

**GENERAL/CROSS-CUTTING COMMENTS**

| # | page/line | |
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| 3 | | In general, the Preface, Executive Summary, and Introduction explain well the purpose of the report and what is in the document |
| 4 | | The overall introduction to regional information is well written. The introduction to each region sets the stage for how that region has unique information needs and how they need to adapt and what are their particular vulnerabilities. The lead authors of each of these areas are well-known experts in their knowledge of the region, coming from academia, local, and federal agencies. Each region has unique attributes and information needs. The format for the regional sections was easy to understand and often pointed to the need for additional research. The "traceable accounts" and "key message" boxes provides easy-to-understand information with references that provide more detailed information. Adaptive and vulnerability information is spelled out in great detail, with clear estimates of observational and modeling trends. The examples of the interaction between climate scientists and stakeholders helped to make the information more relevant to particular regions. |
| 5 | | The language of the sectoral chapters of the report is mostly of a succinct summary form which is nicely brought together through its use of "key messages" interpreted at the end of a section, along with discussion of uncertainties and confidence assessment. Because these key messages and the "confidence" assessment are such a great approach they should be a major focus for further improvement. Some of the deficiencies to note include: |
| 6 | | a) between sections there is a less uniform structure than would be desirable; |
| 7 | | b) some of the messages are given in such a hedged "on the one hand on the other hand" statement (or with such generality), that they have to be true. For example, see p.281 "could help" (or as a made up example similar to several in the report, "climate change may happen and if it does it could have an impact on agriculture"). It would be better to offer suggest positive, unhedged statements and then an appropriate degree of confidence given for them; |

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| 8 | c) not being clear as to what the confidence applies to (e.g. bottom of p 252). In some cases, the key message is subdivided for assessing uncertainty; and that seems like a good idea that might be further applied. (e.g. On p 279, the assessment appears to be only talking about Western U.S. but the key message also has a Eastern U.S. component). |
| 9 | d) Semantically misinforming phrasing: on p 280 "…confidence is high…climate change is projected to reduce forest CO2 intake." There are similar constructions in many places earlier, (e.g, p 79,81,82,84). If something has been projected (e.g. by a model), it has been projected — no doubt about it. What is uncertain is whether the projection is correct. The phase above and other similar ones would work by simply dropping "projection" , i.e. "…climate change will reduce forest CO2"; |
| 10 | e) p 79 key message "…has occurred since 1980." It is meaningless to talk of changes starting from a particular year, although '98 the big ENSO year seems popular among climate sceptics. |
| 11 | General point is that the key messages are an important communication device whose wording should be more carefully constructed than appears to now be the case |
| 12 | Assuming the main purpose of the NCA is to inform decision makers about choices for dealing with climate change and its expected effects, it is useful to see the report through the lens of some distinctions developed in the *IPCC Special Report on Extreme Events (2012)* and in NRC (2013): *Climate and Social Stress: Implications for Security Analysis.* Both those reports are focused on how to think about effects of climate change. These reports distinguish events, exposure, and vulnerability (and its elements: susceptibility to harm, coping, response, and recovery). The NCA appears to focus strongly on assessing events and exposures but does much less about assessing vulnerability. Yet for many decision makers, vulnerability is central because they want to reduce the harm caused by unavoidable, unpredictable events. Insufficient attention to vulnerability is thus a shortcoming of the NCA overall (though not of every chapter). This is not entirely the fault of the report's authors; the USGCRP has not done much to build the base of research, data, and observations that is needed for assessing the vulnerability of sectors and regions. The consequences of this shortcoming of the Program are evident in the NCA report. |
| 13 | The draft largely focuses on negative impacts and risks posed by climate change, moving from experiences of weather-related impacts to modeled future trends in climate. The report does cover climate related risks of the sectors listed in Section 106. There is limited discussion of science uncertainty; for example limited discussion on the skill of models to make forecasts at different scales that would be useful for adaptation planning |
| 14 | The report largely does not put these trends in the context of other large changes expected to happen over the next century (economy, technology, health, and infrastructure). |
| 15 | The report is generally well written, but long and sometimes repetitive. The graphics while clear sometimes are not transparent as to the uncertainty or validity of results shown |
| 16 | While the report is long, there are many areas that could be covered and could add value. The report could put response to climate change in the context of other societal priorities, |

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| | and the priorities, capacities and institutions for each sector. The report largely does not highlight win-win steps to adaptation and mitigation or a prioritization of steps that should be taken. The sector chapters provide the opportunity to discuss such steps for adaptation which could be woven in an e-document with the adaptation chapter to make priorities clearer (otherwise each chapter is too short to develop ideas while at the same time the document is too long); it may be that this should be planned into an ongoing assessment process since it may be to difficult at this stage of preparing the report. |
| 17 | The report at times gives finding that appear different, and is some cases are different, than other assessments (notably the IPCC SREX and AR5 for which the first volume will appear at a similar time as this report). While there is a good effort in the report to give traceable accounts of confidence, these contrast with those of other assessments. In cases where there are apparent differences it is important to explain why, otherwise credibility will be compromised for this assessment and assessments more generally. As is the case with all impacts reports, it is important to be careful to avoid cherry-picking or its appearance (for example selecting a limited time series or specific metric from among many alternate choices); guidelines to avoid cherry-picking and describe how choices avoid bias, could be developed and applied in the report. |
| 18 | There needs to be a serious scrubbing in terms of terminology, grammar, and readability. |
| 19 | The key messages are in general more circumspect than the language in the body of the chapters. The authors need to be more thoughtful as to the "takeaways" in each chapter. There is a greater degree of certitude than is warranted. Many figures and text boxes are specific problem areas. Shrinking clams, increasing floods, etc. are eye-catching and they will become the prime messages, despite the caveats at the end. |
| 20 | The level of detail, literature reviewed, and breadth of issues discussed is generally appropriate for this assessment. While the authors did a good job of presenting individual facts, they were not always so careful in summary statements. Some of the key points were in jargon that would not be understandable to the public (without reading the main text, which should not be necessary). Some summary statements were phrased in an unscientific manner, and could be viewed as promoting an agenda rather than presenting factual summaries of the consensus of the scientific community (see specific comments below). There were also some issues where the effects of climate change were not sufficiently placed into the context of other human stressors—e.g. increased damage from sea level rise due to losses of protecting mangroves/wetlands/etc. The nature of impacts as INTERACTIONS of stressors was sometimes mentioned, but then not made clear for particular examples given. Treatment of CC as embedded within multiple other human drivers need to be consistent and clarified throughout. |
| 21 | Perhaps the report needs more emphasis on the effects of climate change elsewhere in the world on the U.S. A parochial example comes from the Michigan cherry industry which has several times, including last year, lost >90% of the crop as a result of an early warm period followed by frost. The infrastructure of the industry can remain viable when cherries are imported from Poland and the Ukraine. If those crops are also damaged then not only do |

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| | the growers have a very bad year but processors and others in the supply chain may shift away from cherries altogether. The world is increasingly telecoupled and these connections can both reduce vulnerability and offer new risks. |
| 22 | Perhaps there is a need for explaining how the science gets done. Many people who are persuadable but skeptical have a limited understanding of how we do science when studying complex systems. To the extent they have any science background it is often high school physics and chemistry where relatively simple, relatively linear and relatively isolated systems are the centerpiece. Some key points might include: (i) The study of climate change is not new—Tyndall's work on heat trapping properties of CO2, Arrhenius s calculations of climate forcing from fossil fuel burning. What has changed is better understanding of process, better data, better models. (ii) Every major conclusion requires multiple lines of evidence. Models are very important but they are only one of about 7 lines of evidence that climate change is anthropogenic. (iii) Scientists are very careful about data. Much of the data is noisy and none is error free. Working out how to extract the signal from the noise is a major part of the scientific effort, and has been at least since Galileo. |
| 23 | It is fine to use model (in)consistency to indicate if the simulated projections are statistically significant and in a particular direction. But this is not the same as being able to say that the statistically significant change will in fact occur. One needs to test the downscaling methods using historical observational data. For instance, instead of using all observational historical data for calibration, it is better to use part of the historical data (e.g., before 1980) for model calibration, and use data from 1981-2010 to validate the downscaling methods in individual areas and regions. The NCA Report should at least show the multi-model mean differences, when data are available (e.g. for 1981-2010 minus 1951-1980; for 2041-2070 minus 1980-2000). Similarly, for emission scenarios (either SRES or RCP), observational historical data were used for their development (or calibration). The more appropriate approach would be to use part of the historical data (e.g., before 1980) for scenario development, and use data from 1981-2010 for validation. The NCA Report should demonstrate if the same methodology (in SRES or RCP) could realistically project the emission from 1981-2010 if we were at 1981 (with data available from 1980 and earlier). A potentially useful reference: Racherla et al., 2012: The added value to global model projections of climate change by dynamical downscaling: A case study over the continental U.S. using the GISS-ModelE2 and WRF models. JGR-Atmospheres, 117, doi: 10.1029/2012JD018091. |
| 24 | For climate scientists who, by definition, must take a systems perspective, the report is myopic in many regards, missing some key interconnections and history, and instead seeing everything through a climate change "lens." This is not to say that climate change is unimportant, or that human activities are not driving much of this change. But we need an honest assessment of the interplay between the environment, policies, economics, and technology. Our models are not especially good at regional-scale predictions on decadal time scales, but this does not mean that the NCA cannot add value to the decision making process under uncertainty. The challenge is how to use uncertain science to inform these decisions and policies, while recognizing that science cannot provide definitive answers. |

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| | One needs to be cautious about taking simple regulatory approaches (that worked for sulfate emissions) to a much more complex and dispersed "wicked problem." The impact of human activities on the environment goes far beyond the release of greenhouse gases into the atmosphere. Extinctions, declines in ecosystem services, etc. are driven by a range of activities, not just climate change. The report makes mention of these processes as its first crosscutting theme, but in general it assumes that climate change has (or will have) primacy. Multiple stressors are critical, but by taking such a climate-centric perspective, the report distorts the reality of these complex stressors and inadvertently sets up a perspective that reducing emissions will "solve" these problems. For example, the Northwest chapter discusses changes in forests (increasing fires, shifts in species composition, etc.) and declines in salmon populations without a straightforward acknowledgment that the dominant processes today are forest harvest practices and fire suppression (for forests) and hydroelectric dams (for salmon). By overemphasizing the role of climate change, the report may encourage one-sided solutions. |
| 25 | This complexity, when coupled with the uncertainty of our models (especially on a regional, decadal scale), reduces the utility of the assessment for policy makers and decision makers. Most decisions are looking 10-30 years out; even when the models project significant shifts, most of these are 50 years (or more) in the future. In this case, the whole issue of discount rates kicks in as well as the fact that other important (and equally uncertain) processes are equally critical (e.g., population decline, changes in energy technology, global-scale economic downturns, etc.). The report is amazingly optimistic about the quality of the regional-scale projections. The present CMIP process shows that the variability between the models within a scenario is as large as the variations between scenarios. When you go beyond temperature into variables such as precipitation, the models diverge even more and that they cannot replicate the observational record on a regional scale. This is not a criticism of the modeling community; these are difficult processes on challenging time and space scales. IPCC SREX chapter 3 is a good summary of climate extremes and the confidence in past trends and projections: [REF: IPCC/SREX. Chapter 3. Seneviratne, S. I., et al. "Changes in climate extremes and their impacts on the natural physical environment." Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (2012): 109-230].<br>IPCC AR4 Chapter 11 (WG1) provides an assessment of regional climate change including temperature and precipitation indicating areas where the sign of precipitation change differs between models: [REF: Christensen, J. H. , et al. (2007): Regional climate projections, Climate Change, 2007: The Physical Science Basis. Contribution of Working group I to the Fourth Assessment Report of the IPCC , University Press, Cambridge, Chapter 11.] |
| 26 | From a decision support perspective, the present models really can only add another highly uncertain process to an already complex decision process. The uncertainties and variability are just too large. However, if the models could be used to identify how the statistics (frequency, persistence, intensity, etc.) of critical processes might change under climate change scenarios, that would be more valuable than detailed projections. There are some hints of this through the report, but how robust are these projections? And without any |

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| | estimates of the statistics of the projections themselves (in addition to the statistics of the particular processes, such as extreme precipitation), they are not of much value. As an example: A city planner from Chicago wants to know how freeze/thaw cycles might change under climate change, to make decisions about whether or not the city should change its repaving practices. Models might be able to make some projections but the confidence of these projections would be extremely low. A planner still might be able to use such knowledge, but it would need to be weighed against a variety of other uncertain projections (e.g., city finances, changes in traffic patterns, vehicle loads, etc.). |
| 27 | In the section about trends in flood magnitude. Fig. 2.20 (derived from Hirsch and Ryberg 2012) purports to show how flood magnitude trends change as a function of climate. Such information could be extremely useful to land use planners, insurance companies, water system managers, etc. But the Hirsch and Ryberg paper specifically states that: "The *coterminous U.S. is divided into four large regions and stationary bootstrapping is used to evaluate if the patterns of these statistical associations are significantly different from what would be expected under the null hypothesis that flood magnitudes are independent of GM [global mean] CO2. In none of the four regions defined in this study is there strong statistical evidence for flood magnitudes increasing with increasing GMCO2*." They go on to state: "*However, human influences associated with large numbers of very small impoundments and changes in land use also could play a role in changing flood magnitude. Unfortunately, at time scales on the order of a century, it is difficult to make a quantitative assessment of the changes in these factors over time*." That is, floods are both a natural phenomenon and a human phenomenon (land use, water management etc.) Although the draft has lots of waffling words ("suggests," "possible" "contributed" etc.) the fact is that the public will ignore these nuanced phrases and come away with the impression that floods will increase. If the draft cannot get these facts right and if it glosses over model capabilities and limitations, then one must be skeptical of its outcomes. |
| 28 | Climate change is bound up in a poorly-understood complex of policy, economic, and environmental linkages. The notions of risks, vulnerabilities, and impacts and how they work together to help guide policy and investment are covered a bit in the Adaptation chapter, but they need to be woven throughout the report. For example, Hurricane Sandy is frequently brought out as an example of the types of disasters that will occur as the climate warms. Along with the NOAA time series of billion dollar disasters, the report convolves climate processes with complex financial and infrastructure processes. Smith and Katz show that the loss per billion dollar event has not increased (and perhaps has decreased), although the number of billion dollar events has increased somewhat. Thus storms are not necessarily getting more severe (in fact, we have been in a relative drought in terms of land-falling category 4/5 hurricanes) but it is likely that there is more infrastructure at risk and thus there are more events exceeding the billion dollar threshold. We need to temper our conclusions with the uncomfortable fact that our exposure has increased. |

## INTRODUCTION (LETTER TO THE AMERICAN PEOPLE)

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| 30 | P1 | This introduction is very nicely written—very powerful, clear and unambiguous, particularly the first two paragraphs. |
| 31 | P1/L19-21 | "... that is severe enough that some communities..." would sound better as "... so severe that some communities..." |
| 32 | P2/L1-3 | Final paragraph, final sentence: Should this sentence include some reference to our national response? E.g., "...represent steps forward in advancing our understanding of that challenge, its far-reaching national and global implications, and the responses we are and should be making to reduce the threat"? |
| 33 | P1/L8 | Perhaps add something like: "So, too, have fishermen and coastal planners …" |

## 1. EXECUTIVE SUMMARY

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| 35 | | Generally reads as a scientific summary, with an effort to use non-specialist language. The latter is not entirely successful, so the accessibility to lay (including policy) readers is not as high as it might be. This may not be a problem if there are other summary documents in preparation. |
| 36 | | The theme of a mismatch between infrastructure and the actual magnitude of weather fluctuations is one that can be extended easily. Managed systems, including agricultural and forest lands and fisheries, are also structured in specific ways, such as reliance on irrigation, and these structures are also vulnerable because they are part of the infrastructure of those managed systems. In addition, unmanaged systems such as watersheds and protected areas have an internal ecological structure ("natural infrastructure") that is also disrupted by events in a changing climate. This is a time when many are focused on infrastructure (e.g., because of Sandy), so the extension of the concept to ecosystems of importance to humans is worth considering in a high-level summary. |
| 37 | P3/L25 | "variation" not variability seems to be intended |
| 38 | P6/L22-25 | Sentence is garbled. Delete 2nd "and" in 24? |
| 39 | P.11/Table | Table should have a brief caption indicating the basis for selecting observations for inclusion — e.g., to illustrate trends unfolding over times of decades. |
| 40 | P12/L8 | Not clear what is meant by "local economies"; the other items in the list might have in common that they are sources of stresses. If that is what is intended, the passage |

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| | | should say so. |
| 41 | P19/L3-6 | This paragraph suggests to the lay reader that the relative contributions of China, India, and other emerging economies play a key role in the evolution of American climate conditions. Is that taken up in the chapters? |
| 42 | | The lack of confidence language raises concern. |
| 43 | | Report Findings is missing a key finding re R&D needs. |
| 44 | | Inconsistent in treatment of future precipitation. P4 refers to increased precip vs P5 to "reduced water supply." |
| 45 | | Verb tenses are inconsistent, particularly in health section vs others. |
| 46 | P7 | refers to Greenland and Antartica without clear implications for U.S. |
| 47 | | Health Section : Increased risk of zoonotic disease in many regions should be mentioned. |
| 48 | P7/L28 | Is drought an issue in the Great Lakes? |
| 49 | P8 | Should the conclusion on climate change be supported here only by temperature changes. Citing multiple lines of evidence from multiple types of observations seems more compelling even in this brief statement. |
| 50 | P9/L33-34 | The vulnerability of increased irrigation to drought and the conflicts over water use should be noted even here to highlight the cross-sectoral interactions. They are too often ignored. |
| 51 | P10 | It seems odd to single out only disaster modification among ecosystem services. |
| 52 | P4/L28 | not clear what was satellite and what wasn't, given the longer time frame |
| 53 | | This traditional Executive Summary is not effective at communicating to a broad range of readers the information contained in the draft report, particularly given the controversy and complexity of the issues covered. The text requires more than a basic understanding of climate change and its associated vocabulary. |
| 54 | | Several phrases early in the Summary assign responsibility for climate change to human activities, but the text lacks background information to inform/prepare the lay reader to digest these assertions For example, p. 3, l. 6: The phrase "which is primarily driven by human activity" needs more justification/introduction. Suggest adding "predominantly the burning of fossil fuels." |

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| 55 | | Authors should consider adding a sentence or two very early, i.e. paragraph 1 or 2, describing the connection/relative scales of "human-induced warming" and "a naturally varying climate." |
| 56 | | Discussion of risk and uncertainty is not addressed in the Executive Summary, until p. 13, l. 1. These issues should be addressed earlier in the text. |
| 57 | P6/L21 | Is there any information to show that we are on track to exceed A2 either from the U.S. contribution or globally? Information in this section should be supported by some part of the 1100 page report |
| 58 | P12/L8 | What does "local economies" mean. How is "local economies" a stress factor? They are part of the context for understanding the impacts. |
| 59 | P12/L19 | Such as? Which recent events? Need to give an example. |
| 60 | P13 | The whole bullet 4. on tipping points is vague regarding what these break-points might entail. A concrete example would be useful. |
| 61 | | The most important content in the executive summary is found in the Report Findings section. Perhaps move this to the beginning so that it's the first thing readers encounter. The content that is currently at the beginning of the executive summary reads like the introduction to the report, rather than a summary of its most important points. |
| 62 | P5 | second paragraph: The sentence that begins "Some of the key drivers of health impacts include..." is quite long and a bit hard to understand. Either use bullets or divide the sentence into several sentences. |
| 63 | P5 | third paragraph: "Iconic species" will not be understood by many lay readers, and the last phrase of the sentence ("...the potential for extreme events..." is vague. |
| 64 | P5 | fourth paragraph: Perhaps add "leading to contaminated water supplies," or something like that at the very end of the paragraph. |
| 65 | P6 | second full paragraph: There's a verb missing: "Voluntary efforts, the recent shift from coal to natural gas... and federal programs *are* underway and have..." |
| 66 | | Crosscutting themes and issues, #1: The last sentence states, "As illustrated by recent events..."—please specify. |
| 67 | | Report finding #4: At the end of the last sentence, the authors state that heat-trapping gases are *strongly* reduced. This seems to be the wrong word—dramatically or greatly perhaps? |
| 68 | | Report finding #4, second sentence: "Same" should be changed to "some." Should human choices be added to the sources of uncertainty cited in the last sentence? |
| 69 | | Report finding #5: Many lay readers won't understand what is meant by "food |

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| | | security." And a couple examples of "unfamiliar health threats" would be helpful. |
| 70 | | Report finding #5: Much of this section may be difficult for many lay readers. For example, "probability of occurrence of a certain type of event" could be stated more simply as "how often an event will happen," and "exceeding a particular threshold" could be re-stated as "how severe it will be." |
| 71 | P3/L11 | Characterizing the impacts simply as "disruptive" here conveys a very different notion than the message conveyed by the report itself. "Disruptive" suggests something that is temporary, where one ultimately settles into a new equilibrium (e.g., it is disruptive to move from one city to another). While there will certainly be disruption, it is the significant costs incurred as a result of that adjustment period that are important. That idea is not captured by characterizing the changes simply as disruptive. |
| 72 | P3/L14 | This sentence is unclear. It is not clear how using scientific information will provide economic opportunities. |
| 73 | P5/L1 | It is not clear what the word "stresses" is intended to convey in this paragraph. For example, what are "stresses" on "existing social, institutional and legal agreements"? The word is used multiple times in this paragraph, but I don't think the lay reader will have a clear idea of what it means here. |
| 74 | P5/L8 | There is a discussion here of negative health impacts. It should also be acknowledged that warming could yeld some positive health impacts as well, for example, in areas where exposure to cold (or inadequate access to heat) has negative health impacts. |
| 75 | P5/L20 | What does it mean to maintain "a robust public health infrastructure"? One might interpret this as some type of public provision of health services (nationalized health care??). Is that what is intended? |
| 76 | P6/L18 | Replace "worst" with "largest"? The largest changes are not necessarily the most costly (i.e., worst) ones. For example, large changes for which there is low-cost adaptation may not impose large costs. |
| 77 | P6/L41 | The reference to economic opportunities provided by being prepared is unclear. This is the second place in the exectutive summary where this idea is mentioned, and in both places one is left wondering what this is intended to convey. It almost sounds like individuals can be opportunistic and take advantage of (make some money off) other people's vulnerability to climate change. That is probably not what is intended, so some clarification is needed here and above. |
| 78 | P8/L31 | When referencing the costs that are already high, it would be helpful to be a little more specific about what costs have actually been already observed/documented (as opposed to those costs that are projected to occur in the future). |
| 79 | P8/L36 | There is no mention of "threats to mental health" in the discussion up to this point, so it is surprising to see it here as part of a major finding. And there is nothing in the |

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| | | paragraph here that clarifies what is meant by this. It is also unclear what "unfamiliar health threats" (line 41) refers to. And if they are reemerging, then how can they be unfamiliar? Some clarification is needed here. |
| 80 | P9/L37 | The statement that yields of major crops are expected to decline, "threatening both U.S. and international food security" may be true, but it doesn't follow logically. A reduction in U.S. crop yields does not necessarily constitute a threat to food security. To threaten food security, the impact has to be large and not offset by an increase somewhere else. So just saying there will be a yield reduction is not sufficient to support a statement about a threat to food security. |
| 81 | P10/L24 | The text references "large social, environmental, and economic consequences." However, most of the discussion in the report identifies impacts but does not QUANTIFY those impacts, especially economic impacts, and so it is hard to determine (from the report) which impacts will be large and which will be small, which will be economically significant and which will not, etc. The report very thorough documents impacts that have been shown to exist (under either current climate or projected future climate) but does not provide much information on which of these many actual or potential impacts are most significant/important. This is obviously much more difficult to determine, but it is essential for focusing attention on particular concerns. |
| 82 | P11/Table | In the Northeast row, it's surprising not to see mention of the economic impact on, for example, recreation. |
| 83 | P12/L3 | Again, the word "stresses" is used here, while in line 6 the terminology "multiple factors" is used. Are all factors necessarily "stresses"? It seems the key point is that other things are changing as well, and these other changes combine with the climate changes to determine outcomes. |
| 84 | P12/L24 | This is the first reference to a "risk-based framing" for the chapters in the report. This, along with the instruction to focus on most significant impacts, seems to be a key framing issue for the report as a whole. As such, it seems this statement should appear at the very beginning of the executive summary rather that at the very end. |
| 85 | P13/L1 | The introduction paragraph to this section on p. 12 (lines 2-5) lists three themes, but then one turns the page and finds two additional themes. Is there a reason to highlight themes 1-3 in the opening paragraph but not 4-5? |
| 86 | P13/L2-11 | The point could be made here that, not only are tipping points difficult to predict, but their existence can have important implications for management decisions. They make it much more difficult (and important) to design appropriate mitigation and adaptation policies. |
| 87 | P13/L19 | The discussion of this cross-cutting theme seems out of proportion to the others. It could be condensed considerably. For example, everything from line 19 and below could be deleted without losing the main point. |

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| 88 | P20/L8-15 | It is not clear why this brief paragraph is going to be in a box, while the discussions of the other scenarios (e.g., sea level rise scenarios) are not. It is also not clear why it is inserted here and how it relates to the discussion of emissions scenarios on p. 18. |
| 89 | P21/Fig1.2 | There is no reference to this figure in the text. |
| 90 | P18-21 | These pages discuss emissions, climate and sea level rise scenarios. The text states that the report uses scenarios (p. 18, line 11-12) and explicitly states which emission scenarios are used (p. 20, lines 9-11), but there does not seem to be any explicit statement about what climate or sea level rise scenarios are used. In addition, the previous discussion (p. 12, lines 26-28) highlights the importance of "socio-economic" scenarios (e.g., about population growth and development), yet there is no discussion about what scenarios are assumed for these factors. The reader is left with an unclear picture of what role scenarios really play in the report, and, if they play a critical role, how those scenarios are fully specified (beyond just emissions). |
| 91 | general | Many of the paragraphs in the executive summary are followed by a list of chapters that presumably support the statements in that paragraph. While this may be useful for the reader when the list is short (e.g., Ch. 29), it does not seem very useful when the list is very long (listing, for example, 14 different chapters). A long list does not seem to give the reader sufficient direction on where to look for more information to be very useful. |
| 92 | P3/L5 | This statement seems to claim that we can observe human causation while attribution is a statistical and modeling test applied to observations, therefore the statement is not accurate. |
| 93 | | It is unclear if the report is assessing research or actual implementation of adaptation, mitigation and decision support. The report seems uneven in their treatment—i.e. lack of objective metrics to measure implementation across all three, and sometimes shifting focus from implementation to research/theory. |
| 94 | P4/L37 | Should this be 40%? |
| 95 | P5/L3 | Should highlight both interaction with other stresses and on the other hand areas with greater resiliency (examples are not given though it is mentioned at the end of next paragraph). |
| 96 | P6/L27 | If other actions that might be taken in the future are insufficient, then B1 is not feasible; the "actions that might be taken" must be refined to make this a meaningful statement. |
| 97 | P9/L28 | This statement seems more balanced than those in the agriculture chapter that does not mention that agriculture will be resilient? |
| 98 | P20/L2 | Why does this figure not say anything about the uncertainty band on projections whereas the next figure on sea level does? |

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| 99 | | Overall ExcSummary is very nicely written—both comprehensive and easy to read. At the right level for general public. |
| 100 | P3/L17 | Evidence for climate change isn't just the climate data, it's also the observed changes in species & ecosystems that also point to major global shifts in climate. This is an important point to make for the general public to grasp the magnitude of change, and where the strong scientific consensus comes from. |
| 101 | P3/L38 | extreme summer of 2011 in Texas was extreme drought as well as heat—it was the combination that was devastating in terms of impacts |
| 102 | P5/L28 | People may not connect "distorted rhythms of nature" with direct human impacts of CC. Perhaps be more explicit—e.g. how increased asynchrony among species can, e.g., cause poor crop polination? Also, declines in agricultural productivity are a direct human impact. |
| 103 | P8/L34 | Point 5 is poorly worded—it sounds like 'food' and 'water' are impacts—need to add adjectives & clarify. |
| 104 | P10/L1 | There's no mention of species- level changes. Suggest adding to existing sentence: "...are already disrupting WHERE SPECIES LIVE AND TIMING OF KEY LIFE EVENTS, ULTIMATELY IMPACTING ecosystem structures …" |
| 105 | Table 1.1 | To SW impacts, add forest losses from increased pest outbreaks (e.g. pinyon pine deaths from heat and drought stress followed by beetle outbreak) |
| 106 | | Section on health is limited to direct effects of diseases and health conditions within the domain of environmental health (heat stroke, respiratory disease, allergies, etc) and does not mention health threats caused by infectious agents which in some instances may pose more serious threats to human health in the U.S. (pandemic influenza, SARS, dengue fever, West Nile virus, etc.). |
| 107 | P13/L19-35 | Admirable in intent but hard to follow for the average reader. More examples and fewer lists? |

## 2. OUR CHANGING CLIMATE

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| 109 | | The Scientific basis for climate change is good summary of what we know borrowing language for previous NRC reports such as *America's Climate Choices* and newer climate modeling and observations that will be published as part of the next IPCC report. |
| 110 | | The presentation of a wide range of indicators and projections is powerful —and likely to be controversial as a result. |

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| 111 | P31/Fig2.2 | A lay reader sees this as two long-term trends, moving in synchrony since about 1960. It might be helpful to supplement the annual temperature anomalies with five-year averages. It is also surprising that the existing commitment (ll. 20-21) is less than two decades' worth of emissions. |
| 112 | P37/Fig2.7 | This figure shows that the 2 C "limit" commonly discussed is projected to be exceeded even under the optimistic B1 scenario within the lifespan of people now alive. This should be discussed briefly in the text. |
| 113 | P50/Fig2.16 | This striking figure is an object lesson in "shifting baseline." For the people old enough to recall the period from 1958 to now in a single place or region of the country, the large increases in the Northeast and Midwest may be surprising. The figure may be accurate but some people's experience may not obviously align with this figure. Perhaps add a short discussion of the variance between long-term datasets and people's memories of a single place (at minimum in the traceable account on p. 81). It is also germane to discuss the size of the storm events in this dataset —a small, intense storm will not affect much of the multi-state region but may contribute to the tail of the distribution. The uncertainties in the projections are particularly important, since (small) intense storm events are hard to model. |
| 114 | P62/Fig2.24 | On what emissions scenario are these projections based? |
| 115 | P68/Fig2.29 | Caption does not explain gray shading (past), or green (RCP 2.6?). It makes sense that the pink shading narrows, since the ice cover cannot go below zero, but it is unclear why the shaded area for the high-emission scenario should be narrower than for the low-emissions (blue) early in the projected period. |
| 116 | | The report overall does an excellent job in communicating and interpreting what is known from current trends and model projections about future climate change over the U.S.. It is U.S. and impact/adaptation centric. This may be all there is room for but it certainly gives short shrift to the research on basic climate system processes that have historically been much of the USGCRP. In other words, it is mostly about addressing the last clause of SEC 106: "analyzes the effects of global change on the natural environment…." |
| 117 | | It also is very short on international context; e.g., what will be the consequences of climate impacts suffered by other countries on the U.S. well being? Little is said about mitigation except in terms of some carbon cycle discussion. If there were more, it would have to look at the international context to be meaningful; how can we aspire to global equity in energy use without catastrophic climate change—will the U.S. have to reduce its per capita energy use to that of China and India before they start being serious about reducing their exponential growth of fossil fuel use, large investments in coal fired power plants, etc.? As an analogy, the report shows us how to fasten our seatbelts but gives no indications as to how to slow down a rapidly accelerating vehicle. |

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| 118 | | The dicing of the U.S. by clustering of states for the most part makes sense climate wise. However, the "Great Plains" unit stretching from Texas to Wyoming and Montana seems a bit puzzling, unless it was intended as some commentary on the scientific illiteracy of their state governments or the large amount of fossil fuel extraction (or ranching) they engage in. |
| 119 | P54/Fig 2.19 | Is difficult to interpret. "rare cold events" seems to mean an increase in the number of rare cold events. Can this information be displayed in another way? |
| 120 | | It might be helpful to use the key message numbers used at the start of the chapter for each of the messages within the chapter; this would make it easier for readers to locate the content supporting the points made in the beginning. |
| 121 | P28 | Second paragraph, last sentence: Add the specific CAQ where attribution is |
| 122 | P29 | Box: Models used in the assessment: The information here is very important, but will be hard for lay readers to understand. Even if it doubles the length of the box, explaining this more fully and simply would be helpful. |
| 123 | P30 | Ten indicators of a warming world: insert "of atmosphere"—"Air temperature near surface *of atmosphere* (troposhere)" |
| 124 | P31 | Future climate change: add Centigrade after Fahrenheit here, as has been done elsewhere. |
| 125 | P33 | The acronyms used in the figure legends should be spelled out (with the exception of NOAA, which is a commonly understood acronym). |
| 126 | P34/Fig2.5 | For clarity, perhaps replace the word "pathways" with "emissions." |
| 127 | P35 | Recent U.S. temperature trends: First paragraph of text refers to "Appendix, Key Message 6," instead of CAQ. Key message in the appendix is also referenced in the caption for Figure 2.7. |
| 128 | P41/Fig2.10 | Lay reader wonders how changes in frost-free days is applicable to areas that don't have frost (e.g., Southern California)...: Lay reader found this figure difficult to understand. |
| 129 | P55 | Final paragraph of the extreme weather section: The sentence "Attribution of flood events is a relatively new area of research" is unlikely to be understood by lay readers. Preferable: "Research into the causes of floods is relatively new." |
| 130 | P55 | Same paragraph: The last sentence states that heavy rain in the Southeast may have less impact than in the northern Great Plains; lay reader would like to know why. |
| 131 | P57/Fig2.21 | difficult to interpret: What does "PDSI<-4.0" mean? What does the black line represent? How much does the Palmer index over-estimate drought? Why is the correspondence between the red & blue lines (i.e., actual & modeled) so poor between 1900 and 2000? |

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| 132 | P59 | Changes in Storms: The first sentence in the section on hurricanes ("There has been a substantial increase in virtually every measure...") is so direct, powerful, and clear that the authors should consider including it in the key message. |
| 133 | P59 | Later in the same paragraph, the text becomes more difficult to understand; the text starting with "How hurricanes respond also depends on how the local..." and ending with "...increase more uniformly around the world due to increased amounts of heat-trapping gases" is not entirely clear. |
| 134 | P60 | Winter storms: Much of this section reads like a series of discrete facts that are difficult for the reader to integrate. E.g., Heavy snowstorms have increased in the Northeast, but the Northeast has seen a normal number of very snowy winters. |
| 135 | P61/Fig2.23 | What do the acronyms in the legend stand for? The caption discusses both hurricane frequency and strength, but it seems the figure contains only data on strength, ... If there is information here on frequency, this should be explained; and if no, references to frequency should be dropped. |
| 136 | P62/Fig2.24 | Which emissions scenario was used as a basis for this prediction? |
| 137 | P63/L10 | Sea level rise: "Proxy data" is a term that is unlikely to be understood by lay readers; a definition is needed. The same is true for "semi-empirical models"—lay reader wonders if something that's only partly empirical can be trusted. |
| 138 | P64/Fig2.25 | Spell out sea level rise in the figure's legend instead of using the acronym. |
| 139 | P68/Fig2.29 | The meaning of the final sentence is unclear. |
| 140 | | Message 8—This is an example of overwrought language. Yes, there are more cat 4/5 hurricanes but there have been fewer land-falling 4/5 hurricanes. Why isn't this last fact mentioned? Because it doesn't fit the narrative? Why not discuss the hurricanes of the 1930's which would have had much larger impacts than recent hurricanes? |
| 141 | P28 | Yes, there are lots of processes that have changed, but the models are still struggling with the radiative feedbacks (clouds, aerosols, black soot, melt ponds in the Arctic, etc.) Shouldn't we at least identify these issues? Again, we tend to bring global-scale processes (and models) down to regional scales where these models become extremely problematic. |
| 142 | P31 | Shouldn't we show more than just temperature and CO2? Aren't the radiative feedbacks the larger issue than just CO2? |
| 143 | P35/L25-28 | These lines talk about sulfate particles from power plants. 'Yes there is one paper, but it is hard to reconcile this local issue with the larger scale processes controlling temperatures over the eastern U.S. |
| 144 | P63/L25-39 | An example of how the report misses an opportunity to be informative. It gives a huge range of possible rises in sea level, using words like "reasonable" and "useful." Without any estimates of uncertainty, its doubtful whether any policy maker could |

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| | | use this information. Anyone in this situation has lots of "what ifs" and possible scenarios; how does this section help? |
| 145 | P33/L2 | Are these curves the average or median of some set of models? There is no information on model differences or skill of these projections in the report? |
| 146 | P67/L22 | It would be useful to explain why Antarctica has shown an increase. |

## 3. WATER RESOURCES

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| 148 | Fig3.3 | Figure seems to have a lot more colors than indicated in the legend. |
| 149 | | Each of the main headers presents an assertion that could indeed be quite strongly agreed upon by the research community, but as written now in the running text of the chapter bears no sense/level of certainty (or uncertainty). One would have to dig thru the Traceable Accounts charts to get this sense. It would be helpful to develop some telegraphic means to indicate how certain a key finding is (e.g., thru the use of an icon, a color-code, a simple statement at the end of the assertion) within the chapter text itself. |
| 150 | | After hunting through some of the Traceable Accts, it is still difficult to pinpoint exactly what models or model ensembles were used for the findings and graphics presented in the chapter text. As for "Assessment of confidence based on evidence" in the Accts, it is unclear what time frames are spoken about. Thus, the authors might wish to fill in the blank as in this example: "Confidence is therefore judged to be high that precipitation and runoff decreases will continue in southern states over the next XXX years or YYY decades." |
| 151 | | Up to page 117, there are many individual facts and findings, and very little in the way of a roadmap for the user to make sense of these. There are few maps or graphics that aid in synthesizing this information. Thus, while factually on sound ground, the presentation does little to aid the reader. These sections of the text need to be better synthesized as they are presented—otherwise they consist mainly of factoids thrust upon the reader. The situation I would imagine would present a particular challenge for a non-scientist. In addition, the text often presents along w/ this litany of results, mention of particular locations or regions of the country; and, since there is seldom if ever full geographic coverage across the nation this still further fragments the arguments. On the positive side, this is essentially a geography of our knowledge base, which if presented creatively could be made more intuitive to a reader. Right now maps are seldom presented. Would be nice to see some sort of publication or technical appendix or web site presenting these "geographies" (w/ direct connection to the paragraphs in the text) could be made a part of the Traceable Accounts. Figure |

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| | | 3.2 is a good example of the problem. |
| 152 | | Some of the Spotlights fail to link to the issue at hand, or at least leave it to the reader to make the connection. On page 123, there appears a general description of some floods, with no discernible connection to the climate change question. While an informed expert might know what the text is getting at, a less seasoned reader will probably not. Another good example is on Page 128 (Spotlight on Water Management), with no connection to how the changes documented there would impact water management. |
| 153 | P107/L37 | Increased residency time actually cuts two ways. While recalcitrant pollutants may stick around for longer periods of time, a longer duration in fact can aid in the processing of bioactive compounds like nitrogen (see Green et al. 2004). [REF: Green, P. et al. (2004). Pre-industrial and contemporary fluxes of nitrogen through rivers: A global assessment based on typology. *Biogeochemistry* 68: 71-105.] |
| 154 | P108 | Bullets 9, 10: Many of the management challenges associated with Bullets 9,10 are self-inflicted by non-climate related human activities and this goes unmentioned in Bullets 7, and 8. For example, it is well-known that society seemingly unwittingly increases its exposure to hazardous weather because humans tend to settle in and make infrastructure investments in dangerous places [REF: Pielke Jr., R. A. & D. Sarewitz. 2005. Bringing society back into the climate debate. Population and Environment 26(3): 255-268.] |
| 155 | P109/L14 | Might wish to make "Permafrost" BOLD |
| 156 | P109/L17 | "All of these trends are projected to become even more pronounced as the climate continues to warm." Add a clause such as: "…., and as feedbacks to the climate system evolve through changes to the land surface boundary layer." |
| 157 | P110/L11 | It might be more correct to say: "…both solar energy and atmospheric demands for moisture (e.g., through winds and moisture deficits in the atmosphere).." |
| 158 | P110-111 | discussion on ET is a bit repetitive and could be condensed by about 25% w/o loss of content |
| 159 | P111, L16-24 | No mention of the use of satellite remote sensing to infer trends. Also, there is no parallel statement to the one made at the start of the ET section mentioning the role and importance of this component of the water cycle in sustaining crop growing and natural ecosystems, as the intervening hydrologic mediator between transpiration and runoff, and as a hydrologic buffer to some degree against extreme weather, erosion, etc |
| 160 | P112 | Caption for figure: Need more information about the ensembles. A clear reference to another part of the NCA would be in order, as would a literature citation. No notion of error/uncertainty is given |

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| 161 | P112-113 | Multiple mentions of "projections" or "projected," yet with no information on the reliability of these. Is there 100% agreement or merely consensus among the numerical outputs or expert opinion interpreting the outputs. Is a projection the same as forecast? A prediction? Is some nomenclature being used that has been developed in some earlier part of the Assessment being used here? If so, it should be thus pointed out. While this may be able to be dug out of the Traceable Accounts, some of these notions need to be highlighted here in the text, where it is being presented most prominently. |
| 162 | P113/L15-19 | A good part of this writing has nothing to do with drought. Instead, use this first paragraph to define what the operational definition of drought is for the NCA. That writing which does refer to drought is about annual drought, not summer drought as the sub-heading indicates. |
| 163 | P114/L4-8 | While the first clause is well-referenced, the last clause is weakened by the detailed caveat and is unsubstantiated; perhaps it is just a matter of rewording, but as it stands currently, it is unconvincing. |
| 164 | P116/L32-33 | This is but one set of estimates and may substantially understate the value for depletion, at least with respect to the global #: Earlier work by Vörösmarty et al. (2005) put the use of non-sustainable groundwater at from 400-800 km3/yr, with Rost et al. (2008) obtaining similarly high numbers, in fact near the upper end of this range. REFS:<br>*Rost. S., et al. (2008). Agricultural green and blue water consumption and its influence on the global water system. Water Resources Research VOL. 44, W09405, 2008. *Vörösmarty, C.J., C. Leveque, and C. Revenga (Convening Lead Authors) (2005). Chapter 7: Fresh Water. In: Millennium Ecosystem Assessment, Volume 1: Conditions and Trends Working Group Report Island Press.] |
| 165 | P114/L29 | Set-off this spotlight on groundwater as a box to maintain consistency with other such spotlights. |
| 166 | P118/L22 | uses English units. Earlier sections used metric. What is the policy for the Assessment re: standardizing units? |
| 167 | P122/L5 | Change "ecosystem impacts" to "thermal impacts on ecosystems and biodiversity" |
| 168 | P123 | This is a very general description of some floods. Not particularly insightful and it makes NO connection to the climate change question. A sentence or two needs to relate this back to what is discussed in the text as the links between such extreme events and climate change. |
| 169 | P124/L11-12 | With respect to water availability, this clause is a bit of a non-sequiter: "and these challenges will rise as aging hydropower infrastructure needs to be replaced (Brekke 2011)." The following wording could solve the problem: "and these challenges will rise precisely within the time frame that aging hydropower infrastructure will need to be replaced (Brekke 2011)." |

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| 170 | P126 | on Floods: No mention of the role of land use on flooding. Land use and land cover change is critical even under current climate. However, there should be some discussion of the role of LUCC in both exacerbating *climate-induced* flooding (e.g., via impervious surfaces associated with urbanization) and in some cases attenuating (e.g., via reforestation). Furthermore, LUCC will interfere with the detection of *climate-induced* flooding. |
| 171 | P127/L8-10 | A statement appears: "Water management and planning would benefit from better coordination between the national, state, and local levels, with participation of all relevant stakeholders in well-informed, fair, and equitable decision-making processes." The following statement could, very logically, be placed immediately before the one above to amplify its intent: "A recent NRC report (2011) uncovered systematic mismatches between the nomenclature and translation of knowledge between atmospheric scientists and hydrologists as well as between these scientists and the applications community." (This statement could also help to amplify the comments in the paragraph on page 130 defined by lines 12-19). REF: NRC. 2011. Global Change and Extreme Hydrology: Testing Conventional Wisdom |
| 172 | P128/Fig3.8 | Unclear what the single flat red line is near the horizontal axis of the bottom graphic. Also, why does the top panel have only two results and the bottom panel several? What do the several lines actually represent? We also see English units again. |
| 173 | P128 | Spotlight on Water Management. There is no text relating these physical changes to water management per se; left to the reader to fill in the blanks. |
| 174 | P129/L19-22 | The following statement appears be correct: "Infrastructure planning can be improved by incorporating climate change as a factor in new design standards and in asset management and rehabilitation of critical and aging facilities, emphasizing flexibility, redundancy, and resiliency (Brekke et al. 2009a; Means et al. 2010b; Wilbanks et al. 2012)." But it all depends on the time horizon of the analysis. If for example the economic lifetime of the infrastructure is 30 years, that may be an insufficient time for the signal-to-noise ratio associated with various climate change scenarios (or the variability that characterizes the ensemble predictions) to exceed the envelope of historic variability. This was one of the findings of the NRC COHS report cited above. A mention of this point seems prudent in the Assessment report text. Thus, one may conclude that there would be little value in incorporating climate change information, making it difficult to justify the "blanket" statement as given in lines 19-22 that information on climate change would indeed improve planning. |
| 175 | P129/L23-32 | Among the non-structural strategies are improved flood forecasts, telecommunications, and early warning systems (UNISDR 2011). REF: UNISDR. 2011. Revealing risk, redefining development. Global Assessment Report on Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction. Geneva, 178 |

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| 176 | | This chapter is well written and the findings are well documented. The chapter is thorough in its treatment of impacts on water resources. Uncertainties are identified in a reasonable fashion. Major trends are also reasonably projected where a factual or modeling basis exists. The key messages and graphics are clear and appropriate. |
| 177 | | It does miss an opportunity to frame the key message relative to the impact of climate change on water resources. The key message is that, without climate change, existing adaptations appear reasonably capable of accommodating the increased needs resulting from the projected 60 to 85 % increase in the U.S. population. But, climate change dramatically affects this result as, with climate change, a 25 to 35 % short-fall is expected. Thus, dramatic changes in water resource use and management are needed to accommodate the joint affects of population growth (and the associated increase in economic activity) and climate change. |
| 178 | | The report also offers little in terms of the types of changes that will be needed. The need for change is highlighted in Key Message 9, but not the nature of the changes. Key Message 10 introduces the principal of increased resilience and enhanced adaptive capacity without truly describing what this means. A further discussion of the types of changes would more fully frame the effects of climate change on water resources. This is needed for this section to properly frame the discussion on response options. |
| 179 | P120 | The data for the U.S. in figure 3.6 are from 2005 (or likely from a few years prior). Are these shares by sector stable over time? is 2005 an accurate proxy for 2013? |

## 4. ENERGY SUPPLY AND USE

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| 181 | | Limited attention to energy infrastructure such as roads, pipelines, power |
| 182 | P168 | Adaptation language on top of p168 is very broad. |
| 183 | | Extreme Weather section: SREX as a reference? Refers to only precipitation vs other "intensities" of extreme events. Examples P168 (lines 32-33) might also include winter weather. |
| 184 | P169 | Figure refers to Energy when only shows oil and natural gas wells. |
| 185 | P169/L9 | T&D networks missing. |
| 186 | P171 | Check if "cooling degree days' is defined in glossary or prior use. |
| 187 | | Table 4.1 (and 4.3) and elsewhere uses "negative" and "positive' impacts which is vague and interpretable. Suggest an agnostic/science based metric. |

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| 188 | P177 | Resiliency and Adaptation ; Section uses language of "no regrets" vs more technical terms. Some discussion of 'robustness " of adaptation might be appropriate. E.g. is 1:100 yr sufficient or 1:10,000? |
| 189 | P183 | Should address hydro power as well. |
| 190 | L16-22 | Consider policy/regulation and market responses, not just regulated markets. |
| 191 | L23-30 | Add references? |
| 192 | P181 | Table 4.3 Caption — temperature changes etc. affect all regions (caption says "many sectors and regions"). Why are agriculture and infrastructure mentioned in the caption since the table is only about energy? The indicator projections by region are not very helpful, and it's not clear why they need to be repeated in the table. |
| 193 | | The report says very little about U.S. energy consumption relative to other countries and as a share of global consumption. More information on the contribution of the US to global emissions could be included. The executive summary notes that the U.S. contributes 20% of global emissions, but does not provide information on per capita emissions or on emissions of the U.S. compared to other countries. The report misses an opportunity to mention that the U.S. is rapidly becoming a major supplier of fossil fuel to meet its own needs and that it is expected to become a net exporter of fossil fuels by the mid 2020s. Some discussion (perhaps in the energy chapter?) of where the U.S. relative to the rest of the world regarding both its energy consumption and production is warranted given the central role that energy use plays as a driver of climate change. |
| 194 | | The chapter identifies potential risks for energy systems, and potential adaptation measures. The chapter, however, could be improved by putting these measures into the context of measures already taken to harden infrastructure to weather, and changes other than climate (e.g. energy demand and infrastructure improvement) that could occur over the next century. The chapter could be improved by reducing redundancy with other chapters (e.g. transportation). The chapter could also point to institutional barriers and change that would be beneficial. For example, how water will be allocated to energy is an important question not covered in this chapter. |
| 195 | P167/L15 | The weather becoming more extreme statement is not supported by the IPCC SREX statement that there is no such simple conclusion (see IPCC, 2012. page 124); differences in assessment conclusions should be carefully explained otherwise the reader will not know which assessment to believe. REF: IPCC, 2012:: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., et al. (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 1-19. |
| 196 | P167/L19 | This statement is only looking at changes that result from temperature change and not other changes/drivers of energy demand that will change over the 21st century. This should be made clear, and temperature should be put into the context of other drivers of energy demand change. |

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| 197 | P167/L21 | Changes in water demand may be a dominant factor in water scarcity, however, it is unclear in this statement if it is referring only to changes in climate or to all potential changes over the next century. There is an opportunity in this document to consider changes in availability, in relation to current systems for water allocation. |
| 198 | P167/L33 | It would be helpful for the reader to put these drivers of changes in reliability of energy systems in the context of the past trend in reliability. |
| 199 | P168/L30 | It is likely this finding is primarily a consequence of increased exposure. This should be made clear, otherwise this paragraph could be misleading. |
| 200 | P168/L34 | Not clear what a climate (as opposed to weather) event is? |
| 201 | P168/L35 | Markets are a beneficial and extremely important adaptation mechanism, and they lead to adaptation and resilience by adjusting prices. This section, however, gives the impression that allowing for markets to react to upsets is a bad thing—a dependency. The report could consider if the system of markets and reserves (in both the US and Europe) enhanced reliability of the energy system in the examples given. |
| 202 | P172/L3 | It would be helpful to understand how the difference in heating/cooling compares to the range of demand change over the next century due to both technology/building changes, and demand for services. The cases given seem too specific and do not give information about their uncertainty. For example, what does the literature broadly say about the change in building efficiency and heating-cooling demand over the next century compared to the change in heating /cooling days. |
| 203 | P175/L2 | Precipitation model results are known to have significant uncertainty. While this figure may be misplaced in this chapter, it would be helpful to know where models do not agree on the sign of changes in precipitation since this shortcoming of precipitation projections was highlighted in the IPCC AR4 (page 16). |
| 204 | P178/L1 | Many (all?) of these actions have taken place in parts of the energy sector. This chapter could highlight where resilience is good, and lessons learned. |
| 205 | P181/L1 | Not sure how to interpret such short time-scale extremes in water with hydropower; would it be better to look at seasonal extremes? Are the air/water temperatures actually air (not water)? |

## 5. TRANSPORTATION

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| 207 | | Transportation infrastructure is long-lived and designed for a specified climate. The chapter recognizes this and describes risks to this infrastructure and the valuable service that is provided. An opportunity that the chapter misses, however, is the |

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| | | context of the priority of changing infrastructure compared to other infrastructure priorities. Given the costly and long-lived nature of this infrastructure, it would be useful to take advantages of periodic infrastructure investments to make adaptations. A useful topic to cover to facilitate this would be a roadmap of the institutions and engineering practices that would need to be involved (e.g. codes and standards) to make such changes and the timelines and priorities for such changes. |
| 208 | | Another useful topic to cover is information on successes in reducing vulnerability (e.g. from the Gulf Coast), those systems that are robust and why, and those that are not and the barriers preventing them from being more resilient. |
| 209 | P195/L23 | This statement is ambiguous as to whether it applies to the net cost of the transport sector, to every system or can apply to some systems. The traceable account for this conclusion states that there is limited literature but that authors have high confidence. It is still not clear what the statement means. For example, does it mean that the cost of fewer shutdowns from winter storms will be swamped by the costs of flooding? The literature may not be sufficient to make such a conclusion. |
| 210 | P195/L35 | Vehicle vulnerability to climate is not covered in the chapter and does not seem credible. Vehicles are designed for a huge range of climates. Good to recognize these as part of the system but not for impacts. |
| 211 | P195/L37 | Not much in the chapter on institutions and information. More consideration could provide insights. |
| 212 | P202/L20 | Hurricanes increasing in frequency is incorrectly précised from chapter 2. |
| 213 | P201/Fig 5.2 | Caption. Thirteen out of how many of the largest airports? |
| 214 | P203/L15 | Is there another source other than the newspaper to document the 14 foot storm surge from Sandy? How about FEMA? |
| 215 | P204/L7 | The number of damaged cars wasn't countless. This number is available from the Insurance crime bureau, which estimates that 230,000 cars were damaged based on insurance claims: https://www.nicb.org/public-affairs/sandy-vehicles-load-airport-runway |
| 216 | P210/L24 | Tropical Storm Irene also had devastating effects on upstate New York and other states in the Northeast (perhaps make reference to Northeast chapter) |
| 217 | P211/L11 | What does "increasing changes in snowstorms" mean? |
| 218 | | The transportation report is very comprehensive but instead of providing a long list of 'doom and gloom' scenarios, would it be possible to recast some of these potential impacts in terms of basic economics (e.g., how much more it will cost to buy cereal-related projects for different ranges of scenarios in today's dollars?). |

## 6. AGRICULTURE

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| 220 | P243/L13 | How will the ways that climate affects food processing, storage etc. change? What are these new ways? Cimate already affects processing, storage etc.; will climate change bring new and different ways that climate affects these systems? |
| 221 | | The agricultural sector is one sector where there has been a significant amount of work done estimating the economic significance of climate change. Yet that literature is not included in this chapter in any meaningful way. While a few economic studies are cited (e.g., p. 228), their RESULTS are not discussed. Rather, they are cited for statements about the ways that farmers can adapt or expected declines in yields. |
| 222 | | This chapter includes a long list of possible or documented impacts of climate on agriculture. However, it is hard to distinguish what might be considered "first order effects" from "second order effects." In other words, which impacts are likely to be economically meaningful, and to what extent do estimates of the economic implications of these impacts exist. As mentioned in the previous comment, there are estimates of the economic impact of climate change on U.S. agriculture, dating back to the early work discussed by Adams et al. (cited in report) but also including more recent work (such as the Schlenker et al. paper also cited here). Cross-sectional economic analyses incorporate the many ways that climate can affect profitability (including the various channels discussed here) and give an indication of the magnitude of the economic impact. A discussion of the conclusions of these and related studies (see, for example, Fisher et al., American Economic Review, December 2012) would give the reader a better understanding of the current state of knowledge about the economic significance of the long list of possible impacts reported here. As written, this resembles a simple laundry list of possible impacts, with little indication of the importance of the effects either individually or in the aggregate. |
| 223 | P227/L28 | The suggestion here is that, with sufficient adaptation, the agricultural sector can "keep pace" with future climate change, implying that the real cost of climate change for agriculture is simply the cost of innovation. This is a different message than what is given on lines 16-18, where it says that impacts WILL be increasingly negative on most crops and livestock. |
| 224 | P227/L32 | The global transmission of impacts stems from the global integration of agricultural markets. There is no mention of the importance of global markets, which is what is really driving this linkage. This is mentioned in the paragraphs that follow (p. 228) but does not appear as part of the key message. |
| 225 | P228/L29 | There does not seem to be a clear basis for the statement that "such projections often fail to consider the impacts from weeds, …." The reference for this statement is Malcolm et al. 2012, but there is not a complete reference for this citation. As noted above, cross-sectional economic analyses (e.g., of the type conducted by Mendelsohn et al. 1994) embody all ECONOMIC impacts attributable to cross-sectional climate |

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| | | differences, including differences in weeds, insects and diseases. |
| 226 | P229/Fig6.1 | This figure does not appear to be referenced anywhere in the text. This is a general issue throughout the report (i.e., figures are included in a number of places without any discussion of them or reference to them in the text). |
| 227 | P230/Fig6.2 | The caption should make the point that the distribution depends not only on different effects of climate change on different commodities but also in different regions. |
| 228 | P231/fig6.3 | The caption here should state that weather, not climate, was a factor in poor harvests. It was not the overall pattern (climate) that led to poor harvest but rather the specific weather (which is influenced but not fully determined by climate). |
| 229 | P232/Fig6.4 | As noted above, the figures need to be integrated better with the text. Also, the captions tend to be long. Perhaps these figures could be presented in boxes, in which case the long discussion in what is now called the caption could simply be discussion in the box. This would set it aside from the other discussion in the text. In several places, there is information or discussion in the caption that goes beyond what is illustrated in the figure. This seems quite awkward. |
| 230 | P238/L1 | Here is an example of where the report does provide some sense of the magnitude (economic significance) of impacts. This is very useful. |
| 231 | P238/L37 | Is the message here that innovative conservation methods can (fully) offset degradation of soil and water assets? That is what this seems to say. |
| 232 | P240/L4 | scenes similar to what?? |
| 233 | P240/L9 | Can some indication of the cost of installing subsurface drainage be included here? That would help with providing some idea of the economic magnitude of the impact. |
| 234 | P241/L20 | The headings here ("Extreme Precipitation" and "Heat and Drought") seem odd, given the text that follows. The discussion in the section titled "Extreme Precipitation" is primarily about soil erosion and, to a lesser extent, about the impact of extremely HIGH precipitation (downpours) on soil erosion. It says nothing about extremely LOW precipitation. In contrast, the section on "Heat and Drought" also talks about extreme climate events, but in this case it seems to be focused on the impact of LOW precipitation (among other things) and heat stress. |
| 235 | P243/L5 | It seems too strong to say that climate change presents unprecedented challenges TO THE SUSTAINABILITY of U.S. agriculture. It certainly presents new challenges, but not necessarily to the sector's sustainability. And this is certainly not the message in other parts of the chapter, which suggest that innovation and adaptation can offset many of the impacts in this sector. |
| 236 | P243/L11 | Is not clear what it means to say productivity becomes "less reliable." Is that supposed to be a statement about increased variability of yields? |

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| 237 | P243/L30 | How is climate change supposed to affect food processing, retailing, and the ability to purchase food? Some examples to illustrate these effects are needed. |
| 238 | P244/Fig6.10 | This figure seems to be randomly placed here. It does not relate to the discussion in this section. |
| 239 | P252 | One of the references in the evidence base is Malcolm et al 2012, but there is not a complete citation for this reference. |
| 240 | P254 | The confidence for this message is rated as high and very high. However, it is not at all clear what the impacts on food processing and retailing will be and they receive only one line of text (without explicit reference) in the main body of the chapter. Thus, it seems odd that they are noted here in the discussion of confidence. Also, in the description of evidence base, if one tried to link to ERS 2012, which is provided as a key part of the evidence base, and could not find the page. Furthermore, the NRC report (2007) listed here is a report of a Workshop. In order to have high or very high confidence in this key message, it seems that more substantial documentation should be cited. |
| 241 | | There is an apparent difference between the findings of this chapter and NCA-1's agriculture chapter on the impacts/benefits of changes in climate on agriculture. Careful comparison of each of the assessment's finding would be helpful. |
| 242 | P228/L12 | Why is changing the crop type (species) not mentioned here as an adaptation? (is in main text) |
| 243 | P238/L10 | Section on 'weeds, diseases & pests' is heavy on disease and weak on pests. Suggest at least adding that much of increased pest damage will be from (1) new pests moving in (southern pests moving north) and (2) increased generation time that allows more rapid and higher buildup of population numbers during growing season and (3) warmer winters lowering winter mortality, that also allows bigger buildup of numbers. |
| 244 | Fig6.1 | Does this figure display dollar value, land allocation, or calories produced? |
| 245 | P235/L13 | The response of canopy photosynthesis to sunlight is nonlinear, with small increase in photosynthesis occurring near full sunlight and much larger increases occurring under shaded conditions. Consequently, small changes in light near full sunlight associated with variation in solar output will have a negligible effect on crop growth. |
| 246 | | Though less certain than temperature and CO2, it would be worth discussing ozone impacts. |
| 247 | P231/L13 | It should be noted here, that theory suggests that the temperature optimum is dependent on [$CO_2$]. |
| 248 | P232/Fig6.4 | caption: Given that DAYCENT was used here, these effects on yield must be entirely due to decreasing grain-fill period (or growing season length). Without accounting for effects on water stress or physiology and surface energy balance, it is hard to see how you can conclude much here. |

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| 249 | P233/L8 | Really? Citing a personal communication with yourself ?? |
| 250 | P235/L9-11 | This could probably be rephrased in a clearer manner. |
| 251 | P241/L14-19 | Seems important to include the impact of rising CO2 on water use here. |

## 7. FORESTRY

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| 253 | | In addition to regulating C exchange with the atmosphere, forests strongly affect biophysical factors (e.g. albedo and latent heat flux) regulating local climate. Particularly in boreal regions, the relative effect of biophysical factors and contribute more strongly to climate than changes in biogeochemistry. Why, then, are biophysical factors not more thoroughly discussed in this chapter and elsewhere? |
| 254 | P263/L14 | "…of forests to ecosystem change…" should read "…forest ecosystems to change…" |
| 255 | P277/L1 | The authors are editorializing in this paragraph; expressing opinion that may or may not prove to be valid. Recommend striking. |
| 256 | | When looking at impacts on the forestry sector, there are two key pieces of the picture: (1) the biophysical relationships that govern how forest ecosystems respond to climate change, and (2) the economic influences and the behavioral responses (e.g., land use and management changes) that are induced. It would help in understanding this chapter if the importance of these two was explicitly stated at the very beginning. As written, the chapter jumps back and forth between these without making a clear distinction between them and the related evidence regarding them. |
| 257 | P263/L30 | This statement about how information can improve decisions is a general statement that could apply to any sector, not just the forestry sector. It seems odd to include it here and not elsewhere (e.g., in the chapter on agriculture). Maybe this should be a cross-cutting theme, highlighted in the executive summary along with the other cross-cutting themes. |
| 258 | P263/L34 | The opening sentence here should refer more broadly to the ecosystem services provided by forest ecosystems, which include but are not limited to wood products, recreational opportunities, and amenities. This paragraph seems to undersell the importance of forests, especially their ecological value. |
| 259 | P264/L9 | The reference to the bioenergy potential of forests should, if possible, be linked to its implications for climate change. In other words, state why this is relevant to this report. |
| 260 | P264/L18 | It would help the reader to have an example or illustration of why the challenges and opportunities differ across public vs. private land. |

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| 261 | P265/fig | What is the MODIS Global Disturbance Index? |
| 262 | P266/L25 | The phrase "normal yet rare at large scales" is confusing. Does this mean they are frequent at small scales but infrequent at large scales? |
| 263 | P266/L26 | The text refers to a "growing body of research" but provides no reference(s). Need some documentation here. |
| 264 | P267/L16 | The term "mesic" is not likely to be familiar to a lay audience. |
| 265 | P267/L18 | It would help to have an example of the "major challenges to forest management" . |
| 266 | P267/L20-34 | In general, the wording in this paragraph is awkward and unclear. |
| 267 | P268/fig7.2 | This figure is not referenced in the text anywhere, and it is unclear how it relates to the text. Also, the term "fuel treatments" is not likely to be familiar to a lay audience. |
| 268 | P269/L16 | It is unclear how the last sentence in this paragraph relates to carbon uptake. |
| 269 | P271/L7-12 | This is an important recognition of the role of economic factors and other factors. This should be explicitly acknowledged right at the beginning of the chapter. |
| 270 | P271/Fig7.4 | The figure legend is labeled "Forest Production (T/ha/yr)" while the caption says that the figure shows "carbon uptake rates." This is confusing. |
| 271 | P272/L25 | Again, "fuel treatments" is not likely to be a familiar term for lay audiences. |
| 272 | P272 | In general, this discussion of bioenergy potential needs to be linked more clearly to climate change, i.e., what are the implications/conclusions of this discussion for climate change impacts? |
| 273 | P272/L5 | The reference here is to the "environmental" consequences of bioenergy production. Presumably this is intended to be a broad statement, but in its breadth, it is also vague. A more specific statement about CO2 consequences would be helpful |
| 274 | P272/L23-29 | This paragraph should be highlighted (and expanded) more, since it is really the key part of the discussion here. The idea in this paragraph should be included as part of the main message highlighted at the top of the page. |
| 275 | P275/fig7.6 | What are the IMPLICATIONS of this figure for climate change? |
| 276 | P276/L3 | The fact that U.S. climate change policies affect management choices is a general statement that could apply to all sectors, in the same way that the statement about the value of having better information applies much more generally than just in the forestry sector. As suggested above, these common themes should perhaps be highlighted much early, for example, in the section on cross-cutting themes. |
| 277 | P276/L3, 7 | The reference on line 3 is to the effect of climate change policy, while the reference on lines 7-8 is on policies related to forest land, on forest management decisions. These are two different sets of policies, although the language here seems to treat them as synonymous. |

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| 278 | P276/L19 | It is unclear what is meant by this sentence. Does "development" here simply mean "expansion"? |
| 279 | P276/L21 | Was there an explicit statement like this about the profitability of bioenergy in the previous section on bioenergy potential? The statement here is much more explicit than the statement on p. 274, lines 18-22. These two sections should be consistent in their message about the economics of bioenergy. |
| 280 | P276/L22 | The statements here about the importance of other economic factors is a key point that should be made earlier. It affects the previous issues (e.g., carbon management, p. 270) as well. Likewise, the statement about the impact and importance of societal values (lines 30-31) should be highlighted earlier. |
| 281 | P276/L36 | It is good that landowners "may be" able to capitalize on existing mangement options, but will they have an INCENTIVE to do so?? |
| 282 | P277/L2 | An example of regulatory requirements might penalize innovative management would help in understanding this point. |
| 283 | P277/L5 | It is not only the ecosystems that are responding; people are responding as well. And regulations need to embody these responses as well. |
| 284 | P277/L10 | The knowledge gap will impede effective management not only in the forestry sector, but in all other sectors as well. |
| 285 | P282 | It is surprising that the confidence for this message is only "medium." There is no question about whether this message is "true" or not. While the magnitudes of the impacts might be uncertain, the message does not include a statement about magnitudes. |

**8. ECOSYSTEMS, BIODIVERSITY, ECOSYSTEM SERVICES**

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| 288 | P291-2 | A major omission in this introduction is the low visibility of ecosystem condition to those who depend upon benefits from an ecosystem. E.g., the loss of coastal wetlands from development and anthropogenic nutrient inputs lowers the ability to buffer storm surges. But this is a surprise to adjacent residents and decision makers at all levels —despite warnings and appraisals from the scientific community. Such "known unknown" surprises have been repeated so often that they are surely important aspects of ecosystems to the NCA. Furthermore, bringing out these issues at the top-line also serves to highlight the "unknown unknown" issues in ecosystem responses to changing climates. (See also comment on infrastructure as a metaphor in Exec Sum.) |

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| 289 | P292/L11-13 | The concluding sentence is correct but weak. Consider instead: "Advances in estimating ecosystem services, ecological modeling, and methods coupling human dimensions to ecological response are providing important, increasingly actionable insights into ways to manage human systems so as to build ecological resilience for human benefit. The gathering of data through monitoring and remote sensing needed to support these analyses remains incomplete and in need of clearer prioritization, however." |
| 290 | P295/Fig8-1 | Where is this figure referred to in the text? This appears to be a problem with all the figures and the boxes in this chapter. |
| 291 | P296/L16 | A property loss of $1.9 million looks low; is it billion? |
| 292 | P296/L23 | "Almost unrecognizable" seems imprecise given the following text. Some of the discussion talks about shifts in vegetation regime (e.g., conifer to broadleaf forest) and implies that the vegetation regime would be accompanied by its current ecological companions. The ecosystems observed in a particular place would be historically unfamiliar in that case, but not unrecognizable. Elsewhere, however, the text implies that what will transform is the ecological community in a structural sense, forming assemblages previously unknown. That could well be unrecognizable even to trained observers (though the concept of conserving a stage, referenced via Anderson & Ferree 2010, suggests that unrecognizability may not be a dispositive criterion for concern). A comment clarifying which if these is meant, and the limitations in our ability to project either within the time spans of the assessment, would be helpful. |
| 293 | P299/L12 | Needs a citation for adaptive management such as the U.S. Department of Interior's Adaptive Management Technical Guide, http://www.doi.gov/initiatives/AdaptiveManagement/TechGuide.pdf. |
| 294 | P303/L23-29 | This link between these observations and a changing climate is obscure. |
| 295 | P302-5 | Box 2 provides a catalog of observed changes that are correlated with changing climate, and intersperses the list with projections of future change. The projections would be expected to be qualitatively more severe than the observed changes, since the projected shifts in temperature, recurrence of severe disturbances, and sea level rise are all substantially larger than what has been observed over the past century. This is not apparent, however, in a quick scan of the italicized projections, as compared to the plain text observations. This way of presenting observations and projections should be discussed in a caption. |
| 296 | P292/L11 | This sentence while true seems to imply that we need to understand everything there is to know about ecosystems and climate before taking positive steps to reduce damage from climate change. |

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| 297 | P293/L1 | Confusing. Is greater water yield from the Mississippi basin a function of climate change or from land use change. This should be clarified. If it's the latter, we shouldn't attribute the dead zone in the Gulf indirectly to climate change. Also see line 36. |
| 298 | P298/L27 | Invoking mismatches between microbial communities and soil nutrient mineralization seems like a reach that on the surface is not supported by the references provide. …an interesting hypothesis, though. |
| 299 | P291-292 | Key messages and intro: The intro of the chapter could note existing threats to ecosystems — development, urbanization, expansion of food and energy production. All of these stresses are currently doing more damage than climate change and are also undermining the adaptability of ecosystems to climate change. |
| 300 | P299 | Adaptation section. Regarding ecosystem-based management approaches, can the report say anything about how effective these approaches have been? are there some examples of successes that could be pointed out? |
| 301 | | Several topics in this chapter have relevance to health that is not mentioned. For instance, each of the key messages have a health dimension: |
| 302 | | *Key Message 1.* [Water quality and flow influence risk for enteric diseases as well as the distribution and abundance of mosquitoes and other vectors of human disease.] |
| 303 | | *Key Message 2.* [Fires, floods and storms have a direct influence upon human health as well as indirect influence by affecting vector populations. |
| 304 | | *Key Message 3.* [Changes in the geographic distribution of plants and animals will directly influence the distribution and abundance of disease vectors (ticks, mosquitoes, fleas, etc.) and reservoir hosts of zoonotic diseases thus changing the distribution of disease risk to humans.] |
| 305 | | *Key Message 4.* [Insect vectors also have phenologies that can increase risk of human disease by increasing the transmission season for vector-borne pathogens. Avian migration can influence the seasonality and geography of bird-borne zoonotic pathogens such as West Nile virus and Eastern equine encephalitis.] |
| 306 | | *Key Message 5.* [Management decisions should consider potential impacts upon vector-borne and zoonotic diseases which could result from activities such as wetlands restoration and species relocations or reintroductions. The discussion on increased vulnerability of invasive species should be extended to exotic pathogens of humans as well as wildlife.] |
| 307 | P291/L13 | Tone of "key messages" is unscientific in places, and may turn off the reader. Suggest the following changes: pt3 "… changes in some regions will be great enough that novel communities of plants and animals will emerge." |
| 308 | P291/L22 | pt4—correction "Timing of … HAS SHIFTED, leading to ….." |

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| 309 | P291/L25 | pt5: This needs to be placed in lay language—the reader should not have to read the main text to understand the key points. The average person equates "ecosystem" with all wildlife, nature, etc. Suggest rephrasing to make distinctions clear here and throughout. For same reason, suggest replacing 'biodiversity' with 'wild species'. Also, find another term for "ecosystem based management approaches"—the public will not likely understand what that means. Possibly "holistic mangement approaches"? "Management approaches that view whole systems rather than each species separately"? "Systems-based management"? |
| 310 | P292/L4 | Need better phrasing than "distorted rhythms of nature"—sounds like a meditation ad. Again, need more scientific phrasing. |
| 311 | P292/L34 | This section is poorly written. Need to clarify that higher N & P ultimately come from human activities—not heavier precip. Need to clarify that is an interaction of human-driven fertilization and increased transport of these pollutants. |
| 312 | P293/L4 | Again—Gulf Coast dead zone was there long before climate change—need to clarify this and then discuss how CC has & will affect already-existing dead zones. |
| 313 | P293/L41 | This is first mention that N&P come from fertilizing farms (& add high intensity feedlots, and automobile exhaust)—this needs to be moved to beginning of discussion of impacts of increased floods/discharge. |
| 314 | P296/L21 | Again, less evocative and more scientific wording is appropriate. Simply say something like "existing plants and animals may disappear from some regions, and be replaced by novel communities" |
| 315 | P296/L33 | Phrasing needs to be more careful as to causation. Increased fires in SW desert is also due to invasive grasses that burn taking over areas that used to be cactus dominated (non-burn systems). |
| 316 | P296/L39 | Most of the studies used in Chen et al (2011) are from the UK—16 UK out of 22 total studies—with 69% of species from UK+Finland. Add some refs that are more geographically diverse to support such a broad statement—e.g. Root et al 2003, Parmesan & Yohe 2003, Parmesan 2006, Rosenzweig et al 2008. |
| 317 | P298/L4 | Changes are not just predicted, they've already occurred. Change wording to "…HAVE SHIFTED …" |
| 318 | P300/L7 | Two more very good reviews of conservation strategies for climate change are: (1) Mawdsley et al (2009). A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. Conservation Biology, 23(5), 1080-1089. and (2) Pettorelli, N. (2012). Climate change as a main driver of ecological research. J. Applied Ecology, 49, 542-545. |
| 319 | P302 | Very nice figure (8.4) |
| 320 | | Few ecosystems in the U.S. are managed purely for the benefit of biodiversity. The discussion of planning makes no mention of the need to engage not just scientist and |

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| | | managers but also the public (those interested or affected by a decision). Yet linking scientific analysis to public deliberation is at the heart of adaptive risk management and has been repeatedly recommended by the NRC and the literature. This approach is crucial because very difficult value choices will have to be made as climate change alters ecosystems, drives local extinctions, and even shifts the landscape in many parts of the U.S. highly valued by the public, but with different segments of the public having very different views about the best course of action. Without up -front linking of the scientific analysis to public deliberation, trust could be shattered making effective management almost impossible. |
| 321 | | The idea behind Figure 8.4 is great (while the map is a bit clunky). It would be nice to see this approach used in the rest of the report. |

## 9. HUMAN HEALTH

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| 323 | | Section on health is limited to direct effects of diseases and health conditions within the domain of environmental health (heat stroke, respiratory disease, allergies, etc) and does not mention health threats caused by infectious agents which in some instances may pose more serious threats to human health in the U.S. (pandemic influenza, SARS, dengue fever, West Nile virus, etc.). This chapter overemphasizes the direct impact of climate and weather on health conditions traditionally considered to be within the discipline of environmental health (heat stress, respiratory ailments, allergies) and only superficially covers infectious diseases which are traditionally excluded from the discipline of environmental health. Much more research on climate change impact has been done within the discipline of environmental health because climate change issues fit well within the mission of this discipline. The effects tend to be direct and are therefore predictable. Accurate assessments can be made on current impacts and therefore projections into the future can easily be made. In contrast, infectious diseases have received relatively little attention in relation to climate change and the impacts are less direct requiring a more in-depth understanding of the processes involved. Without a basic understanding of how climate and weather influence infections in humans, projections into the future and adaptation planning cannot be made. The reasons for the imbalance between environmental health and infectious diseases are understandable and not unexpected. Nonetheless, infectious diseases do pose real and serious threats to public health and should be considered more fully in a discussion of climate change and health. This constitutes a major gap in our knowledge that should be recognized and addressed prominently in this report. |

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| 324 | | The Traceability section on infectious diseases (limited to insect and rodent-borne diseases) is not well documented and many of the references actually contradict the statements attributed. This has been a contentious topic suffering from a lack of objective studies that can be referenced. Nonetheless, admission that knowledge is weak and uncertain is preferable to citing contradictory or ambiguous references. The assessment should truthfully reflect what has been published rather than conveying a misleading level of confidence. Some example REFS: *Rogers DJ, Randolph SE. 2006. Climate change and vector-borne diseases. In: Hay SI, Graham A, Rogers DJ, editors. Advances in Parasitology, Vol 62: Global Mapping of Infectious Diseases: Methods, Examples and Emerging Applications. San Diego: Elsevier Academic Press Inc; p. 345-81.<br>*Gage, KL, Burkot, TR, Eisen, RJ, et al. 2008. Climate change and Vectorborne disease. American Journal of Preventive Medicine. 35:436-450.<br>*Lafferty, KD. 2009. The ecology of climate change and infectious diseases. Ecology, 90:888-900.<br>*Mills, JN.; Gage, KL.; Khan, AS, 2010. Potential influence of climate change on Vector-Borne and Zoonotic Diseases: A review and proposed research plan. Environmental Health Perspectives, 118:1507-1514. |
| 325 | P334/L10 | Key drivers should include changes in growing season and changes in the spatial distribution of rainfall and droughts that influence the distribution and abundance of disease vectors and reservoir hosts of zoonotic diseases. |
| 326 | P340/L10 | National, rather than global deaths should be included for wildfire effects. Other figures and health statistics should be checked for consistency of geographic base and reflect national data. |
| 327 | P343/L29 | Diseases directly transmitted by humans, such as influenza and meningitis have geographic differences in seasonality and fungal diseases such as coccidioidomycosis are dependent upon rainfall. Climate change can have impact upon directly transmitted disease as well as those that are vector-borne or zoonotic. |
| 328 | P?/L39 | The list of nationally reportable vector-borne and zoonotic diseases is much more extensive. The geographic distribution of nearly all, if not all of these diseases is dependent upon local climatic conditions and landscape features, and the intensity of transmission is commonly influenced by weather. While other factors mentioned (immunity, socioeconomic, etc.) can influence disease incidence, the fundamental ecology of the pathogen is highly dependent upon environmental factors that will be affected by climate change. Although because there have been so very few studies on the impact of climate change on infectious diseases to cite specific examples, dependence upon climate is well established in the literature for many of these diseases. |
| 329 | P345/L8 | The figure caption does not cite the correct reference for the maps displayed. The correct reference is Brownstein et al. 2005 EcoHealth 2:38-46. |

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| 330 | P353/L21 | Chikungunya is not a fatal disease. Population devastation is an exaggeration of the effects of this disease. Debilitated would be a more appropriate term that reflects morbidity rather than mortality |
| 331 | p357 | The Key Message on' Diseases from Insects and Rodents' cites the following references: Lafferty 2009; McGregor 2011; Tabachnick 2010, Epstein 2010; Reiter 2008; Rosenthal 2009; Russell 2009. But if one actually looks at these references, you find that they convey a far more equivocal, cautious message about our state of understanding than the NCA Key Message does. |

**10. WATER / ENERGY / LAND USE**

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| 333 | P398 (Fig10.4) | The caption highlights one tradeoff between the high levels of withdrawal (once-through) versus consumption (with cooling ponds/towers). It completely misses the crucial differences between these technologies with respect to the thermal pollution of rivers and threats to aquatic life. Furthermore, there is no discussion of the electrical production efficiency/losses associated with these alternatives. |
| 334 | P399/L39-40 | This statement: "A typical horizontal well for shale gas production requires from 2.5 to 5 million gallons of water, frequently from streams, reservoirs, or groundwater (DOE 2009a), but also from private water, municipal and re-used produced water" is sloppy on two scores: (i) what does this volume represent? Construction phase, operations? Daily, weekly, annual, lifetime use? and (ii) it presents what seems to be a large number, but this has absolutely no bearing on anything unless placed into some comparative context. For example, the range given would represent the equivalent of the approximate water use by a small city of 25,000-50,000 for a day, or daily consumption by one or two combined cycle natural gas cooling towers (500MW), or 10-15 minutes of operation of a 500MW once-through nuclear power plant. |
| 335 | P399-402 | Some explicit mention should be made of the politics/litigation/citizen concerns regarding fracking (e.g. the situation in NYS vs Pennsylvania), irrespective of the political constraints of motivation associated with carbon mitigation. A good place to mention this would be in the last paragraph on p.400 or the first paragraph on p.401. |
| 336 | P401 | First paragraph under Solar Power Generation. "*Efficient solar power requires long days with few clouds. Such conditions are prominent across the Southwest U.S., and, with few exceptions, current and pending utility-scale solar facilities are located in the Southwest where sparsely populated land is available. Climate change, however, is projected to affect surface and groundwater supplies within this already arid region (see Ch. 20: 11 Southwest).*" Figure 10.4 indicates a generally extremely low water requirement for solar power systems, except for wet-cooled CSP, and then only in |

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| | | terms of its consumption relative to other power production technologies. "*Another technology for utility-scale electricity generation—concentrating solar systems, requires up to 15 acres per MW and wet cooling consumes 1,040 gallons of water per MWh.*" The remainder of this section indicates there will be limits to such systems as described for SEGs. And, for photovoltaics which require less water, there are land and protected species issues (as the text indicates). But one misses the overall assessment of the value of solar technologies for truly reducing the nation's carbon emissions. Ending the paragraph with "*Thus plant designs will have to carefully balance cost, operating issues, and water availability.*" is not a very strong or compelling statement. |
| 337 | P403-4 | on Biofuels: While there is some discussion of tradeoffs with respect to land and water, there is no discussion on the tradeoffs associated with biofuels on: impacts on soil carbon and long-term fertility; the net return on energy investment of biofuels; impact of N2O emission side effects that at least partially negate the CO2 "credit." |
| 338 | P404/L10-13 | Need to mention explicitly that this potential pollution from nutrients comes from the industrial fertilizers necessary to grow these crops. |
| 339 | P404/L39-41 | The first and second sentences in the paragraph seem at odds: "Carbon capture and storage (CCS) technologies have the potential to reduce emissions from coal- and natural gas-fired plants by 90%, allowing continued use of fossil fuel in a carbon-constrained future. In addition, capturing and storing carbon dioxide emissions from the combustion of biofuels represents one of very few potential options for reducing atmospheric CO2 (IPCC 2005)." First off, 90% under what conditions and with what loss of efficiency or $$ costs? Next, the second sentence has the seemingly contradictory / oxymoronic notion of "capturing and storing from combustion of biofuels," as combustion releases CO2. And right after the 1st sentence on CCS, the phrase in the 2nd sentence about biofuels as ("one of very few potential options for reducing atmospheric CO2") makes little sense. Also, this section was presumably about geologic carbon capture, with biofuels discussed earlier; but the very next sentence will completely throw a non-technical reader: "Carbon from the atmosphere accumulates in growing plants that are used to produce a biofuel. When the biofuel is combusted, the CO2 is captured and stored, constituting a net removal of CO2 from the atmosphere for as long as storage continues and the standing stock of plants is sustained." Although an informed reader understands the closed looped concept that the authors are trying to describe, the wording (actually the word ordering) is tortuous and will completely confuse the less initiated reader. The phrase "When the biofuel is combusted, the CO2 is captured and stored," initiates this trainwreck. If the chapter is trying to discuss biofuels per se, this should have all been discussed under the preceding section. Very awkward and confusing. |
| 340 | P404-5 | section on CCS: No mention at all of the geologic issues associated with such technology; nor the stability of CO2-enriched, injected groundwater; nor assessment |

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| | | of whether or not there are enough suitable sites across the U.S. to make any meaningful contribution to the CO2 mitigation aim. |
| 341 | P405-6 | Section on Challenges to Reducing Vulnerabilities: The use of the Columbia Basin is instructive, but the text dives into what is essentially a "Spotlight" on this particular basin. It needs a little more text to stage the multi-dimensional issue. Figure 10.7 offers little but some nice colors. A more instructive graphic might be a visual depicting the various interconnections between climate-induced changes and response planning that are discussed in the text, maybe a well-crafted box and arrow diagram could achieve this. |
| 342 | | This chapter is clearly written from an energy perspective. An unkind but perhaps accurate comment may be that the chapter should be retitled "Where are we going to get the Water and Land we need to Produce Energy?" For instance, see Key Message 2, which is all about the resources necessary to meet energy needs |
| 343 | Fig.10-3 | Does not show interactions between water energy and land. The effects of energy and land are indicated for water in that the quantities used for energy (thermo-electric) and agriculture are shown. But, the energy and land data are not related the other spheres. |
| 344 | Fig.10-4 | Does present interesting data on the water required for a variety of energy sources. What would be interesting is a joint presentation of the amount of resource embedded in the other. For example, what is the embedded energy and land in different water uses, etc. What is the embedded energy and water in agriculture? For example, nitrogen fertilizers are necessary to maintain our productivity and they are produced by the Harber-Bosch process, which is very energy-intensive. It would be interesting if a diagram was created which illustrated the major interactions and interchanges between water, energy, and land use. This would be a contribution to allow for the joint impacts of climate change to be identified. |
| 345 | | The discussion supporting the third key message is not very compelling. It illustrates the interactions but provides no indication of how joint consideration of water, energy, and land use can lead to better outcomes. A discussion of what the improved outcomes might be is needed to support this key message. |
| 346 | | Overall: structure of chapter does not address water, energy, land, AND CLIMATE in upfront materials. Suggest restructure to describe the inteactions of ELW either separately or specifically include the CLIMATE interactions within or in a 2nd section. |
| 347 | | The chapter could use a good conceptual figure. |
| 348 | | Some refs to consider: • Döll, P., Hoffmann-Dobrev, H., Portmann, F.T., Siebert, S., Eicker, A., Rodell, M., Strassberg, G., Scanlon, B. (2012): Impact of water withdrawals from groundwater and surface water on continental water storage variations. J. Geodyn. 59-60, 143.<br>• Morgan Bazilian, et al.;Considering the energy, water and food nexus: Towards an |

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| | | integrated modelling approachEnergy Policy, Volume 39, Issue 12, Dec 2011, P 7896-7906<br>• Shah T. (2007): Groundwater, a global assessment of scale and significance, in: Molden (ed) Comprehensive Assessment of Water Management in Agriculture, Earthscan, Colombo, International Water Management Institute.<br>• Gerten D., Heinke H., Hoff H., Biemans H., Fader M., Waha K. (2011): Global water availability and requirements for future food production, Journal of Hydrometeorology, doi: 10.1175/2011JHM1328.1<br>• McCornick P.G., Awulachew S.B. and Abebe M. (2008): Water-food-energy-environment synergies and tradeoffs: major issues and case studies. Water Policy, 10: 23-36<br>• Shahbaz Khan, Munir A. Hanjra; Footprints of water and energy inputs in food production—Global perspectives, Food Policy 34(2), 2009, pp 130-140.<br>• A.K. Plappally, J.H. Lienhard V; Energy requirements for water production, treatment, end use, reclamation, and disposal;Renewable and Sustainable Energy Reviews, Vol.16, Issue 7, September 2012, P.4818-48<br>• World Energy Council; Water for Energy; 2010. |
| 349 | P386/L24-25 | Include natural gas, nuclear. |
| 350 | P388/L15 | "Energy mix" should include not just renewables. |
| 351 | P389/L15-22 | Possible to add more examples? Refs? |
| 352 | P391/Fig10.2 | Why not also show power demand or some other indicator to illustrate the interactions? |
| 353 | | Section on "Options for Reducing Emissions." It is unclear that the mitigation technology descriptions belong here or in the Mitigation chapter. Or is this section trying to address "E-L-W-C interactions and implications for mitigation"? |
| 354 | | Similarly, the section on "Challenges to Reducing Vulnerabilities" vs the adaptation chapter or be refocused on E-L-W-C interactions and implications. Again, this needs a powerful conceptual figure and is too dependent on singular case examples. |

**11. URBAN INFRASTRUCTURE / VULNERABILITY**

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| 356 | | This is a well written chapter which also covers the essential issues and messages in a clear and succinct fashion. |
| 357 | | This chapter is unbalanced in its singular focus on adaptation and vulnerability and none on mitigation. It lacks quantitative assessments of how much U.S. urban areas contribute to emissions and why it's important to focus on cities in the context of |

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| | | climate change. The chapter is too descriptive with many examples from hurricanes and little offered in terms of how places have overcome obstacles or robust strategies to mitigate or adapt to climate change. The implicit message in the chapter is that adapting to climate change will be like responding to a hurricane. There needs to be a wider discussion of the range of climate change impacts on cities beyond storm surges and sea level rise and at least some discussion of what cities can do to reduce emissions. Cities are engines of economic activity in the country, but there is no discussion of how climate change will impact urban economies. Are there some cities that will be more vulnerable than others? The chapter is silent on this. Are there some adaptation strategies that are more appropriate for large cities? Coastal cities? Old cities? Similarly, are there mitigation strategies that are more suited for NYC than Knoxville, or regional variations? The chapter could be greatly improved if there were more geographically-specific details about what communities can do. There are a lot of geographically-specific examples (mainly on Katrina and NYC), but little in terms of lessons learned or synthesis of different strategies. |
| 358 | | Section on Urbanization and Infrastructure: This section could expand its definition (currently missing) of infrastructure. This section currently only addresses water, energy, and transport. |
| 359 | | Section on Essential Services: This focuses too much on describing their interconnections rather than what can be done. Also, most of this section is comprised of examples. It would be more useful to know how communities can respond or prepare, rather than providing so many examples. |
| 360 | | Section on Social Vulnerability: Like the earlier sections, too focused on example of Katrina, and not enough about what can be done. |
| 361 | | Section on Trends in Early Adaptation: Most of the country is not like NYC. It would be more useful to a larger community if there were examples from smaller communities. How about including examples from places like Chattanooga or Denver? |
| 362 | | Key Message 4: How can cities overcome "barriers to implementing and incorporating wider governmental, general public, and private efforts"? |
| 363 | L33-34 | Why cities are early responders (causality) is not established in the literature. Restate to be more factual (e.g., many cities have developed climate action plans). |
| 364 | L39 | This sentence structure suggests that climate adaptation plans cause the expansion of urban landscape. |

## 12. INDIGENOUS/NATIVE LAND AND RESOURCES

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| 366 | | The chapter argues that tribal areas are poor and disadvantaged, have inferior infrastructure, and are highly dependent on natural resources, all of which will increase their vulnerability to climate change. While argument makes sense based on the general findings of the vulnerability literature, the empirical evidence on climate change impacts and vulnerabilities of tribal populations is quite thin for all areas covered in the chapter other than the Arctic. The chapter should emphasize the need for more research on impacts, vulnerability and adaptation of tribal areas and populations. |
| 367 | | In the section on traditional knowledge, the connections between climate change and traditional knowledge need to be untangled. Traditional knowledge clearly has a vital role to play in understanding climate change impacts and promoting adaptation. Climate change may also contribute to loss of traditional knowledge if the impacts are so severe as to disrupt communities. However, the loss of traditional knowledge is not (yet) primarily being driven by climate change. This loss has more to do with broader societal forces—development, globalization, assimilation, changes in lifestyle preference among young people, and so forth. The role of these other factors should be acknowledged and the causality(ies) between climate change and loss of traditional knowledge should be clearly laid out. |
| 368 | | In the section on Water Quality and Quantity, might water infrastructure shortcomings also exacerbate vulnerability to climate change and limit adaptation options? |
| 369 | P442/L12.1 | Is the map displaying percent Native American of each county's population? How were the map categories selected (8 and above, 3.0 to 7.9, 1.5 to 2.9)? These seem like relatively low percentages; the map makes it appear as if N.A. populations dominate these areas. |
| 370 | P443/L8 | The literature used to demonstrate poor socioeconomic conditions and vulnerability is all grey literature. It would be useful to include evidence from peer-reviewed literature on socio-economic conditions in tribal areas. |
| 371 | P443/Fig 12.2 | The caption mentions "mitigate and adapt" to climate change, but all of the projects seem to be associated with mitigation. |
| 372 | P444/L4 | What percent of Alaska's land base is this (44 million acres)? |
| 373 | P453/L25 | Why is there a reference to a non-U.S. location here? The text should specify that this is non-U.S. and should explain its relevance. |

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| 374 | | The chapter is clearly and well-written and particularly strong in the focus of impacts and potential threats to indigenous communities. The discussion of indigenous knowledge was particularly interesting, especially the idea that climate change may pose challenges to the application of this knowledge. Similarly to the rural communities chapter, there is relatively little focus on adaptive capacity building. This could also have brought a different and welcome dimension to the discussion. |

**13. LAND USE / LAND COVER CHANGE**

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| 376 | P472/L17-26 | There is a third reason. The benefits of altering land use include many effects that are not captured by the landowner or even the community to which the land parcel belongs. As a result, many changes that might be effective (at least over the long term) do not make sense until there is a change in the institutional arrangements to handle these commons issues. (Cf. 478/15-479/2, where there is an acknowledgment that climate is likely to have a minor impact on choices made, even though these choices will affect the resilience of communities. This is a commons effect.) The authors surely know this perfectly well, so the question is why this reason is left out. |
| 377 | P473/L14 | The time period for estimating cumulative land cover changes seems to be relevant because it is similar to the time scales mandated in the Global Change Research Act. This might be pointed out. |
| 378 | P476 | The projections reported here will seem mysterious to nonspecialist readers. Are these estimates based on economic models that drive land use changes? If so, what has been their ability to backcast? Is the rapid growth of the Sunbelt over the past two generations likely to be a model for other regions (or itself) in the next half century? Fig. 13.2 suggests that the proportions of land use will change slowly for the next 4 decades. |
| 379 | P479/L5 | "Low density housing" here is what is called suburban and exurban development earlier, and it would be useful to connect back to that terminology in discussing the wildland-urban interface. |
| 380 | | The chapter starts off with the message that individual land use decisions of people, government, organizations can have effects on climate change impacts and reduce effects on the climate. But then the remainder of the chapter largely describes land use and land use change patterns in the U.S. and the impacts of climate on these patterns, with little discussion of land management strategies that can be undertaken to mitigate or adapt to climate change. There are some examples of land decisions (e.g., p. 478), but no prioritization of what land decisions are likely to have the biggest impact. What's the message for land managers at local, regional, or national scales? It would be useful to have a clearer message about how best to mitigate climate change |

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| | | through land use practices, or the land uses and land covers that will be most threatened by climate change. |
| 381 | P481 | Some assessment of these land use plans would be useful. |
| 382 | P483 | Urban land use patterns, especially the link between land use and transportation are key determinants of urban emissions. This issue is also not covered in Chapter 11. See the works of Robert Cervero, Kevin Krizek, and Brian Stone. |
| 383 | Fig 13.2 | Why are the trends virtually constant for the 2010-2050 period? It's hard to believe that this will be the case, especially with current trends of baby boomers and <30 preferring to move back to cities. |
| 384 | | General comments: While this chapter provides important data on land cover and land cover change for the U.S, it for the most part very general and with support from anecdotes. Most of the chapter side steps specific predictions and in many places the coupling between LUC and climate is not well developed. |
| 385 | P475/T13.2 | The difference between net and gross LUC and how they were calculated was not clear. |
| 386 | P477/Fig13.2 | It's really hard to see LUC as the percentage changes are so small. Is there a way to redraw that makes the changes more obvious? |
| 387 | P479/L1-17 | This is an example of highly anecdotal information that it is difficult to generalize. |

## 14. RURAL COMMUNITIES AND DEVELOPMENT

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| 389 | | The chapter presents a clear and well-researched profile of current economic, social, demographic, and environmental conditions in the rural United States. The chapter does a nice job of covering the major dimensions of climate change impacts, vulnerabilities and adaptation in rural areas. |
| 390 | | One weakness of the chapter is that it says very little about the implications of mitigation policies and projects for rural communities. For example, mitigation policies that affect coal production could have a substantial economic impact on many rural communities, as could policies to promote production of non-fossil fuel energy such as wind. |
| 391 | | While many of the general factors that are thought to increase vulnerability of a community to climate hazards such as an aging population, high poverty rates, and lack of mental health care are present in rural areas, most of the evidence presented in the chapter is indirect. For example, regarding mental health, the discussion on p. 504 notes a) the lack of access to mental health providers in rural areas and b) the (non- |

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| | | rural) evidence that climate change can harm mental health, but provides little direct evidence that climate change will affect mental health in rural areas. The chapter should acknowledge that there is a lack of systematic research on rural vulnerability and point out that there is a need for additional empirical research in this area. (The chapter calls for additional work on both impacts and adaptation. A similar call for work on vulnerability (and mitigation) could also be included.) |
| 392 | | This comment applies to both the rural and urban chapters: Where do suburban and especially ex-urban areas fit into either the rural or urban chapters? Most U.S. residents live in suburban and ex-urban areas that are neither urban nor rural. Ex-urban areas are characterized as "metro" but many of them share more qualities with rural areas than cities, including actively functioning resource-based economies, particularly tourism and agriculture. Suburban areas are more like cities in terms of their landscape and infrastructure, but, institutionally, they may have very limited capacity for adaptation planning. A suburban municipality within a large metro area can have upwards of 100,000 residents, but it will not have the institutional capacity for dealing with climate change (e.g., planning office, emergency management office) that a much smaller city would have in another part of the country. |
| 393 | P496/Fig 14.1 | Are there any changes since 2000 based on the 2010 census data? The map should perhaps label the white counties as metro. Many of the very large counties in western states that are classified as metro are quite 'rural' in character. This is true in the East as well. Neither Massachusetts nor New Jersey have any rural counties yet both have substantial areas that would be considered rural based on presence of resource- or agricultural-base economic activity. |
| 394 | P496/Fig 14.2 | What does economic dependence entail? Does this mean that the identified sector accounts for the largest share of employment in the county? |
| 395 | P497/L9 | Does this assessment of agricultural resiliency match the assessment in the agricultural chapter? |
| 396 | P499/L24 | What about the expected need for use of more herbicides and pesticides to maintain agricultural productivity (see p. 242, line 9 in the agricultural chapter)? This would add to local pollution exposure in rural communities, particularly for farm workers. REF: Wolfe, et al, 2011: "Agriculture" in (Rosenzweig, et al, eds.) Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. Annals of the New York Academy of Sciences, 1244, 2-649. |
| 397 | P500/L5 | The direction of causality is confusing. Might reword to say that climate change will also contribute to increased demand for water for both energy and agriculture, which will then exacerbate water scarcity. |
| 398 | P504/L14 | Might also note that power and communication outages as the result of extreme events in rural areas often take longer to repair, which contributes to the isolation and |

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| | | vulnerability of elderly residents who may not have cell phones. Lack of cellular coverage in rural areas is still an issue in some places and can create problems for emergency response during power failures.<br>REF: Jacob, K., et al, 2011: "Telecommunications" in (Rosenzweig, C., et al , eds.) Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation in New York State. Annals of the New York Academy of Sciences, 1244, 2-649. |
| 399 | P506/L20 | This paints a gloomy view of the potential impacts of green energy development in rural communities. Might land-based energy production like wind-power or solar potentially benefit local land owners and local communities? The idea that green energy production can be both sustainable and equitable is being discussed in the scientific and policy literature and should not be simply dismissed as something that is not likely to benefit rural communities. A separate table with the projections by region might be more useful (to which this table could refer) |
| 400 | | It is nice to see the authors' social-ecological focus and attention to the role of natural capital in shaping the vulnerability of rural communities. |
| 401 | | It is surprising that there is no mention of immigrant communities living in rural settings, (for example, colonias in the U.S.-Mexico border). While they are exposed/sensitive to most of the impacts described in the chapter, they are also often disconnected of the formal institutional arrangements that provide rural communities (even if inadequately) with the means to cope and adapt to climate impact. The fact that these communities often include illegal immigrants makes the problem particularly complex. |
| 402 | | While there is some description of responses and risk management, there is not much on adaptive capacity building of rural systems. In particular, a discussion of how the implementation of risk management affects (positively and negatively) long term risk reduction, access to resources and sustainability of the social ecological systems where they live would have significantly enriched the discussion. It could also be of practical interest to planners and decision-makers (e.g. how to design policy that foster climate resilient pathways combining mitigation, adaptation and sustainable development, for example). Even if the evidence in the U.S.-focused literature is not very robust at this point, there is an emerging literature focusing these issues on less developed countries that could inform this discussion. |

## 15. INTERACTIONS WITH BIOGEOCHEMICAL CYCLES

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| 404 | P521-22 | Startling to see that discussion of Nr does not mention that some compounds are greenhouse gases. There is a passing mention at 520/17 re N2O but it would make sense to highlight direct contribution of Nr to radiative balance here. |
| 405 | P523/L24 | Should the reader infer that "cleaning agent" refers to chemical interactions that remove methane from the troposphere? The way these sentences are structured makes the idea of "cleaning" hard to follow for a lay reader. It's a good expository idea. Consider as a replacement for ll. 21-25: "Once released into the atmosphere methane can be removed through a variety of chemical reactions. One of these depends upon hydroxyl radicals which serve as a "cleaning agent" reducing methane concentrations. But pollution in the form of VOCs and oxides of nitrogen are depleting hydroxyl radicals, and in the future this effect is expected to increase the lifetime of methane in the atmosphere, raising its contribution to changes in the average temperature of the atmosphere." |
| 406 | P526-8 | This is an important and troublesome section. The real finding is multiple stressors rather than the connection between climate and biogeochemical cycles. Perhaps the authors would rewrite along this line (526/23-25): "Climate change is one factor interacting with other forces of human origin to change the natural world's behaviors and rhythms. Those behaviors are reflected in shifts in biogeochemical cycles (which measure the movements of key elements through the complex pathways of the biophysical world). The shifts in biogeochemical cycles are, to a substantial degree, the product of human activities now —we have become a planetary 'force of nature.' Those shifts, in turn, result in a complex set of multiple, interacting stressors that press upon humans and the ecosystems we rely upon for well-being. The complexity of the world reflected in biogeochemical cycles, in turn, must be respected when taking actions intended to moderate or mitigate the adverse effects of human-caused change." |
| 407 | P527/Fig15-4 | Caption seems to make better sense if rewritten as "Many Factors are Affected by Changes in Biogeochemical Cycles." |
| 408 | P529/L7 | "land-based" ignores the potential for managing marine ecosystems as C sinks. Better "land- and marine-based." As noted at 42-43 aquatic habitats (and marine —need a citation for this) remain scientifically uncertain, so "land-based" is appropriate in 9-26. |
| 409 | | This chapter seems to be based on a fair reading of a complex scientific literature. Although specific technical comments are offered below, overall the drafters have done a thorough scientific review. This is a difficult area, with many scientific uncertainties remaining in the nitrogen cycle. Yet there can be no doubt that human alterations of the flows of nitrogen (in large measure from the application of fertilizers in agriculture) are causing fundamental changes in the natural world. These changes |

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| | | are implicated in the changing climate, although the global-scale changes in biogeochemistry have even wider implications, such as seasonal hypoxic zones ("dead zones") in coastal marine systems. |
| 410 | | General comment: As in other chapters, there is no discussion of biophysical consequences of land use change. Will this be discussed elsewhere? |
| 411 | P521/L5 | The term "sink" implies permanent removal from the energy system and the C cycle. Burial of plant material to create fossil fuels is as close as it gets to a "sink." Everything else, including forests, represents a transient residence with a defined mean residence time that is less than infinity. We should really strive to define a more accurate term than sink when referring to the MRT of C in various pools, lest we give the false impression that storage in most biogeochemical pools is permanent. Ditto with "sequestration" (pg 524, ln 21). |
| 412 | P525/Fig15.3 | This figure is hard to understand and its not discussed in the text. What is the meaning of the labels on the x axis? Also, the colors in the legend do not match the figure. |
| 413 | P528/L10 | Remove brackets from the sentence that begins, "A Critical Load…" |
| 414 | P529/L1 | Here again, shouldn't we offer a more thorough discussion of "sink" and "store"? What is the meaningful time scale? Days, months, years, decades? |
| 415 | P530/T15.1 | Agricultural soils are reported as a C sink of -8 Mt C/y in this table. This is hard to imagine. Under the most highly productive perennial grasses, these soils accumulate about 1 t/ha/y and under most cases of annual cultivation these soils loose at least this amount of C annually. |
| 416 | P519/L18 | CO2 has increased by >40% since 1765 not 30%. |

## 16. REGION: NORTHEAST

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| 418 | | Other than the obvious and non-geographic specific consequences of increased frequency of heat waves and increased ozone levels, there is little discussion of health issues specific to the Northeast. It should be recognized that two of the most important epidemics caused by vector-borne diseases, Lyme disease and West Nile virus, originated in the Northeast. Although the role of climate change in the emergence of these diseases has been speculated without convincing evidence, it is well documented that tick populations are expanding their ranges northward and mosquito populations are regulated by both rainfall and temperature. The Northeast may be more vulnerable to other tick-borne diseases and exotic vector-borne pathogens. |
| 419 | P561/L29-35 | Would it be worth noting that the estuaries are critical habitat for breeding for many |

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| | | species of economic and cultural importance to the region? |
| 420 | P565/L21-23 | The idea of a 100 or 50 year event in a 30 year time span will confuse most readers. |
| 421 | | Could a figure like Fig. 16.3 (projected increase in the number of 95 F days by 2041-2070) be construed as overdriving our forecast headlights given all the (likely) unjustified mesoscale detail shown? |
| 422 | | Heat wave issues are mentioned for the Northeast but nowhere else. Could a naive reader conclude that more frequent heat waves will only be a problem in the Northeast? |

## 17. REGION: SOUTHEAST AND CARRIBEAN

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| 424 | | Among the litany of negative climate change impacts discussed here, there seem to be some inconsistencies within the chapter and with other parts of the NCA report. For instance: (i) The chapter says that temperatures in the region have been rising (p.586), but Figure/Caption 8 in the 'CAQ appendix' (p.1068) indicates there has been no warming in the southeast. (ii) The chapter discusses the uncertainties associated with precipitation projections, and shows that portions of the region may get more rain (p.587), which seems at odds with statements elsewhere in the chapter (p.598) about the threat of severe droughts. We suggest that the chapter authors try to reconcile these different statements as clearly as possible. |
| 425 | | A map delineating the regional boundaries should be added at the beginning of the chapter. |
| 426 | P587 | Line 16 says, "Projections of future precipitation patterns are less certain than projections for temperature." Text describing the certainty/uncertainty of both temperature and precipitation should be added. |
| 427 | P591/L13 | This paragraph provides examples of roads and the costs associated with addressing their sea level rise vulnerability. Consider moving this information to a box as examples of infrastructure already being impacted, since the specifics provided are not introduced well in the text. |
| 428 | P599/Fig 17.11 | Depicts trends in water availability. The caption suggests that average annual water yield for the ten-year record of 2001 to 2010 is being compared to the average annual projection for the fifty year period of 2010 to 2060. Additional explanation is need to explain why the base period was chosen, and what the statistical confidence is for the projections. |
| 429 | P596 | The discussion on vector-borne disease in a warming climate is an underestimate of the potential importance. Other sections in this chapter suggest that southern Florida is |

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| | | likely to become more tropical and less temperate. As a tropical island connected to the mainland, south Florida has the potential for hosting a variety of tropical vector-borne diseases including dengue fever, Venezuelan encephalitis and other untreatable viral infections that could easily expand into the more populated areas of Florida and other southeastern states. |

**18. REGION: MIDWEST**

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| 431 | P617/L21 | One could take issue with the clause "…[t]he regions role as a net absorber of carbon….]. While most young and maturing forest are indeed "carbon absorbers," land in row crop agriculture is a net source of C to the atmosphere. What is not made clear in this chapter, is when agriculture land and forests are taken together, is the entire region a net absorber of C? |
| 432 | P625/L10 | Given that the assessment's primary goal is to evaluate effects and vulnerabilities to climate change, a discussion of the effectiveness of bicycles etc. seems a bit out of place. |
| 433 | P631/L1 | Why use Fahrenheit in a scientific assessment? |
| 434 | | There should be more emphasis placed on the role of increasing CO2 in altering moisture dynamics. The current discussion on CO2 effects on crops focuses only on the fertilization effects on photosynthesis. While this is a direct and primary effect on C3, the indirect effects of increased moisture availability during periods of drought appear to be the primary response of C4 to elevated CO2 (e.g. Leakey et al., 2009; De Souza 2013 ; Hussain et al., 2013). Because this is a climate report and crops play such a major role in regulating climate in the Midwest, consider adding a brief discussion on CO2 and water. There is also pretty strong evidence that O3 will reduce water use efficiency, at least of soybean, perhaps this could also be discussed, if not here than in the chapter on agriculture. REFS:<br>• Hussain MZ, Vanloocke A, Siebers MH, Ruiz-Vera UM, Cody Markelz RJ, Leakey AD, Ort DR, Bernacchi CJ. 2013. Future carbon dioxide concentration decreases canopy evapotranspiration and soil water depletion by field-grown maize. Glob Chang Biol. doi: 10.1111/gcb.12155.<br>• de Souza, A.P.; Arundale, R.A.; Dohleman, F.G.; Long, S.P.; Buckeridge, M.S.; . 2013. Will the exceptional productivity of Miscanthus x giganteus increase further under rising atmospheric CO2? Agricultural and Forest Meteorology. 171. 82-92.<br>• Leakey, ADB (2009) Rising atmospheric carbon dioxide concentration and the future of C4 crops for food and fuel. Proceedings of the Royal Society B: Biological Sciences 276: 2333-2343. |

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| 435 | P617/L21 | Agree with your remarks here. This is an important area to clarify. |
| 436 | P618/L5 | "some America's great cities," rather subjective and awkwardly phrased. |
| 437 | P618/L30-33 | This is a little difficult to understand, perhaps try an alternate description. |
| 438 | P619/Fig18.1 | caption: Trend implies a rate of change. Suggest: rephrasing or giving the slope of this line. |
| 439 | P620/L9 | The $CO_2$ offset in Leakey 2009 is for moisture stress. There is no offsetting affects for temperature. |
| 440 | P626/L7 | Should probably stick with "heat trapping gasses." |
| 441 | P626/L30 | "Prices" here is a little vague. |
| 442 | P627/L7 | This could potentially be a bit misleading. This could be interpreted as 10 consecutive days. Recommend rephrasing "the 10 rainiest days can contribute as much as 40% of total precipitation in a given year." Also, given the information in the following sentences, it is important to give a timeframe for the numbers presented here. |
| 443 | P629/L12 | "Northern reaches" is not the best descriptor. |
| 444 | P631/L9 | There should be a caveat made here with regards to the period selected. This must correspond to the satellite record, but it is important to clarify if the 1970's had particularly high ice coverage as a result of the well documented period of anomalously cold temperatures. |
| 445 | P617/L33 | Should this be Great Lakes rather than Great Lakes region? |

**20. REGION: SOUTHWEST**

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| 448 | | The chapter collates a wide range of literature on climate-related stresses to humans and ecosystems of interest to humans. It is noteworthy that there is no attempt to estimate the magnitude of the vulnerabilities, either in terms of measures of well-being such as Disability-Adjusted Life Years or in economic metrics such as dollars or percentage losses of regional GDP. This is a task for research, perhaps. |
| 449 | P692/Fig. 20.3 | If the area of the circles is meant to correspond to the numbers, they don't look quite right. E.g., the ratio of diameters of the largest (CA) to the smallest (UT) circles should be 2.65 (square root of the energy generation numbers). But I measure this ratio as approximately 1.7. |
| 450 | P696/Fig. 20.5 | The import of this comparison is in the covering up of the substructure shown beneath the parked cars in the Feb 1 image. But the two images are not cropped the same, so the force of the comparison is weakened. If there is more image in the Jan 20 figure, so that |

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| | | it can be zoomed out, that would make the figure more forceful. |
| 451 | P697/L13-17 | The larger population at risk with a 3-ft rise is presumably estimated with a model or set of assumptions about settlement density once the rise occurs. Over the past century, however, the density of settlement may have increased markedly. So being clear about what is assumed for the future and benchmarking it to what has happened through economic development and cultural preference is worthwhile. The social science point to make is that changing settlement patterns have dramatically increased exposure to sea level rise, forest fires, and drought. That is a point often not considered, despite its relevance to questions of changing land use in the decades to come. |

**21. REGIONAL: NORTHWEST**

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| 453 | | Except for ocean acidification, all of the issues referred to here have been "wicked problems" for decades (water, coastal erosion, forest health). Changes in the various dependencies (shifts in crops as a result of changes in world demand, forest practices that leave more undergrowth, etc.) are just some of the "non-climate" processes that are critical. What does climate change bring to the party? A change in the statistics, such as magnitude and frequency? Moreover, are these non-climate processes, such global economic growth and changes in technology, more likely over the next 50 years? And will they have a greater impact? |
| 454 | P737 | Key message #1: The message is that the timing of snowmelt will change. The text in the evidence base notes that there is "good agreement" but that "trends [are] less certain because of climate variability." Moreover, it is stated that "current and future interannual and interdecadal variations in climate will enhance or obscure long-term anthropogenic climate trends" is a key uncertainty. Now this is all correct, and one might conclude that this is a result to watch but that's too uncertain upon which to base shifts in policies or practices. However, this subtle message is lost in the text of the chapter. Instead, the reader would go away with the conclusion that this is a scientific certainty. |

**24. OCEANS AND MARINE RESOURCES**

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| 456 | | The planet has one ocean and one atmosphere. By continuing to pluralize the ocean the authors lose the opportunity to showcase that the ocean is connected throughout the world, to the atmosphere, land, ice, and seafloor. Climate is more than the average of weather. The authors could showcase this connectedness by careful choice of their words. |

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| 457 | | This chapter requires a good editing. It is duplicative, does not flow from evidence to interpretation, fails to demonstrate evidence, mislabels figures, and needs a good spell/grammar check. The key messages are wordy and hence require multiple readings to understand the point. They could be simplified to enhance understanding. For example, message three could be stated: Significant marine habitat loss will continue to occur due to climate change particularly in Arctic and coral reef ecosystems. In other areas (are there specific areas identified yet?) habitats may expand with associated shifts in species distribution, abundance, and productivity. Message 4 is very confusing and could be simply stated: Rising sea surface temperatures have been linked with increasing levels and ranges of diseases in humans and marine life. Messages 5 and 6 need work as well. |
| 458 | | Throughout this chapter as well as probably the entire report, there are not clear uses of the terms "impacts, " risks" , and "vulnerabilities." |
| 459 | P836/L28 | Please do not use the word "manmade." Gender neutral language should be used. |
| 460 | P837/L3-15 | Figure caption is incorrectly stated. The figure shows seas surface temperature anomalies, not sea surface temperature. The figure does not allow the writer/reader to infer the loss of biological diversity as stated in the last two sentences of the figure caption. This conclusion should be developed in the narrative following the introduction of the figure. |
| 461 | P838/L2 | Satellite observations of what? Presumably ocean color, but it would be nice to showcase why you need these types of satellite observations. |
| 462 | P840 | Prior to this box the only source of ocean acidification that was discussed was atmospheric carbon dioxide. This particular example illustrates other sources of natural, episodic events that create ocean acidification in local/regional waters. The introduction of these natural sources that can interact with human caused change should be mentioned before the box or it should be mentioned in the first paragraph of the box. |
| 463 | P840/L3-4 | Has there not been evidence that the polar bear can evolve/adapt to land-based habitat? Wasn't some work that shows the early polar bear had spent considerable time using the habitat on what is now Greenland. The question probably is will the polar bear if given enough time, adapt to other habitats? |
| 464 | P842-843 | Is the section titled Coral Reef Ecosystem Collapse a box? I see an "end box" notation but not a "begin box." In any case this section uses language that is too technical. Line 25: "flattening of the three dimensional structure"; Line 28: "the symbiosis between coral and its associated algae partner." Line 27: delete "other." Need to explain these terms and processes. |
| 465 | P844/L24-34 | Out of place; move to right after line 13? The topic of the paragraphs are jumping around from diseases in marine life and diseases in humans. |
| 466 | P845/L2-7 | Suggest rewriting the key message. Suggestion: Altered environmental conditions due to climate change will affect human uses of the ocean (transportation, resource use and |

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| | | extraction, leisure and tourism activities and industries). (Suggest deleting the next sentence—I don't think marine activities have ever been "designed"). Human uses of the ocean depend on the current state of the ocean's ecosystem services. Climate changes that result in ocean conditions that are significantly different than the current state may significantly disrupt the economies, access, and enjoyment of the ocean areas. |
| 467 | | Do you want to mention governance of the ocean in your key message? Also should you not mention that there will be opportunities resulting from this climate disruption of the marine environment—and there will be some winners in a new climate regime. |
| 468 | P845/L8-17 | An entire paragraph on the Arctic and security yet no mention of the International Law of the Sea? |
| 469 | P845/L24 | Are these numbers for marine tourism or tourism in general? |
| 470 | P845/L31-32 | Not mentioning increasing probabilities of more extreme events? |
| 471 | P846/L15 | "Greater effect" should be replaced with "positive effect." |
| 472 | P846/L17-19 | This sentence is out of place. |
| 473 | P846/L20-23 | Seems to be a different topic than lines 23-29. |
| 474 | P849/L16 | As far as one can tell, the chapter has illustrated "impacts" not "vulnerabilities." |
| 475 | P849 | "New information and remaining uncertainties"—lots of grammatical errors in this table. |
| 476 | P851 | First sentence in "new information and remaining uncertainties" is not discussed in the narrative yet is an important point. |
| 477 | P855 | Are the authors convinced that there is "high" confidence that adaptation planning can help mitigate the impacts of ocean conditions"? Is hard to see the strong evidence for this rating. |
| 478 | | As with the other chapters, there is a disconnect between the material in the chapter and the material in the traceable accounts. Frequently, the chapter text is a bit overheated whereas the table material is more circumspect. Second, the chapter makes allusions to ongoing multiple stressors but the takeaway message is that climate change is driving us to destruction. The coral reef example is a classic. Yes, climate change adds to the stress, but reef destruction has been going on for decades. Fish harvesting, invasive species, etc. may be more important drivers. The report could have added more value if there were climate science insights into how climate might change the nature of these stresses, impacts of new threats, etc. Instead, it leads to the illusion that climate is dominant. The New England fisheries text box is another example. This has been a long saga (with NOAA closing the fishery recently). We need to address these issues—is climate change |

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| | | really a driver? |
| 479 | | The fact that the chapter never mentions the U.S. Commission on Ocean Policy is very troubling. USCOP identified many of the same issues, but it took a governance focus rather than a climate change focus. So two smart groups can take essentially the suite of issues, do a sophisticated diagnosis, and come up with very different approaches. Interesting! |
| 480 | Fig24.3 | An example of how a simple graphic can be misleading. It is a compelling image, but the text in the traceable accounts states "how those responses will cascade through foodwebs and ecosystems is still uncertain... much remains to be learned." "... predictions of ecosystem changes have low confidence." The image of shrinking clams is at odds with the final message that we really don't know what will happen. |

**25. COASTAL ZONE DEVELOPMENT AND ECOSYSTEMS**

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| 482 | | This chapter succeeds in highlighting the very significant risks associated with our nation's exposure and dependency in/on coastal zone development and ecosystems in terms of climate change impacts. |
| 483 | | Key message 1 is that coastal lifelines are increasingly vulnerable. Key message two is that these coastal vulnerabilities have national economic impact. The messages could be stated more succinctly than currently described in the text. |
| 484 | P867/L21 | The portion of key message 3 addressing displacement of vulnerable populations is problematic, i.e. you could argue that moving vulnerable populations from the most at risk areas is positive. Decreasing diversity is not a positive outcome, however, in terms of risk reduction moving to less vulnerable locations is an appropriate adaptation response. The message would be stronger if it ends after the word "communities." Another alternative might be to separate this message into two, one about socioeconomic factors increasing climate change impacts by limiting adaptation options, and the second around loss of diversity on the coast, which is a community value issue that should be addressed as part of adaptation planning. |
| 485 | P869/L32 | Delete "and" before ocean acidity. |
| 486 | P871/Fig 25.3 | This graphic is confusing. Why was 1992 used as the base elevation for panels a and b? Panel c uses "mean high water level during the tide gauge record" as the base elevation. Suggest re-titling Panel C as "100-year return flood elevations above MHW," and separating panels a and b from panels c and d. |
| 487 | P875 | Adaptation Examples—Mid-Atlantic box is missing text at the end. |
| 488 | P877/L8 | Has coastal been defined? |

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| 489 | P881/Fig 25.7 | This is a compelling figure that illustrates the connections from the coast to the rest of the country. However, suggest re-labeling to Louisiana Coast to Inland Economic Connection. Or add to the Caption text explaining figure is one example, i.e. Louisiana. |
| 490 | P882/L20 | See earlier comment re: Key Message 3. |
| 491 | P885/Fig 25.9 | Needs a legend and scale, i.e. red indicates land loss? |
| 492 | P887/L1 | Adaptation Planning. Here vs Adaptation Chapter? |
| 493 | P887/L33 | "A robust finding is that the cost of preventative hazard mitigation is 4 to 10 times lower than the cost of inaction" Should this be a key finding? |
| 494 | | The "Social Vulnerability Index" does not seem especially compelling. These indices are extremely sensitive to the underlying assumptions and weights. If the team feels that the SoVI is powerful, why does it appear only in this chapter? |
| 495 | P883/L5 | States that "217,000 individuals are currently exposed." Since census data are statistical, putting out the number 217,000 (and not 218,000) gives a false impression of precision. |
| 496 | P888/L14-18 | It is stated that changes were made to the National Flood Insurance Program that ensured that the "program is fiscally sound." Actually, that is not the case. These "reforms" helped but the program could not pass muster in front of any state insurance commission—there is no way it can pay the claims that it could reasonably expect in the next decades. Most people think it needs a more radical transformation to move towards a system like Germany or the UK where private insurers can write the policies (and assume the risks.) The present program, although tweaked, will continue to assume greater risks and inadvertently encourage infrastructure to be built without regard to risk. This seems to be inherent in government-funded approaches that 1) can print money and 2) respond to political pressure, not economic pressure. |

## 26. DECISION SUPPORT

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| 498 | P927/L35 | The heading is followed by text that presumes the value of decision-making as a means of making choices. This is well-known to be incomplete as a description of choices made by individuals and institutions (e.g., Kingdon, John W. 1995. Agendas, alternatives, and public policies. New York: HarperCollins). Making a decision entails creating a record that supplies a basis for reasoned selection of options. In contrast, choices can be made A) by habit or continuation of existing practices (as is common in a large fraction of budget choices, for instance), or B) via negotiation and |

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| | | compromise that has little or no basis in knowledge of the connection between choice and outcomes. In this light, making choices through explicit decision making (and with decision support) is important for reasons of accountability, because a decision may be more traceable when outcomes emerge. For that very reason, actors who make choices may avoid decision support as a way to avoid or weaken accountability. This is a phenomenon that needs to be recognized in the chapter; it is likely, moreover, that behavioral research on the relationships among rules, incentives, and power can help to illuminate when decision support is likely to be used. That would guide further investment in decision support in a way that is not yet done but is needed. (The points made here extend the discussion on 929, and that may be a reasonable place to include consideration of this critique.) |
| 499 | P928/L7 | On "more difficult," cf. Layzer, Judith A. 2012. The Purpose and Politics of Ecosystem-Based Management. M.P. Weinstein and R.E. Turner (eds.), Sustainability Science: The Emerging Paradigm and the Urban Environment, DOI 10.1007/978-1-4614-3188-6_9, Springer Science+Business Media. Pp. 177-197. This article reports on a comparative evaluation that concludes that ecosystem-based management leads to outcomes that are arguably lower in quality than decisions reached without the elaborate investment in decision support that lies at the heart of EBM. Layzer is skeptical on the point raised at 929/30-31 (facilitators). Authors may not agree with Layzer but her research (in this article and a 2008 book, Natural Experiments) should not be ignored; it may suffice to include a brief discussion at 940/33, where a "need" for science translators is asserted. |
| 500 | P928/L15 | "Learning by doing" includes trial and error learning. Trial and error utilizes decision support in a logically different way than planning based upon deterministic models of the system being managed, in the sense that decision support does not aim at a prediction of outcomes. In particular, learning-based choice strategies require different, sometimes larger investments in monitoring than situations (e.g., designing a bridge) where predictive analysis is available. This should be acknowledged, perhaps in the related discussion of handling uncertainty and complexity. |
| 501 | P930/L1-15 | Good introductory mention of boundary spanning. Should add to Traceable Accounts the helpful typology in Clark, William C., Thomas P. Tomich, Meine van Noordwijk, David Guston, Delia Catacutan,Nancy M. Dickson, and Elizabeth McNie 2011. Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR). PNAS, doi 10.1073. |
| 502 | P933/L7-12 | The "cone of uncertainty" seems to imply that scenario planning or RDM can predict the range of outcomes. This is incorrect: RDM is a way to specify a (large) range of scenarios so as to study the implications of known variations in known variables. That is valuable but it is not the same as analyzing uncertainty. |

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| 503 | P933/L16 | This subsection raises a significant point: when is decision support worth using? The text is inconclusive, however. Authors suggest that the value of information and analysis can be negative at the margin —a notable assertion that is important to the NCA as a whole. If so, how would one know whether decision support should be used or developed? If knowledge on this point is not readily available, what research is needed, and is there a precautionary policy that should be adopted in the meantime? The text on 934f implies that risk analysis and management is generally a good conceptual framework —is that the precautionary policy? Note also that value of information is not listed on 941 as a topic needing further research investment. |
| 504 | P936/L28-31 | Are the approaches included meant to be a representative sample? The list of approaches has a systematic feel to it (analytic methods, data management, etc.) but no system is mentioned. Authors should articulate some rationale; a claim of representativeness may be sufficient. |
| 505 | P939/L33 | "Lack of tools" is not enough of the story. To be useful for learning, tools need to be maintained over time, and that is very difficult without routine use by a community of users with resources to support maintenance. [REF: Curtice, Corrie, Daniel C. Dunn, Jason J. Roberts, Sarah D. Carr, and Patrick N. Halpin 2012. Why Ecosystem-Based Management May Fail without Changes to Tool Development and Financing BioScience 62:508-515]. The implication of this paper is that it may be unwise to invest in more tools until a focused appraisal of use, including analysis of extension and consultancy models for public agency users, is carried out. |
| 506 | P941/L5 | "Ongoing evaluation" faces the problem of defining a counterfactual —what would have happened absent an intervention. In a non-stationary climate, it is particularly important to be aware of counterfactuals, since the background assumption of stationarity may not be valid over the time scales relevant to an evaluation (or to perceptions of change and risk). This is worth considering at this point. |
| 507 | P942 | Unclear why authors do not offer a confidence rating on the scientific basis for their normative judgment. Cf. note on Layzer above, 930/1-15. |
| 508 | P944 | Remaining uncertainties rating might look at (frail) basis in evaluation literature on use and effectiveness of these tools. Note partial relevance of Curtice et al (comment on 939/33); the implication there is that it may be unwise to invest in more tools until a focused appraisal of use, including analysis of extension and consultancy models for public agency users, is carried out.. |
| 509 | P945 | Remaining uncertainties rating might look at nearly absent basis in evaluation literature on use and effectiveness of science communications. An anecdotal example is Goldston, David 2008. Getting it across. Nature 45:16. |
| 510 | | This chapter doesn't assess the state of decision support. Instead, among research needs at 941.21-11, it calls for "comprehensive analysis of the state of decision support for adaptation and mitigation." Is this an abdication of the task? The chapter identifies |

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| | | decision frameworks and "tools" that are available, but doesn't assess their quality or usefulness, or the match between tools and decisions. Arguably, for example, there is better information available to support mitigation choices than adaptation choices, but the chapter doesn't go there. |
| 511 | | The chapter describes what an ideal decision support system would look like, but doesn't assess the extent to which such systems are in place, generally or for particular classes of decision makers or decisions. |
| 512 | | This is a well-written chapter that provides recommendations to improve our decision support infrastructure. The key messages are well supported in the text. Key Message 1 (p. 925) is particularly critical to improving climate change policy development and decision processes. |
| 513 | P926/L24 | "value questions that arise" needs to be re-stated or clarified. |
| 514 | P926/L28 | Suggest rewording "identification of climate risks and opportunities" to identification of risks and opportunities associated with climate change, OR combine with previous sentence. |
| 515 | P934/Fig 26.5 | Suggest moving this figure so it comes after p. 935, lines 10-20 which explain the terms in the Risk Assessment box in the figure. Also suggest equalizing (in size) the Risk Assessment and Risk Perception boxes, which feed into the Risk Management box, which should also be centered to better demonstrate the equality of assessment and perception. As currently drawn the feedback loop from Risk Management does not affect Risk perception. Authors should confirm this intent with text. |
| 516 | P936/L32 | Comparative Tradeoff Methods. |
| 517 | P937/L32,39 | The use of the term "objectives" is confusing. Recommend defining objectives for purposes of this section. |
| 518 | P939/L40 | Agree that use of "ensembles" is a valuable objective. Given the public's understanding of modeling ensembles in weather contexts, particularly hurricane forecasting, , the addition of a Box or text discussing the current utilization of ensembles in terms that will resonate with many readers should be considered. |
| 519 | P941/L23 | Restate to better align with the other bullets, i.e. Investments in understanding the cost and benefit of non-market ecosystem goods and services analyses … are needed. |
| 520 | | The chapter is clearly written, informative and nicely organizes information focusing on the several kinds of decision support models that have been and can be applied to climate-related decision-making. They meet the challenge of summarizing and synthetizing a broad literature that spans decision science, STS, risk analysis, etc into a short and concise chapter. The authors did a good job of describing different decision frameworks and offering readers information on the many ways science and decision-making intersect in mitigating and responding to climate change. When thinking about the goals for the chapter, one can imagine there are two main 'uses'. First, as a |

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| | | roadmap for decision-makers to quickly access current decision frameworks and get started thinking about how their own decision needs can be informed by existing models. Second, as a scientific synthesis of the literature focusing on science-society interface, aiming at identifying gaps and future research needs. |
| 521 | | The chapter is that it offers a somewhat unidimensional description of the existing models that might fall short from meeting both goals. While the authors recognize the many dimensions of informing decision-making (lines 24-29, p. 926), the chapter is mostly normative in its description of different decision frameworks, paying relatively little attention to the empirical literature focusing on the opportunities and challenges of applying these frameworks. It begs the question: if these models are available and useful, why aren't decision makers adopting them more readily? Figure 2.6 defines 'effective outcome' as knowledge (and its desirable characteristics) rather than use (decision outcome). The focus in on the knowledge production function, instead of decision-making/usability. Empirical literature shows that not all knowledge that is credible, relevant and legitimate gets used. In contrast, when the chapter actually focuses on empirical examples of use (e.g. Denver water and data management), it comes to life. That could be attractive to decision-makers looking for ways of incorporating scientific information to their decision processes. Unfortunately there is not enough of it. For example, there is an endorsement of participatory/interactive science production and use processes (whose effectiveness is well-documented empirically) but scantly any mentioning of the challenges and limitations of these processes shown in the literature. It also mentioned the need to better understand means of increasing use of climate information but not much on how to scale up usage to a broader number of users outside interaction-intensive processes (which have been shown difficult/costly to scale up). If the goal is to inform decision-making actors about current frameworks, the chapter needs more examples and a practical roadmap of where to start and examples where users can see themselves. If the goal is to synthetize the knowledge and identify gaps it needs to pay more attention to the empirical literature focusing on actual climate information use, its opportunities and challenges and what we still need to understand to design better DST and processes to deploy them. |
| 522 | | Lines 39-40 p. 926 references? |
| 523 | | Typo on figure 26.2 (Relevance). |
| 524 | | This is a well-written chapter whose contributors include some of the country's best-known experts in decision science. This is clearly a strength, but it may also be a weakness. Much of the chapter consists of generic discussions of what the authors refer to as "idealized" models of decision-making processes. There is no discussion of what makes climate change such a challenging decision problem. The reasons given by the authors are not particularly persuasive; many problems call for decisions where there is considerable uncertainty, where scientific information is lacking or difficult to access, and where stakeholder interests are diverse and often conflicting. Almost no |

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| | | emphasis is given to what *is* relatively distinctive about climate change decision making, which is that the adaptive management capabilities of our institutions are seriously challenged by complex problems that unfold on long time scales. How can we ensure that there are mechanisms to sustain sound decisions and effective policies over time while having the flexibility to alter those that do not seem to be working? (See, for example, an article by Richard Lazarus in the Cornell Law Review on the "superwicked" problems of climate change). The chapter does not take into account the context in which decisions regarding climate change are being made in the U. S. Mitigation and adaptation decision making are highly politicized, and this is further complicated by the fact that responses to climate change are being framed as a threat to economic recovery. In placing so much emphasis on what they acknowledge is an "idealized" perspective on climate decision support, the authors spend very little time discussing how climate-related decisions are made and decision support tools are used in real-world situations. The authors review different approaches, such as tradeoff methods, scenarios, and integrated assessment models, without discussing research on how those tools have been employed, and to what effect. There has been research on integrated assessments, such as the RISAs (see, for example, Roger Pulwarty and co-authors, "The Regional Integrated Sciences and Assessment Program: Crafting Effective Assessments for the Long Haul"). What does that research and other studies tell us about the use of such assessments and how they influence decision making? What about other tools? |
| 525 | | It is unclear why the authors chose to discuss the "knowledge enterprise" system that was developed to provide information to decision makers during the Deepwater Horizon oil spill (a crisis situation), nor is there detailed information on what decisions it informed. The same is the case for other data management systems and other decision tools. Problems associated with such methods are not discussed; for example, in the case of data management tools, what if data are missing or contradictory, or so abundant that they actually hamper decision making? Various tools are introduced, but little is said about how they have been used to support actual decisions in U. S. communities. For example, a brief mention is made of a land-use planning tool that has been employed in Florida, but there is no discussion of its impact on land-use planning decisions—only that it provides information "in a context that is relevant to decision makers." Who are the decision makers? Who are the stakeholders? What climate-related decisions are being considered? The Denver Water case is a little more detailed, but readers get little information beyond being told that the utility is "using scenario planning." Who specifically is using it within the organization, what impacts is its use having on decisions, who are the stakeholders, and are they involved in the process? If the scenarios are making a difference in the decisions that are being made by Denver Water, why is that the case? How have regulators, the general public, and other stakeholders had an influence on decisions. |
| 526 | | The chapter contains some imprecise statements. For example, it is stated that "Social |

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| | | scientists and psychologists have studied people's concerns about risks…and found that people view hazards with which they have little personal knowledge as highly risky, and they especially dread them." This is a broad generalization that simplifies complex risk perception issues. I have no personal knowledge of what it is like to fly in a hot-air balloon, but that doesn't automatically mean that I see that activity as highly risky, or that I dread it. Some of the chapter authors have a comprehensive knowledge of the risk perception literature, so its curious why they chose to use these kinds of shorthand explanations for risk perception phenomena. |
| 527 | | The title of the chapter suggests that readers will learn about what is happening in the U. S. in terms of "supporting policy, planning, and resource management decisions." However, the chapter doesn't provide that kind of information. It mainly summarizes well-known points from the decision science literature and from a few NRC studies. The emphasis is on "idealized" models and general knowledge on decision support processes and tools. |
| 528 | General | This chapter makes a number of statements that are rather vague, confusing, and in some cases unsubstantiated. The organizational structure is also difficult to follow. Unlike in other chapters, the text following the three key messages is not directed toward those specific messages, but rather jumps around frequently, making the logic/structure of the chapter hard to follow. |
| 529 | P925/L22 | The first statement of key message #1 is an example of an unsubstantiated statement. While it might be true that it is important to create an appropriate process IN ADDITION TO having good scientific information and tools, what is the evidence that supports the statement that having such a process is AS IMPORTANT AS having good information and tools? Both are important, but I don't think there is a basis for saying one is more important than the other. |
| 530 | P925/L28 | These tools are available and used for a number of different decisions, not just decisions about climate change adaptation and mitigation. There is a need to put these tools and processes into the broader framework of decision making about a broad range of issues AFFECTED BY climate change. There is also experience with using these tools, and the state-of-the-art not just in terms of development but also in terms of use should be discussed. |
| 531 | P925/P30-37 | Some of these do not seem to rise to the level of a key message, and the support for them is not provided in the text. For example, while it may be true, the need to improve reward structures is not substantiated in the text and is too specific for a "key message." |
| 532 | P926/L5-9 | It is important to describe this "idealized" process explicitly and to highlight it (rather than burying it in a single paragraph in the introduction). However, it is equally important to refer back to the steps of this process at various points (both here and throughout the report) to show how the various pieces fit together and contribute to better decision making. There are statements about improving decision-making |

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| | | throughout the report (see, for example, the chapter on forestry) but they don't link to the discussion here. |
| 533 | P926/L40 | The lay public is not likely to understand the differences among decision "frameworks, "tools," and "processes." More specifics, or examples, of these are needed to help distinguish among them. |
| 534 | P926/L42 | The issue is not "climate change decision making" but rather "decision making in contexts affected by climate change." |
| 535 | P927/L21 | Individuals don't just make decisions about preparedness. They make behavioral decisions/choices every day that affect emissions of GHGs. |
| 536 | P927/L38 | It is fine to say that having an "effective" process is helpful, but this statement is not particularly helpful. It begs the question "what IS an effective process?" There is presumably a large literature on, for example, participatory processes, which identifies best practices. What are those? Can't some findings from the literature be built into this key message? |
| 537 | P928/L5-6 | Adaptive risk management is a type of management strategy (not a decision support tool), but it doesn't necessarily involve a collaborative process with researchers and (all) stakeholders, i.e., while it might involve "interaction between decision-makers and the scientific/technical community," it does not necessarily "engage all affected parties." Yet, the discussion here suggests that this is an example of the type of process being advocated in Key Message #1. |
| 538 | P930-1 | The discussions about "bridging the gap" and using "models and tools" lead the reader to wonder how the discussion here links to the other two key messages. These links between the key messages (and the discussions of them) is unclear. For example, if a discussion of "tools" is appropriate under Key Message #1, then why is there another key message specifically related to tools? |
| 539 | P932/Fig26.3 | There is no explicit link to climate change in the discussion (caption) of this figure. |
| 540 | P933/L16 | While it is important to include a discussion about the value of information, it is not clear how it relates to Key Message #1 |
| 541 | 934/L12-13 | The implication here is that cost-benefit analysis cannot incorporate uncertainty. This is not true. There is a large literature on doing cost-benefit analysis under uncertainty, going back to the early work by John Graham in the American Economic Review. |
| 542 | P935/L38 | Is the reference here to a "focus on short time horizons" a disguised reference to discounting? The entire issue of discounting (including private vs. public discount rates) is missing from the report. It would not normally be in a section on "risk perceptions," but it is a critical consideration in decision making. |
| 543 | P936/L8-24 | This discussion about the adequacy of incentives is very confusing. In the first part, it is not clear how, for example, "ensuring continuity of service" is an option with "sufficient incentives." Second, and more importantly, what does it mean for |

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| | | incentives to be sufficient or insufficient. For what?? Simply saying "to adapt to emerging conditions" is not a meaningful benchmark to measure whether incentives are sufficient or insufficient. Overall, it is unclear what the point is of this paragraph on Risk Management Strategies. |
| 544 | P936/L32 | This is the only place in what I've read where I have seen an explicit reference to tradeoffs. Yet, nearly all decisions involve tradeoffs, and the key is how to recognize, evaluate, and make decisions in the presence of these tradeoffs. I think this notion of tradeoffs needs to be elevated to a much higher level, at least in this chapter if not in the report as a whole. |
| 545 | 936/L37-41 | Why provide a detailed explanation of multi-criteria methods but not the other methods included in this list of possible approaches? |
| 546 | P938/L8 | What is an "end-to-end climate change indicator system"? This terminology is not likely to be familiar to most readers. |
| 547 | P938/L16 | It is not clear why the Nordhaus, Stern and Weitzman references are used here. The main point (and focus) of the Stern-Nordhaus debate is not related to the statement in the text about the need for multiple participants in the process. It seems very odd to use these references here. |
| 548 | P938/L27-8 | Similarly, these are very odd references to cite regarding non-economic metrics. All of these references focus on economic valuation methods. While they might mention non-economic methods, that is certainly not what these references are about. |
| 549 | P938/L30-34 | The list here (e.g., "implications of land use changes" and "transportation investments") are not examples of "decision frameworks." |
| 550 | P938/L36-37 | Is "Decision Support Analysis" the same as "Data Management"? The distinction (or, more generally, the link between data management and decision support) is unclear here. |
| 551 | P939/L32-41 | Not clear how this discussion relates to "keeping pace with scientific advances." |
| 552 | P940-41 | There is a lot of repetition between the discussion here and the text in previous sections. In addition, it is not clear how the discussion on p. 941 provides specific support for Key Message #3. |
| 553 | P942-945 | Why is there no need for assessment of confidence in this chapter? This is indicative of an over-arching problem with the chapter, namely, that it is not (as currently written) based on "evidence" regarding the effectivess of decision support tools and processes. |
| 554 | | This chapter does not describe how scientific and technological information <u>is</u> being used to support decision-making, but instead describes how it <u>should be</u> used. (The Denver water system example is a nice exception, showing how uncertainty can be incorporated into decision-making.) It would be helpful to see more examples in this chapter. If readers were given examples of how various organizations are applying the |

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| | | principles described in the chapter, the usefulness of the information would be greatly enhanced—i.e., readers could see how the principle can be applied. |
| 555 | | Overall, the writing in this chapter is difficult to understand unless you're already familiar with the information; much of it would be inaccessible to lay readers. The chapter would benefit from a re-write to simplify and clarify the language with lay readers in mind. Even the title isn't clear—the lay reader doesn't know what "decision support" refers to. Changing the sub-title would help—e.g., "Bridging the gap between scientific understanding and societal decision-making" (referring back to the language used in *Introduction to Response Strategies*). Perhaps the definition of decision support that starts the section, "Who are the decision-makers," can be moved to the beginning of the introduction. Lay readers would also appreciate a glossary at the beginning, as can be found in the adaptation chapter. |
| 556 | P925 | Perhaps add a key message prior to the first one listed here, stating that governments, agencies, businesses and individuals are faced with the development of policies and programs to reduce the dangers of climate change impacts, and must do so without knowing precisely how great their future vulnerability to these impacts will be. |
| 557 | P925 | Key message #2: A one-sentence definition of what is meant by "frameworks" and "tools" would help lay readers. |
| 558 | P925 | Key message #3: Lay readers won't understand the points made here. It should be re-stated in simpler language. |
| 559 | P926 | First sentence of the final paragraph: Either present definitions of the terms used here in a glossary, or add a reference to the page number where the terms are defined more fully. |
| 560 | P927 | The section "What is decision support?" could be clarified; i.e., definitions of processes, decision-support tools and services should be added here. The chapter headings where each of these topics is discussed should use the terms again, so readers can make the connection easily. |
| 561 | P928/Fig26.1 | The meaning of "Frame decision" is unclear; replace, perhaps, with "Define the problem," (or the question, or the issue)? |
| 562 | P929 | second bullet: risk perception*s* ("s" is missing). |
| 563 | P929 | Last sentence on the page: Adding a sentence or phrase defining "multi-criteria analysis" would help lay readers; an example would also be great here. |
| 564 | P930 | Perhaps change the title to "Decision Support Processes," to clarify the connection between this section to the definition of decision support on p. 927. Would like to see the discussion of boundary processes expanded. The chapter makes clear that this is important, but does not describe who the people are who will do this work, what they will do or how they will do it. This would be valuable information for readers. |

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| 565 | P931 | Perhaps change the title to "Decision Support Models and Tools," again to connect the section to the earlier definition of decision support. |
| 566 | P931 | Last sentence has a misstatement; it refers to management of climate extremes—something we wish we could do, but clearly cannot... |
| 567 | P932/Fig26.3 | Figure uses the term "multi-criteria evaluation framework," which has not been defined in the text yet; lay readers won't understand this. |
| 568 | P934 | The figure showing the links between risk assessment, perceptions and management could be dropped—it contains little useful information, and an example demonstrating how this is/has been done effectively would be far more useful to readers. If the figure is retained, something more is needed to clarify how public risk perceptions can be used in risk assessments. |
| 569 | P935 | Last paragraph of the section on risk assessment: Examples would clarify what is meant by exposure, sensitivity and adaptive capacity. |
| 570 | P935 | The definition of risk perceptions is vague and doesn't capture the concept well, and the summary of the relevant research overlooks some of the most important work & insights in this area. Perhaps include the work by Elke Weber on risk perceptions and climate change. There's much to be said here about the barriers to building public support for mitigation and adaptation policies because risk perceptions are low, and there's a growing literature on how to overcome these barriers. |
| 571 | P936 | Risk management strategies section, word missing? "...the private section faces challenges in providing coverage..." — *insurance* coverage? An example at the end of this section would be helpful as well. |
| 572 | P937 | Scenarios and scenario planning: Lay reader wonders what "framing" refers to in the sentence that begins, "This works well..." |
| 573 | P938 | Lay reader will wonder what is an "end-to-end climate change indicator system." |
| 574 | P938 | In Box 2, the sentence that begins, "Although values are defined differently..." has an example that's marked off by a dash at the start and a comma at the end. A dash is needed at the end. |
| 575 | | This chapter is in some ways exemplary. But it approaches the problem as one of developing and deploying the right tools. Two issues and literatures were notable by their absence. First is the near consensus in NRC documents for almost more than a decade that thinking about linking science to decision making is best approached as linking scientific analysis with public deliberation (NRC, 1996. 1999, 2008. 2010). This chapter discusses the process too often as "speaking truth to power." Given the controversial nature of many tradeoffs that have to be made, more attention should be give to the process of engaging the public as a critical part of decision support. Second is the lack of attention to policy networks rather than to isolated decisions makers. |

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| | | Emerging literature certainly suggests that the most important ways to influence decision making is by thinking about how to influence not single hypothetical decision makers but the networks through which information flows (Frank et al. 2012; Henry 2011; Henry 2009). Working with networks gives great leverage; ignoring them means that decision support tools may have little influence. REFS:<br>*Frank, Ken, I-Chien Chen, Youngmi Lee, Scott Kalafatis, Tingqiao Chen, Yun-Jia Lo, and Maria Carmen Lemos. 2012. "Network Location and Policy-Oriented Behavior: An Analysis of Two-Mode Networks of Coauthored Documents Concerning Climate Change in the Great Lakes Region." Policy Studies Journal 40:492-515<br>*Henry, Adam Douglas. 2009. "The Challenge of Learning for Sustainability: A Prolegomenon to Theory." Human Ecology Review 16:131-140.<br>*Henry, Adam D and Thomas Dietz. 2011. "Information, networks, and the complexity of trust in commons governance." International Journal of the Commons 5:188-212.<br>*NRC. 1996. Understanding Risk: Informing Decisions in a Democratic Society.<br>*NRC. 1999. Perspectives on Biodiversity: Valuing Its Role in an Everchanging World.<br>*NRC. 2008. Public Participation in Environmental Assessment and Decision Making.<br>*NRC. 2010. Advancing the Science of Climate Change. |
| 576 | | The chapter acknowledges the interactive nature of decision making and the need to engage the public (a better term than stakeholders, in my view) in places like 927:36-41 but the idea is not carried through consistently. For example, there is no indication in Figure 26.1 that this could not be done by a group of technocrats working in isolation. |
| 577 | P929 | The problem also comes up at the end of 929 when a grocery list of techniques is offered. NRC 2008 offers diagnostic questions and best practices that are probably more appropriate here than just a list of methods (some of which are supported by careful evaluations in the literature, some of which are not) |
| 578 | | The discussion of risk assessment and risk perception is fairly standard but would benefit greatly by more recent accounts that acknowledge risk processes are embedded in complex social and psychological processes (Renn 2005; Rosa et al. 2013). This discussion is less subtle than it should be, given the contentious nature of many of the decisions that have to be made in dealing with climate change. What is said is not incorrect but it does not go nearly far enough in working through the issues of using a risk frame. |
| 579 | | It seems odd that the chapter never mentions trust. A substantial body of literature demonstrates the crucial importance of trust in making collective decisions and that trust is very fragile (Fehr 2009; Henry and Dietz 2011; Leach and Sabatier 2005; Siegrist et al. 2007). This is especially true given the complex nature of U.S. public views on climate change and especially the differing views about science in the public (McCright and Dunlap 2010; McCright and Dunlap 2011) (This gets back to the issue that the chapter sometimes reads as if the decisions were being made only by |

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| | | corporate executives with more or less absolute authority when many of the most important decisions will be made by elected or appointed public officials.) REFS:<br>*Fehr, Ernst. 2009. "On the Economics and Biology of Trust." Journal of the European Economics Association 7:235-266.<br>*Henry, Adam D and Thomas Dietz. 2011. "Information, networks, and the complexity of trust in commons governance." International Journal of the Commons 5:188-212.<br>*Leach, William D and Paul A Sabatier. 2005. "To Trust an Adversary: Integrating Rational and Psychological Models of Collaborative Policymaking." American Political Science Review 99:491-503.<br>*Siegrist, Michael, Timonty C Earle, and H Gutscher. 2007. Trust in Cooperative Risk Management: Uncertainty and Skepticism in the Public Mind. London: Earthscan.<br>*McCright, Aaron M and Riley E Dunlap. 2010. "Anti-Reflexivity: The American Conservative Movement's Success in Undermining Climate Science and Policy." Theory, Culture, and Society 27:100-133..<br>*McCright, Aaron M and Riley E Dunlap. 2011. "The politicization of climate change and polarization in the American public's views of global warming, 2001-2010." Sociological Quarterly 52:155-194. |
| 580 | P929/L7 | What is a group value (other than the average of individual values? Perhaps what is meant is group *norms*. |
| 581 | P929/L17 | One could argue those interested in a decision, even if they don't have a direct or indirect "stake," certainly have a right to engage. |
| 582 | P936 | Discussion of scenarios and scenario planning should mention Robinson's work on "backcasting" which is one of the origins of this approach (Robinson 1988). |
| 583 | P937/L16-18 | It is common for discussions of values and valuation to get muddled. Elsewhere in the chapter there is reference to individual values, that is those things that people consider important, which is different from the outcome of asking them to do a valuation (Dietz et al. 2005). It would be helpful to police this throughout the chapter. |
| 584 | | Some examples of studies that examine real-world decision-support efforts:<br>*Ferguson, D. (2009). Evaluating climate assessment and translational science efforts in the US Southwest: Lessons from a CLIMAS pilot evaluation project. Presentation at the Climate Prediction Applications Science Workshop, March 24-27.<br>*McNie, E. C. (2008). Co-Producing Useful Climate Science for Policy: Lessons from the RISA Program. Environmental Studies Program. University of Colorado, Boulder.<br>*Pulwarty, R. S., C. Simpson, and C. R. Nierenberg. (2009). The Regional Integrated Sciences and Assessments (RISA) Program: Crafting effective assessments for the long haul. In: C. G. Knight, and J. JŁger, editors. Integrated Regional Assessment of Global Climate Change, Cambridge University Press, .<br>*Bales, RC, DM Liverman, and BJ Morehouse. (2004). "Integrated assessment as a step toward reducing climate vulnerability in the southwestern United States." BAMS. |

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| | | 85:1727-1734.<br>*Lemos, MC and BJ Morehouse. (2005). "The co-production of science and policy in integrated climate assessments." Global Environmental Change Part A 15:57-68.<br>*Miles, EL, AK Snover, LCW Binder, ES Sarachik, PW Mote, and N Mantua. (2006). "An approach to designing a national climate service." PNAS 103:52.<br>*Kirchhoff, Christine J. "Understanding and enhancing climate information use in water management." Climatic Change (2013): 1-15.<br>*Lemos, M. C., C. Kirchhoff & V. Ramparasad (2012) Narrowing the Climate Information Usability Gap. Nature Climate Change, 2, 789-94.<br>*NRC. 2008. Public Participation in Environmental Assessment and Decision Making, National Academy Press.<br>*Dilling, L and Lemos,MC. 2011. "Creating usable science:Opportunities and constraints for climate knowledge use and their implications for science policy." Global Environmental Change 21:680-689.<br>*Moser, Susanne C and Julia A Ekstrom. 2010. "A framework to diagnose barriers to climate change adaptation." Proceedings of the National Academy of Sciences 107:22026-22031. |

## 27. MITIGATION

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| 586 | P955/L19 | Surely this is a chapter in which there should be at least one key message about the GHG emissions of other nations and the basis for American policy to mitigate on an international basis. At present there is only a simple statement of the rapid pace of GHG emissions, as compared to benchmark scenarios. Yet a discussion of the shortcomings of the FCCC (well known in the policy literature) would seem to fall within the scope of the NCA. It would also of course be good to outline the state of knowledge about constructive steps going forward. |
| 587 | P957/L15-19 | Caption should make clear that "sink" does not mean that CO2 is removed from the atmosphere or water column so that the radiative forcing and acidification processes have taken place, and will continue to do so. This is in contrast to the portion that goes into long-term storage in land and in deep sediments. |
| 588 | P962/L15-19 | Should cross-reference Ch. 13 (land use) and 16 (biogeochemistry). |
| 589 | | Key messages contain vague language ; e.g. "within a few years." Msg 3 covers intensity history but omits absolutes. Msg 4 should include ," without other actions" as a caveat, as stated the msg assumes no action. Msg 5 is vague if "lower emissions' is net, gross or based on some other metric. |
| 590 | | Section on co-benefits is particularly weak, with old references. Suggest revising and |

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| | | updating references. Kri Ebi can help with that. REF: P. Epstein at Harvard also has recent work. Annals, NY Acad Sci, 1219, Ecol Econ Review Feb 2011. |
| 591 | | Renewables should include all, not just wind solar and biomass (e.g., hydro, geo, kinetic, etc)…. |
| 592 | P966/L9 | Infers that 'these' technologies are only in the R&D phase, vs commercial. Suggest rephrasing to "market maturity." RETs were $257B of economic investment in 2011 and nearly 50% of all new power capital expenditures. |
| 593 | | Under research needs, the last bullet under social and behavioral sciences is important but the chapter is missing any text on the subject. |
| 594 | | The chapter is clear in its presentation of what it covers and I found no obvious errors. That's not surprising given the quality of the writing team. But I don't think it does justice to the best ways to think about problems of mitigation, particularly in a context where considerable attention should be paid to both the potential effects of climate change on mitigation and on the interplay between mitigation and adaptation efforts. That is, there should be a tighter connect between this chapter and Chapter 3-Energy Supply and Use. The authoring team is composed of top scholars on the economics, engineering and modeling of energy and greenhouse gas emissions, but they seem to be missing a good bit of recent literature that is relevant to this chapter. |
| 595 | P959/L25 | The list of factors here are appropriate for an IPAT/Kaya sort of decomposition. But that approach masks the fact that there are decisions underpinning all these factors and that over the last decade or so we have learned a great deal about drivers. A substantial literature examines drivers and their dynamics (for reviews see: Levy and Morel 2012; Rosa and Dietz 2012, Dietz et al, 2010). While this report may not want to get into details on current understanding, the IPAT/Kaya formulation is too simplistic, does not reflect the state of the science and implies a mechanistic response to reducing emissions. Recent work shows that substituting renewables for fossil fuels yields a less than proportional reduction in fossil fuel use. That is an important finding for understanding policy impacts. REFS:<br>* Rosa, E.A. and T.Dietz. 2012. "Human Drivers of National Greenhouse Gas Emissions." Nature Climate Change 2:581-586.<br>* Dietz, T., E.A Rosa, and Richard York. 2010. "Human Driving Forces of Global Change: Examining Current Theories." Pp. 83-132 in Threats to Sustainability: Understanding Human Footprints on the Global Environment, edited by E. A. Rosa, A. Diekmann, T. Dietz, and C. Jaeger. Cambridge, Massachusetts: MIT Press.<br>* Levy, M.A. and A.C. Morel. 2012. "Drivers." Pp. 3-30 in Global Environmental Outlook 5, edited by United Nations Environment Programme. Nairobi, Kenya: United Nations Environment Programme |
| 596 | | The rest of the paragraph reveals the limits of the framing—it seems to imply that only prices and "autonomous" technological changes matter. This stark statement is |

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| | | incorrect because it greatly oversimplifies. The rest of the chapter restricts consideration to this narrow scoping save for a few minor nods to voluntary programs. The analysis ignores shifts in preferences among the public, demographic shifts more complex than simple population growth, etc.. For example, ongoing shifts in dietary preferences can have a huge impact on emissions (Carlsson-Kanyama and González 2009; Popp et al. 2010; Stehfest et al. 2009; York and Gossard 2004). Changes in number of households seems to have more impact on the environment and probably on emissions than changes in the size of the population per se (Cramer 1997; Liu et al. 2003). There are many more examples of well researched understandings of drivers that are masked by this simple formulation. The framing matters because the effects of climate change on emissions and the interplay between adaptation and mitigation requires a more nuanced understanding than IPAT/ Kaya formulation and the unitary focus on prices and technological change allows. A decade ago there was little research going beyond this simple approach, now there is. (e.g.,see Rosa and Dietz. 2012). The report should reflect the state of the science. REFS:<br>*Carlsson-Kanyama A, González AD.. Potential contributions of food consumption patterns to climate change. Am J Clin Nutr. 2009 May; 89(5):1704S-1709S..<br>*Cramer, J. C. A demographic perspective on air quality: Conceptual issues surrounding environmental impacts of population growth. *Hum. Ecol. Rev.* **3,** 191–196 (1997).<br>*Liu, J., Daily, G.C., Ehrlich, P.R. & Luck, G.W. Effects of household dynamics on resource consumption and biodiversity. *Nature* **421,** 530–533 (2003).<br>*Popp, A., H. Lotze-Campen, B.Bodirsky. Food consumption, diet shifts and associated non-CO2 greenhouse gases from agricultural production**.** *Global Environmental Change*, 2010; 20 (3): 451.<br>*Rosa, E.A. and T.Dietz. 2012. "Human Drivers of National Greenhouse Gas Emissions." Nature Climate Change 2:581-586.<br>*Stehfest, E., L.Bouwman, D.P. van Vuuren, M.G. J. den Elzen, B. Eickhout, P. Kabat . Climate benefits of changing diet. Climatic Change (2009) 95:83–102<br>*York, R. and M.H.Gossard. 2004. "Cross-national meat and fish consumption: exploring the effects of modernization and ecological context." Ecological Economics 48:293-302. |
| 597 | | The limitations of this approach are striking in the lack of consideration of the "energy efficiency gap" (Hirst and Brown 1990; Jaffe and Stavins 1994). The gap is far from trivial. It has been estimated that, in the U.S. household sector alone, closing the gap using on-the-shelf technology and minor behavioral changes could reduce total U.S. GHG emissions by over 7% (Dietz et al. 2009). Nor are differences in program effectiveness minor, as seems to be implied in the traceable account (p. 975). In fact, different implementation strategies used with identical technologies and identical financial incentives can produce results that vary in success by an order of magnitude (Stern et al. 2010). REFS: |

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| | | *Dietz, T., G.Gardner, J.Gilligan, P.Stern, and M.Vandenbergh. 2009. "Household Actions Can Provide a Behavioral Wedge to Rapidly Reduce U.S. Carbon Emissions." Proceedings of the National Academy of Sciences 106:18452-18456.<br>*Dietz, T., P.Stern, and E.Weber. 2013. "Reducing Carbon-Based Energy Consumption through Changes in Household Behavior." Daedalus 142:78-89.<br>*Jones, Christopher and Daniel M Kammen. 2011. "Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities." Environmnental Science and Technology 45:4088-4095.<br>*Stern, P., G. Gardner, M. Vandenbergh, T.Dietz, and J.Gilligan. 2010. "Design Principles for Carbon Emissions Reduction Programs." Environmental Science and Technology 44:4847-4848.<br>*Thollander, Patrick and Jenny Palm. 2013. Improving Energy Efficiency in Industrial Energy Systems: An Interdisciplinary Perspective on Barriers, Energy Audits, Energy Management, Policies, and Programs. London: Springer<br>*Vandenbergh, M., P.Stern, G.Gardner, T.Dietz, and J.Gilligan. 2010. "Implementing the Behavioral Wedge: Designing and Adopting Effective Carbon Emissions Reduction Programs." Environmental Law Review 40:10547-10554. |
| 598 | P958 | The relationship between emissions and concentrations is widely misunderstood, even by many with training in science . Perhaps another paragraph, a diagram or perhaps a box might make a contribution to better public understanding of this issue. |
| 599 | Fig 27.3 | "Forestry" should be "Forest" in the figure. |
| 600 | | Generally a good and balanced view of mitigation topics, however, many topics were not covered in this chapter and their absence leads to incomplete and potentially misleading information for the reader. Topics that are important to consider are: |
| 601 | | · Different emission scenarios and different pathways. The SRES scenarios chosen for this study are 'no additional climate policy' scenarios, whereas this chapter seems to seek to match the timing of the B2 scenario with mitigation policy. The RCPs exhibit different pathways that are not monotonically associated with their stabilization level. Further exploration of pathways would test and might better illustrate what seems to be a thesis for this chapter — that we have only a few years for mitigation. IPCC AR5 will assess hundreds of scenarios based on recent literature, and the EMF study referenced in the NCA report (Clarke et al, 2009) includes tens of scenarios that show different pathways to stabilization at different levels. In these scenarios, the relation between near-term emissions trajectories (e.g. 2005-2010) and the outcome in 2100 are largely unrelated (as can be seen in NCA figure 1.1). |
| 602 | | · Economic efficiency and distributional effects of policies being considered in the chapter. For instance:<br>*NRC, 2010. Limiting the Magnitude of Climate Change. National Academy Press (p.174-182)<br>*Casillas, C E and D M Kammen. 2012. "Quantifying the social equity of carbon |

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| | | mitigation strategies." Climate Policy 12:690-703.<br>*Gough, Ian. "Carbon mitigation policies, distributional dilemmas and social policies." Journal of social policy 42, no. 02 (2013): 191-213. |
| 603 | | · The effectiveness of a set of policies that are not comprehensive (both within the U.S. and globally) to reach various levels of mitigation. |
| 604 | | · The shift to natural gas in the U.S. has made a large contribution to changing the trajectory of US GHG emissions. Some discussion, connection with the energy chapter, and discussion of what is causing limits to this shift both in the US and internationally would be timely. |
| 605 | general | Most other chapters were organized around the key messages. In other words, each key message was presented, followed by the text specifically supporting that key message. That is not the structure of this chapter. Is there a reason that this chapter departs from the other structure? |
| 606 | P955/L33 | Given the beginning of this sentence, should it read "greenhouse gas emissions IN THE U.S. are expected to continue to rise."? |
| 607 | P955/L36 | This key message refers to aging forests as the reason the carbon sink from forests is expected to decrease. But this is not the same message as one gets from the discussion on p. 962. |
| 608 | P956/L16 | In what sense does the chapter provide an "analysis" of activities contributing to emissions? What type of "analysis"? |
| 609 | P959/L12 | The heading here is "Industrial Emissions" and yet the discussion is broader than that. For example, the second paragraph refers to other sources. But then the discussion of "driving forces" seems to be back to focusing on industrial emissions. Where the discussion refers to industrial emissions and where it refers to total emissions should be clarified. |
| 610 | P960/Fig27.2 | Why are these projections included here? And don't trends/projections depend on policy decisions? A clearer indication of the assumptions underlying these projections (e.g., BAU) is needed here. |
| 611 | P962/L40-42 | Why does Table 27.2 appear in the text before Table 27.1? |
| 612 | P962/L40-42 | The categorization here (R&D and commercialization/development) doesnt seem like a useful categorization of the actions in use, and Table 27.2 does not make use of this categorization. What about regulatory approaches? A glaring omission here are automobile fuel economy standards (CAFÉ), which are not voluntary standards. Although CAFE is included in Table 27.2, it is not included in the text, which leaves the reader with the impression that there are no regulatory approaches being used. |
| 613 | P965/L9-10 | What does it mean to "manage the economic costs"? |
| 614 | P965/L40 | There is an important distinction between technologies that are technologically |

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| | | feasible and those that are economically competitive at current prices. This distinction needs to be clearly made. More generally, there is a key distinction between the technological feasibility of mitigating emissions and the incentives in place to do so. |
| 615 | P967 | It is useful for this chapter to have a research needs section. A comparable section was not included in the other chapters, but perhaps it should be. |
| 616 | P967/L16-19 | This last research need seems correct, but not well supported by any of the discussion in this chapter. More discussion is needed in the text to lead up to this research need. Also, while there is reference to "regulatory and subsidy programs," it is notable that there is no reference to a tax-based policy (such as a carbon tax or cap-and-trade system). One understands the need to avoid an appearance of suggesting a particular policy approach, but referencing regulatory and subsidy approaches without referencing tax-based policies (the instrument of choice for most economists) by itself seems to implicitly signal a preference for these approaches over tax-based policies. This is inappropriate. Perhaps simply refering to the costs and effectiveness of both voluntary mitigation efforts and "alternative government policies aimed at increasing mitigation." |
| 617 | | This chapter is well-written—clear, easy-to-read, with a great deal of valuable information. But the authors should reduce the use of acronyms wherever possible—they force readers to keep looking back in the text to recall the acronym's meaning. |
| 618 | P956 | In the first paragraph of the emissions section, the sentence that begins "These gases cause radiative 'forcing'... will be difficult for many lay readers to understand. |
| 619 | P958 | The fourth paragraph contains a central point about the stabilization of CO2 emissions—a figure illustrating this point would be useful for emphasis and clarity. |
| 620 | P959 | Industrial emissions: A definition of flaring would be useful, and the last paragraph on the page could be clarified and simplified. |
| 621 | P960/Fig27.2 | What emissions scenario is being used here? |
| 622 | P961 | In the first paragraph on land use, reverse the order of the sentences so that stocks and flux are defined before they're discussed. |
| 623 | P964 | Box on co-benefits: The meaning of the sentence beginning , "Methane reductions have also..." isn't clear. |

## 28. ADAPTATION

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| 625 | | The chapter lacks an analysis of how knowledge enters into adaptation; this is essential to an assessment of the knowledge that exists or does not. While one might infer a latent theory of how knowledge enters into adaptation from the case studies, that would indicate starting with the cases —and a reasoned statement of how they were chosen and what they illustrate. As it is, the chapter begins with a long discussion of existing activities devoted in part or whole to climate adaptation, with several listings that appear to be illustrative of the scope of activities. How this fits into an assessment of knowledge isn't made clear, though. There does not appear to be an analytical principle underlying the selection of activities summarized. The assessment document might do well to draw on existing conceptual frameworks that describe the kinds of knowledge needed to assess and reduce vulnerabilities to climate change and therefore the progress of efforts to advance adaptation. Examples include NRC (2009, 2010, 2013) and IPCC (2012). The assessment could either adopt one of the frameworks in the literature or develop a new one building on the literature. As it is, the re-compilaton and expansion of the lists of activities in map form does not add anything. These lists of activities are followed by a discussion of the adaption "process" (998-1000) that indicates an absence of knowledge or process for accumulating reliable knowledge as climate becomes increasingly non-stationary. This may indicate that the considerable efforts aimed at adaptation will be faced with continuing surprises. If that is the state of knowledge, it is salient to note that congressionally approved aid for Sandy ($60 billion) is larger than the public debt of all 50 states (about $50 billion). The cost of surprise, in human, ecological, and economic terms provides a way to articulate the value of reliable knowledge, applied in a coherent fashion. This does not seem to be in the chapter as drafted, however.<br>REFS: *IPCC 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change<br>Adaptation. A Special Report of Working Groups I and II of the IPCC . Field, C.B., et al, eds. Cambridge, UK, and New York, NY: Cambridge University Press.<br>*NRC, 2009. Informing Decisions in a Changing Climate.<br>*NRC, 2010. Adapting to the Impacts of Climate Change.<br>*NRC, 2013. Climate and Social Stress: Implications for Security Analysis. |
| 626 | P993/table | The entry for New York, describing flood planning with FEMA, is poignant in the wake of Sandy. Have there been changes since the storm struck? |
| 627 | P1005/table | This listing of barriers stands in interesting contrast to the discussion of decision support in Ch. 26. Virtually none of these barriers can be hurdled by knowledge alone. |
| 628 | P1006/L1-21 | The underlying premise of these paragraphs is that getting organizations to work together will overcome the barriers laid out in 1005. That is not plausible. |

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| 629 | P1007/L2-21 | What is the framework within which these lines of research appear to be compelling? Are they ripe from the standpoint of science? Is the need so urgent, given observed changes that may be related to a non-stationary climate that the research should be funded even without good ideas of what to do? These conceptual frameworks in the adaptation literature noted above can also be useful in justifying and setting priorities for lines of research. |
| 630 | P1014-7, 1019 | The compilation of lists in the chapter, without an articulation of how they were chosen, makes it hard for the reader to grasp how authors could dismiss the questions of uncertainty and confidence. What one might infer from the list-making is that earnest people in a wide range of institutions are raising awareness of climate change by doing things that respond to anticipated stresses from a changing climate. These things are not coherent in the aggregate, and they will not forestall surprises like Sandy (which struck what is arguably the most alert city in the nation). So grouping them together as adaptation asserts a wholeness that is absent. It is that finding, about the lack of coherence in the use of climate science, that may be most important in a national assessment, particularly as the nation awakens to the reality of a non-stationary climate. |
| 631 | P1018 | Surely there are uncertainties about multiple stresses that lead to issues of confidence? This would seem to be logically connected to social choices about how urgent the multiplicity of stressors is as a cause of problems and surprises. |
| 632 | | This chapter mainly assesses the state of adaptation *planning activities* around the country, but does not assess vulnerability or adaptive capacity. Should it? Or is this the job of the regional and sectoral chapters? |
| 633 | | Earlier chapters do not take a consistent approach to assessing vulnerability or distinguish all the aspects of vulnerability. The term also seems to be used inconsistently. For example, in Chapter 16 (Northeast), Key Message #1 says that flooding "will increase the vulnerability of the region's residents, especially populations that are already most disadvantaged" (549.16-17). "Vulnerability" here apparently means harm or damage. Elsewhere, it seems to mean exposure: "Historical settlement patterns and on-going investment in coastal areas and along major rivers combine to increase the vulnerabilities of people in the Northeast to sea level rise and coastal storms" (557.21-23). Chapter 11 (Urban) treats vulnerability in more detail and with more coherence. |
| 634 | | The chapter notes that evaluation of adaptation mainly uses "process-based rather than outcome-based indicators" (1000.4-5), but the research section does not identify a need to develop outcome indicators. Such indicators presumably would be measures of vulnerability, adaptive capacity, coping capacity, etc. |
| 635 | | The chapter focuses on providing an insight into what is happening—and to some extent, not happening—in relation to adaptation to climate change (CCA) is the U.S.. In that context, it does provide an entry point to activity on adaptation in the U.S., |

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| | | but it fails to deal effectively with the barriers to further progress and the most promising opportunities. Some examples: The chapter quickly (pg 984 ln 20) takes up the common refrain that adaptation is difficult because we do not have adequate climate projections. Is this really a major barrier in a technologically sophisticated and well-educated country with access to the best of environmental information, modeling expertise and decision making techniques? If it is, why then have many European countries, and Australia and Canada, apparently made more progress in tackling adaptation? Yes, lack of precise projections is often cited as a barrier, but here I would have expected this idea to be analyzed in more detail. Given adaptation's entanglement with many other stressors and societal goals, where is the analysis of whether the uncertainties in climate projections are any greater impediment to action than other socio-economic projections? |
| 636 | | The chapter repeats the point that most agencies/actors are engaged only in planning and not implementation. This is true and a numerical inevitability of any new and developing activity. But the discussions of the barriers to more implementation are shallow. We have a comprehensive table of dot points; some U.S. specific, others very generic and often more applicable to developing countries. But it is not a huge help on where to focus efforts. |
| 637 | | The section on overcoming the barriers simply lists the need for more cooperation. NIDIS is a good example of the problems with progressing adaptation in the U.S., but not necessarily a 'best practice' example. The services it provides is excellent and needed—with or without climate change, but its engagement with climate change has, by my reading, been fraught with problems. It's web page introduction links its existence to NOAA's climate related goals that include climate change, but its direct engagement with climate change issues appear to be driven mainly by that of the First Nation users and subject to political debate (see House Committee on Science, Space & Technology hearing on July 25th 2012). NIDIS could be used as an excellent case-study of Federal institutional issues but it will require greater depth of analysis than here. |
| 638 | | Other issues that are contentious within the global adaptation debate but are only mentioned in passing in the chapter include "is mainstreaming adaptation the way ahead and what does this mean in practice?" and the process and interpretation of benefit cost analysis in adaptation decision making. Maybe this is asking more of the authors than what can be achieved within the context of the NCA. But GCRA Section 106 seems to be requesting this sort of advice. Adaptation very specifically raises the issues of "global change" v "climate change" and, possibly more importantly, just what constitutes science. There is a need for a better treatment of the social, behavioural and economic disciplines, but there still seems to be an over-powering caution amongst the climate change community in assessing and interpreting these fields. |

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| 639 | | The authors indicate in the chapter introduction that they will highlight "efforts at the federal, regional, state, tribal, and local levels, as well as initiatives in the corporate and non-governmental sectors to *build adaptive capacity and resilience* towards climate change." What this means is that adaptive activities that are under way are not being given much emphasis. This is an important point; many of the activities discussed in the chapter involve planning to act, or establishing frameworks for action in the future, as opposed to adaptive activities that are under way. It would have been nice if the authors had been more clear on this point, or if they could have organized chapter discussions along those lines. Which actors are getting ready to plan, which are planning, which have adopted plans, and which are implementing plans? Where is most of the attention currently focused? What is the status of adaptation measures overall? Much of the chapter consists of laundry lists of measures that are being undertaken around the country (see Table 28.6), again without any effort to develop a typology of those activities. Can't these efforts be classified and presented in a more systematic way? |
| 640 | | Regarding climate change and extreme events, the authors seem to have missed some opportunities to make connections. For example, the Disaster Mitigation Act of 2000 required states, local jurisdictions, tribal governments, and U. S. territories to develop plans for mitigating hazards to which they are exposed. Pursuant to the law, tens of thousands (literally) of hazard mitigation plans have been developed and submitted to the Federal Emergency Management Agency. A very small amount of research has been undertaken—mainly at the University of North Carolina and Texas A&M—to assess the content and quality of some of those plans, mainly plans in coastal areas. It would seem useful to explore the extent to which climate hazards are being incorporated into those plans (they have to be updated regularly) and the extent to which plans for mitigating floods, coastal hazards, wildfires, and other climate-related hazards, if implemented, might also help reduce vulnerability to climate-related hazards. The Army Corps of Engineers, which has major responsibilities for flood control nationwide, is attempting to take climate change into account. Community flood loss-reduction measures are currently rated for purposes of setting flood insurance premiums under the National Flood Insurance Program—what's called the Community Rating System. What communities are incorporating climate change into their flood loss reduction plans? Do such measures increase adaptive capacity for climate-related hazards? Is the CRS a useful tool for encouraging climate change adaptation in flood-prone areas? What is going on with federal and state coastal zone management programs? What adaptive actions have been stimulated by California's AB 32 and other state legislation? |
| 641 | P1007 | The chapter indicates that "areas of needed research include…adaptation to extreme events," but it is unclear how much the authors are aware of existing research in that area. Much of what has been learned from 60 years of research on adaptation to extreme events is transferrable to both research and practice on climate change |

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| | | adaptation (see, for example, the NRC report *Facing Hazards and Disasters: Understanding Human Dimensions*). The authors could have placed more emphasis on these natural connections. For example, the extreme events literature contains typologies of forms of adaptation and provides important insights on barriers to the adoption and implementation of loss-reduction measures for extreme events such as hurricanes and floods, as well as factors that facilitate adaptation, such as state-level enabling legislation and the presence of loss-reduction coalitions and advocates. The U.S. has done more of this kind of research than any other country, beginning with the seminal work of geographer Gilbert White, and this literature should be tapped for its many insights. |
| 642 | | It is surprising that the chapter's discussions on barriers to implementation of adaptation action make no mention of the fact that there are organized movements in the U.S. that oppose climate change adaptation. This is a politically sensitive topic, but it is intellectually problematic to argue that "lack of funding, policy and legal impediments, and difficulty in anticipating climate-related changes at local scales" constitute important barriers without also noting that in the U. S. there are groups that actively oppose such measures, because they are framed as part of the U. N.'s "Agenda 21," or advocated by ICLEI, or because adaptive measures interfere with property rights, or because they could constitute illegal "takings." Including this kind of information in the NCA may be viewed as a non-starter, but the fact remains that a number of politically active local groups have opposed climate change adaptation measures on these grounds, and there are movements that oppose sustainable growth and development planning, comprehensive land-use planning, and other measures that could include climate change adaptation. This opposition is an empirical fact, and it should be acknowledged in the NCA. Like other chapters in the report, this one is curiously devoid of references to the political and economic interests that are active in the climate change arena. The avoidance of these empirical facts is understandable, but it results in an incomplete picture of the current climate-change action landscape |
| 643 | P984/L17 | Update building and landscaping codes to "protect against disease vectors?" This seems like a stretch. |
| 644 | P995 | It's reasonable to talk about risks, but shouldn't we be balanced? What about the opportunities? Risk is something that all businesses face, and it's hard to make a compelling case for risks given our high level of uncertainty. However, we might think about the opportunity space. |
| 645 | P1000 | The discussion of the adaptation process is geared towards agencies and large businesses that either have the mandate or the capital and staff to play in the climate adaptation arena. We should think about how do we engage a broader spectrum of organizations and businesses. The present approach does not downscales to these smaller entities. |

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| 646 | | The NIDIS discussion is very good, but in a way it is a counterexample to the approaches laid out. It worked because it had a clear and understandable focus on an issue that affects a wide spectrum of organizations. Climate adaptation is broad and diffuse, operates over a range of time and space scales, and it is convolved with a range of other processes. Think about flood control. It is tied into water rights, amounts of impervious surfaces, the National Flood Insurance Program as well as the natural environment. On the other hand, drought is really focused on the amount of water available. The problem is how to distribute a limited resource. Floods and their impacts are much more interlinked between the social and natural worlds. Perhaps the lesson learned from NIDIS is that it worked because it was bounded in its scope. |
| 647 | | This chapter is very well-written, well-organized, and easily accessible to lay readers. The glossary at the start of the chapter was quite helpful; it would be good to see other chapters follow this example. The tables summarizing the various types of adaptation actions taking place give the reader a clear sense of the scope and variety of the national response. |

## 29. RESEARCH AGENDA FOR CLIMATE CHANGE SCIENCE

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| 649 | | This chapter seems to build strongly upon the America's Climate Choices and USGCRP strategic plan documents. There is strong emphasis on adaptation science and decision support, while mitigation seems to be given less emphasis. |
| 650 | | It would be useful to identify existing agency research programs that are pursuing these objectives in whole or part. The reader unfamiliar with federal research may perceive these priorities as new, even though significant work is already underway. |
| 651 | P1038/L15-16 | Particularly in light of the priority set on traditional knowledge (ll. 20-23), there should be studies of community-based natural resource management arrangements and the conditions under which they are effective. |
| 652 | P1041/L18-29 | In light of the intense focus on job creation in public policy discussions, it would seem useful to include studies of labor markets. One has the (not well informed) impression that much of the growth in employment in environmentally related job specialties over the past half century originates in widening regulation of environmentally consequential activities. If, as some expect, growth in that and other aspects of the public sector is constrained in the future, the capacities described here will need to arise from private sector and civil society demand. That possibility could be illuminated through studies of the labor market. |

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| 653 | | The goals as structured, do not address the criticality of integrating adaptation and mitigation. Further goal 7 does not warrant self standing. It is a sub element of either 5 or should fit elsewhere. |
| 654 | | Is there a rationale for the ordering of the research areas identified? If they are not in a priority order, then that should be said. And they will have more impact if they are not listed in the same general order that they have been in previous reports. |
| 655 | | In a time of stable or declining budgets, it would be very helpful to get priorities from a process like the National Assessment. Having just completed this huge and very well done exercise, no one is in a better place to make recommendations about what research is *most* needed to make the ongoing assessment process better. A list of 37 equal priorities is only of modest help. |
| 656 | | Because of the heavy involvement of federal agencies, it would be useful for the research recommendations to indicate how they could be handled by existing programs and where new initiatives would be needed. For example, given RISAs, RCAs, CSCs, etc., who might effectively take up what part of the research agenda? |
| 657 | P1036/L21-28 | If the goal is to provide better projections, then the better understanding of uncertainties needs to consider uncertainties in emissions scenarios that come from projections of population change, economic growth, technological change, preferences, etc. It seems appropriate to understand how much of uncertainty in future projections comes from the climate system (and our models of it) and how much comes from uncertainty about emissions trajectories. The contributions to uncertainty will of course vary depending on what is being predicted over what time scale and at what spatial resolution. |
| 658 | P1037/L7-8 | This bullet deals with a critically important and complex line of research and needs a few sentences of elaboration. Also, the term "experiments" is not clear. To some disciplines experiments involve randomization and control groups, to other disciplines an experiment is large scale coordinated data collection. The former kind of experiment will play little role in expanding our understanding of the effects that are the point here. |
| 659 | P1037/L9-11 | Tipping points and thresholds are important not just in climate systems but in coupled human and natural systems and need to be studied with high priority. |
| 660 | P1037/L12-15 | The phrasing here is hard to follow: The importance for various kinds of decision making of various types and sources of uncertainty? |
| 661 | P1037 | The difference between bullets 1 and 3 is not clear. Bullet 2 on federal clearinghouses (not sure what is meant, examples?) seems of much more narrow scope that the other priorities in this list. Bullet 4 mixes what is largely a problem in physical climate sciences (how well do various approaches to downscaling work?) with a social/ policy sciences question (what's the best way to deploy such information and what information is really needed?). They are related but different people would actually |

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| | | do the work for each, perhaps informing each other. On the last bullet: while it would be neat to know more about these strategies, to what extent are they actually useful, given the current technological organization of our communities? They may be very relevant, but the case should be made, as it's not obvious. |
| 662 | P1038/L26-28 | This makes it seem as if energy technology and economics are all that matter, when a variety of other social factors are important drivers of GHG emissions and human responses to climate change. See comments on the mitigation chapter. |
| 663 | P1039/L1-3 | What is meant by "socio-economic analyses?" |
| 664 | P1039/L4-6 | This seems very narrow compared to the rest of the items on the list. |
| 665 | P1039/L7-9 | Why only with regard to mitigation? Why not drivers overall and decisions about adaptation? |
| 666 | P1039 | Research Goal 4. It is admirable that the need for social data is mentioned at least in passing. But this needs elaboration. The social data needed is the only data on this list that is an orphan—with no federal agency in the GCRP with responsibility for it. What is needed should be specified in more detail. Specifying what is needed is essential given the lack of engagement with this kind of data by the GCRP agencies. Bullet 1 has the same problem—a mention without enough detail for anything operational to happen. |
| 667 | P1040/L17-20 | While "socio-economic issues" (what this means is not entirely clear) influence use of information, so do cognitive factors on how people process information which makes the way in which information is generated and provided of great importance. As this para is phrased I don't see that considered. |
| 668 | P1040 | Bullet 1: It's not clear whether this is about research on how to communicate effectively on the things in the list that follows (e.g. transferable vulnerability assessment techniques) or it's about research on the processes listed themselves (e.g. improved understanding of consumption patterns and environmental consequences). |
| 669 | P1041/L31-37 | Current education seldom provides an understanding of coupled human and natural systems. What is the rationale for the particular list given here at the end of the bullet point. For example, why only "economic" sustainability? |
| 670 | P1041/L33 | Better to say "biological, physical and social" |
| 671 | P1042/L2-5 | What about historically black colleges/universities? I would suspect that any vulnerability analysis would show that the African-American community also has high vulnerability and is underrepresented in the appropriate sciences. |
| 672 | P1042 | Research Goal 7. Certainly much more can be done with scenarios. But it's not clear how much of what is called for involves "downscaled" scenarios for levels of decision making involved in adaptation and resilience building. If that is intended, then some |

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| | | discussion of the sharp rise in scenario uncertainty at the local to regional level is warranted. We are finding that downscaled climate models may not have sufficient skill to be useful for some key parameters in some regions, and the same may well be found for downscaled scenarios. Or perhaps what is meant is that given the importance of scenario uncertainty in generating uncertainty in projecting climate change and impacts, better global scenarios are needed because when one follows the chain of analysis down to the local to regional level, this would aid in adaptation planning. |
| 673 | | Title does not reflect content in this chapter. The content focuses on research for the assessment process, but there is reason to be skeptical that research to support assessment is the same as research that actually can be transitioned into tools for decision-makers, products and policies that allow societies to make adaptation decisions, and investments that will lead to new energy and water systems. |
| 674 | | While the chapter talks about more research on impacts and risk assessment, it does not take the step of the research needed to identify and quantify vulnerabilities and options for societal action. The latter would begin to engage communities, engineers, and scientists. |
| 675 | P1036 | **Research goal 1**: The high priority research goal 1 needs do not mention ocean/coastal marine resource impacts and vulnerabilities. Going through the list: |
| 676 | P1036/L25-28 | Missing coastal environments and healthy ocean |
| 677 | P1036/L29-34 | Ocean circulation also important for not only global transfer of heat but also water cycle and carbon cycle |
| 678 | P1037/L1-6 | Does not mention any of the ocean stressors: pollution, fishing practices, unsustainable resource extraction |
| 679 | P1037/L26 | It is not just sea level change that produces risk but also the compounding effect of increased probabilities of storm surge from extreme events. |
| 680 | P1037/L17-19 | Missing the largest part of the water cycle—the ocean—and the impact it might have on water availability (monsoons, etc) |
| 681 | | **Research Goal 2**: The terms risk, vulnerability, adaptation, resilience are all used here and require some good definitions. Many of these bullets are not what one would necessarily call a research agenda, but rather are capacity building. It is surprising that indigenous knowledge is mentioned but not other experiential based knowledge. |
| 682 | | **Research Goal 3:** It's not clear how many of these bullets are going to lead to the exploration of options and actions. In order to better link the fate of carbon emissions with effectiveness and timescales of mitigation measures we need to have some proposed mitigation measures. The second bullet refers to land-based decision-making but is completely missing the increasing use of the ocean and coastal resources. The 4$^{th}$ and 5$^{th}$ bullets call out for "understanding" but how is this |

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| | | understanding going to lead to action. Again, in the 5th bullet there should be mention of ocean energy development and water availability impacts. |
| 683 | | **Research Goal 4**: Missing critical ocean state variables, extreme events, and the lack of an integrated coastal ocean observing system. There is no discussion of needed essential variables. |
| 684 | | **Research Goal 5**: Is this list carried out via "desk studies" or does it require real experiments? |
| 685 | | **Research Goal 6**: Why are Native American colleges and universities called out but not other minority institutions? |
| 686 | | **Research Goal 7**: It seems as though this goal should include something about responsibilities at various levels (Local, state governments; industry; public; communities). |
| 687 | | *Research Goal 1:* The only mention of health in this section is "healthy wetlands" (line 27) |
| 688 | | *Research Goal 4:* Indicators should include trends and changes in all environmentally sensitive infectious diseases in addition to those that are vector-borne. |
| 689 | | Overall, this chapter seems to take a different approach to social science than *Advancing the Science of Climate Change* or the GCRP Strategic Plan. Rather than being highlighted and identified as a priority in which there has been little investment and relatively little commitment by agencies, social science is there most often by inference in some of the topics mentioned. Perhaps this is because the authoring team included only two social scientists, both geographers who are world class experts on adaptation. So to them the need for social science efforts to address some of the topics listed is obvious, but this may not be true of the GCRP/ NCA agencies who have very limited social science capacity and thus struggle to include it despite apparently good intentions. One could argue that the NCA has to again make the point that we cannot carry out the research needed without a serious commitment to and investment in the kinds of social science research needed to support the overall agenda. |
| 690 | P1039-40 | The absence of specific identification of the kinds of social science data needed is strking. |
| 691 | | If the NCA is not capable of looking across the issues discussed and identifying research priorities, I wonder who would ever be in a position to do so. Granted the immense amount of work undertaken may not have left time to hammer out a consensus on research priorities. But for all the good work we have seen with the NCA and the GCRP strategic plan, we still have no set of research priorities, only lists. These lists are not as integrative as the ones available in the ACC reports. To be sure, the NCA is not the activity to adjudicate the relative priorities to be given to |

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| | | basic science, mitigation and adaptation. But within the realm of adaptation/ vulnerability/ resilience it is well poised to say what is needed to do a better job in 5 years and 10 years. |

**30. THE NCA LONG-TERM PROCESS**

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| 693 | P1050/L6 | Since "a much larger effort" is proposed, it would be helpful to know which audiences are targeted now, and the rough cost estimated for the web and communications effort. NASA's effort to gain users for its satellite data may be a useful benchmark. |
| 694 | | Overall, language is cautious and unclear about the goals, breadth and depth of a sustained process. E.g. p 1048; lines 9-13. |
| 695 | P1049/L13-15 | Should include "other energy-economic-climate models" not just IAMs. "projects' are referred to as "infrastructure"; this seems odd. Line 32 refers to "utility and timeliness of future synthesis reports" vs perhaps "informing robust decision making." |
| 696 | P1050 | Refers to "two-way" communication 'among partners" vs "effective communications." |
| 697 | | The chapter does not make clear why we should have sustained assessments. How have assessments been used? What have been the tangible outcomes? What has changed in terms of taking action that incorporates climate change information in the multitude of decisions that are made? What new information products have come out of the assessment that is being sustained? |
| 698 | | In this chapter the sustained assessments are to "evaluate the nation's vulnerabilities to climate variability and change and its capacity to respond." If this is the vision then one would expect the research agenda to be very different than what was proposed in the previous chapter. Also such an evaluation would require very different assessment than what has been done. However in lines 31-36t it would appear that the sustained assessment would be more of the same, rather academic, assessment strategy that currently is being used. |
| 699 | | Sustained assessment of health impacts and adaptation must adopt a more comprehensive coverage of disease threats in addition to direct impacts (heat stress, allergy, mental health, etc.). This would require a multidisciplinary effort within the health sector (environmental health and infectious diseases) and cross-sectoral efforts between the health sector and ecosystems science, biodiversity, hydrology, forestry, etc, as well as capacity building. |

## APPENDIX 1: COMMONLY ASKED QUESTIONS

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| 701 | | This may be one of the most-read sections of the report because informal science educators are asked these questions all the time, and many are nervous about responding to skeptics—particularly when they're in front of an audience. The questions and answers are clear and simple, and they explain the science in terms that most people would understand. |
| 702 | | It would be helpful to have definitions available for some terms—either by links, footnotes, or a glossary. Photographs would also be a useful addition for the people who struggle with charts and graphs (sea ice shrinkage, glaciers melting, etc.). |
| 703 | | One of the most common misconceptions in the U.S. is that the scientific community is in widespread disagreement about the reality and causes of climate change (36%, as of Sept. 2012). The appendix has an excellent section clarifying the scientific consensus (CAQ J). But it would be good to see the text of the question be re-stated in terms of this issue, i.e., "Isn't there a lot of disagreement among scientists about whether climate change is happening and whether humans are causing it?" |
| 704 | | Terms that need definitions for lay readers: forcings, radiative, proxy data, feedback, infrared spectrum. |
| 705 | P1057 | CAQ A: The text explaining the difference between weather and climate is excellent. It would be useful to expand the final paragraph, which is goes to the heart of the question. |
| 706 | P1065 | CAQ D: The final paragraph refers to the "warmest winter everywhere except in the Southeast." Should this say "...everywhere in the U.S. except..."? |
| 707 | P1067 | CAQ E: The authors might consider adding a sentence stating how long emissions stay in the atmosphere; it brings home the point that *rapid* action is needed. |
| 708 | P1068 | Figure 8: This is a great figure, but another showing just the U.S. would be a good addition. With a U.S. map, readers would be able to identify their home state, and everything that helps localize the issue for readers can increase their readiness to support mitigation efforts. |
| 709 | P1068 | Figures 8 & 9: The two figures appear to be in conflict: Figure 8 shows no warming in the Southeast, but Figure 9 shows the region as increasing by about 1 degree. Figure 9 also appears to have a small error in the vertical axis, i.e., a -.05 above zero, as well as below it. |
| 710 | P1070 | CAQ F: The second paragraph states that heat-trapping gases are transparent to the sun's energy, but opaque to the heat radiating back from earth—the lay reader wonders why that would be so. A sentence or two clarifying the difference would be helpful, and can actually be found in the answer to the next question (i.e., G, third paragraph). Perhaps readers could be referred to G for further information. |
| 711 | P1074 | CAQ H: This answer is particularly nice. The question is raised so often, and this answer refutes it clearly, simply and directly. |

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| 712 | P1076 | CAQ I: An example or two would help lay readers understand the research being described here. The last sentence of the answer (increasing likelihood of extreme weather) could be dropped because it doesn't address the question. |
| 713 | P1078 | Figure 14: The data are impressive; I'd suggest deleting the map that is behind the graphs to make the page less busy and easier to read. |
| 714 | P1080 | CAQ J: A climate skeptic could say in response to the last paragraph, well, how can you be so sure climate change will be harmful when you don't know how sensitive the climate is to emissions, how emissions affect clouds, etc. While acknowledging what we don't know is important, it's also critical that we don't give the skeptics more ammunition. Would it be possible to include what *is* known in all these areas? E.g., "We know sea levels will rise, but don't know exactly how much—somewhere between one and four feet over this century." The point made in the last sentence in the response to CAQ S would bear repeating here. |
| 715 | P1081 | Figure 15: This figure is very complex and contains many terms that lay readers won't understand. Anything that can be done to simplify the figure would be helpful. |
| 716 | P1082 | Figure 16: The figure is redundant with Figure 14. Most readers probably won't read all the questions in the appendix, however, so the redundancy may not be a real problem. |
| 717 | P1083 | CAQ K: Again, an excellent response to one of the assertions often made by skeptics. |
| 718 | P1076/L16 | Are there attribution studies that actually conclude it is ***impossible*** to explain many aspects of warming without human activities ? (EU heat wave in previous sentence is an example). |
| 719 | | The use of questions is an effective communication tool, however, the choice of questions, tone, and lack of rigor can be both polarizing and argumentative and can detract from the credibility of the NCA. The questions largely are about climate science and not about the assessment for the U.S.; given the general nature of the questions, there are ample other sources of such information (for example, the IPCC assessments). And in some cases the informal answers (e.g. using analogies) can lead to inaccurate overgeneralization of scientific evidence. |
| 720 | | The figures are not referenced in the text answers to the questions; and the captions, referencing, and traceable accounts are incomplete. |
| 721 | P1057/L15 | The comparison between human choices and climate variability is a poor analogy for climate statistics especially since it has been argued by some (and perhaps in the NCA) that emissions scenarios cannot be assigned a probability. Suggest avoiding such analogies and focusing on climate. |
| 722 | P1057/L26 | Asserting that we know the physics "relatively well" does not present a clear basis for the answer to the question. The lack of assessment of uncertainty of projections in the NCA and such a simple assertion leaves a very weak basis for the reader. |

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| 723 | P1058/L3 | The figure does not fit the caption. For example, there are no day to day changes in the figure. |
| 724 | P1067/L18 | Text erroneously states that the last decade (unequivocally) is the warmest in 2000 years. Analyses have attempted to answer this question and have estimated the likelihood that this may be true. |
| 725 | P1067/L22 | This an overgeneralization (e.g. the specific time context is not given and therefore it may or may not be true) and does not apply to all time periods; the Earth has had periods of warming and cooling. |
| 726 | P1074/L16 | Suggest removing "exactly"; pattern matches are not exact. |
| 727 | P1076/L16 | Attribution studies have not found unequivocal results therefore "impossible" is incorrect. |
| 728 | P1076/L19 | Attribution of extremes is of very limited confidence as assessed by the SREX. For example, SREX states (p9) "only low confidence of the attribution of any detectable changes in tropical cyclone activity to anthropogenic influences." |
| 729 | P1077/L3 | It is incorrect to claim attribution is certain for the systems in the figure. Even for temperature, attribution is a probability statement (e.g. very likely). For other features (e.g. floods), ability to attribute to climate (and other factors) is much poorer. |
| 730 | P1078/L2 | The certainty of the assertion "only" in the figure and caption is not consistent with attribution studies or IPCC conclusions. |
| 731 | P1080/L16 | "nothing short of remarkable" and 97% without reference seems argumentative. |
| 732 | P1085/L8 | Suggest that the trend for both Antarctica and arctic sea ice be quantitatively described instead of saying simply "little trend." |
| 733 | P1088/L1 | This seems like a very small set of papers considering how many on climate change are published? |
| 734 | P1089/L10 | "cannot be altered" is not true; it is insensitive to greenhouse gas emission reduction. |
| 735 | P1089/L25 | 12F is higher than shown in the chart on page 25 (or about 4C given in the scientific literature); why are uncertainties not given for all projections? |
| 736 | P1090/L7 | Since no uncertainty is shown in the curves, one cannot tell how to compare sensitivity to scenario to uncertainty. Caption is confusing since only scenarios are mentioned. It is not mentioned how the curve is derived from models (median, average, ?). |
| 737 | P1091/L10 | "many areas" is not consistent with the IPCC SREX which assessed that this may occur in some areas with medium to low confidence. Overconfidence is expressed with regards to projections of extremes throughout the NCA. |
| 738 | P1091/L16 | "has clearly increased" implies high confidence in attribution which is not true for most weather extremes. This should state precisely for which extremes there is high |

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| | | confidence attribution, otherwise this is providing misinformation. |
| 739 | P1091/L18 | The analogy to steroids in not appropriate. If one reads the IPCC SREX response to the FAQ (is becoming more extreme, p.124) next to this paragraph, one is left with the impression that this draft is hype. |
| 740 | P1092 | reference for the caption conclusions should be provided and validity assessed through traceable account (this is not commonly covered in assessments). |
| 741 | P1093/L24 | "availability of calcium carbonate" does not make sense? Perhaps concentration of carbonate ion is what is meant? |
| 742 | P1095/L7 | "supersaturated with calcium carbonate minerals" does not make sense. |
| 743 | P1095/L8 | "concentration of these minerals" does not make sense. |
| 744 | P1095/L11 | 30% — shouldn't this now be higher since CO2 has increased 40%? |
| 745 | P1095/L15 | Should also mention that there are large variations in pH in ocean sediments. The 20 million only refers to inferred average ocean surface pH. |
| 746 | P1095/L23 | The shell shown seems to not include the actual pteropod (only the shell). Is this all the evidence that we have (it is not convincing or particularly relevant since shells have always been dissolving on some parts of the sea floor)? |
| 747 | P1096/L1 | This text does not answer the question of trust and the NCA largely does not discuss uncertainty of projections. Clearly we would not trust the models in the same way we trust those that, for example, control airplanes. |
| 748 | P1096/L14 | "do a good job"? No proof provided. Projections of precipitation differ in sign between some models which is hard to describe as "good job." |
| 749 | P1099 | Should show estimates of uncertainties in projections. |
| 750 | P1100 | This section seems to go further than the executive summary says we know about tipping points. It should be explained that there is not a consensus among models about major tipping points occurring this century. |
| 751 | P1108 | Variability or vulnerability? This chart needs discussion if included. |
| 752 | P1109/L11 | Biofuels? The land use and life cycle emissions of corn ethanol mean it cannot contribute significantly. |
| 753 | P1109 | This page only describes end use and not power generation which has large scope for reducing emissions. |

# Appendix B
# Panel Member Biosketches

**Warren Washington** is a senior scientist at the National Center for Atmospheric Research (NCAR). He has published more than 150 papers in professional journals and co-authored a book entitled, "An Introduction to Three-Dimensional Climate Modeling." He has served on the National Science Board (chair, 2002-2006), the NOAA Science Advisory Board, President's National Advisory Committee on Oceans and Atmosphere, several panels of the National Research Council, the Secretary of Energy's Advisory Board, among others. Washington areas of research are in the development and use of climate models for climate change studies. He has also served as President of AMS and a member of the AAAS Board of Directors. He is a member of the National Academy of Engineering, American Philosophical Society, and the American Academy of Arts and Sciences. He has received many awards, including the Le Verrier Medal of the Societe Meteorologique de France, the National Weather Service Modernization Award, and the AMS Dr. Charles Anderson Award. He has honorary degrees from the Oregon State University and Bates College. In 2010, he was awarded the National Medal of Science by President Obama.

**Kai Lee** joined the David & Lucile Packard Foundation as a program officer in 2007, and leads the Science subprogram in Conservation & Science. The science subprogram provides support for science that informs decision making in the near term, advancing the strategies guiding the conservation activities of the Foundation. He also provides program support and liaison for the Monterey Bay Aquarium Research Institute, the Center for Ocean Solutions, and the Aldo Leopold Leadership Program. From 1991-2007, Lee taught at Williams College and is the Rosenburg Professor of Environmental Studies, *emeritus*. From 1991-98 and 2001-02, he directed the Center for Environmental Studies at Williams, and from 1973-91 taught at the University of Washington in Seattle. He is the author of *Compass and Gyroscope* (Island Press, 1993) and coauthor of *Our Common Journey* (National Research Council, 1999) and *Humans in the Landscape* (W.W. Norton, 2012). He is a National Associate of the National Research Council. Lee was a White House Fellow and represented the state of Washington as a member of the Northwest Power Planning Council. He was appointed in 2009 to the EPA Science Advisory Board and served until 2011, when he became vice-chair of the Committee to Advise the U.S. Global Change Research Program at the National Research Council. Lee also served as vice-chair of the panel that wrote *Informing Decisions in a Changing Climate* (NRC, 2009). He holds a PhD in Physics from Princeton University.

**Mark Abbott** is Dean and Professor at the College of Earth, Ocean, and Atmospheric Sciences at Oregon State University. He received his B.S. in Conservation of Natural Resources from the University of California, Berkeley, in 1974 and his Ph.D. in Ecology from the University of California, Davis, in 1978. He has been at OSU since 1988 and has been Dean of the College since 2001. He served on the National Science Board from

2006 until 2013. Dr. Abbott's research focuses on the interaction of biological and physical processes in the upper ocean and relies on both remote sensing and field observations. Dr. Abbott is a pioneer in the use of satellite ocean color data to study coupled physical/biological processes. He has also advised the Office of Naval Research and the National Science Foundation on ocean information infrastructure. He is currently president of The Oceanography Society and chairs the Committee on Earth Science and Applications from Space for the NRC.

**Doug Arent** is Executive Director of the Joint Institute for Strategic Energy Analysis at the National Renewable Energy Laboratory (NREL). He specializes in strategic planning and financial analysis competencies; clean energy technologies and energy and water issues; and international and governmental policies. In addition to his NREL responsibilities, Dr. Arent is Sr. Visiting Fellow at the Center for Strategic and International Studies. Dr. Arent was appointed as a Coordinating Lead Author for the 5th Assessment Report of the Nobel Prize Winning Intergovernmental Panel on Climate Change (IPCC) and serves on the National Research Council Committee to Advise the U.S. Global Change Research Program. He is a member of Policy Subcommittee of the National Petroleum Council Study on *Prudent Development of North America Natural Gas and Oil Resources*, and the American Academy of Arts and Sciences Steering Committee on *Social Science and the Alternative Energy Future*. Dr. Arent is a Member of the Keystone Energy Board and serves on the Advisory Council of the Smart Cities Council. Dr. Arent served from 2008 to 2010 on the National Academy of Sciences Panel on *Limiting the Magnitude of Future Climate Change,* and also served on the Executive Council of the U.S. Association of Energy Economists. Prior to coming to his current position, Dr. Arent was Director of the Strategic Energy Analysis Center at NREL from 2006-1010. Prior to joining NREL, he was a management consultant to clean energy companies, providing strategy, development and market counsel. Dr. Arent has a Ph.D. from Princeton University, an MBA from Regis University, and a bachelor's of science from Harvey Mudd College in California.

**Susan Avery** is President and Director of the Woods Hole Oceanographic Institute (WHOI). She holds a Doctorate in Atmospheric Science from the University of Illinois. Prior to WHOI she was on the faculty at the University of Colorado, Boulder (UCB) for 26 years, most recently holding the academic rank of professor of electrical and computer engineering and Fellow in the Cooperative Institute for Research in Environmental Sciences (CIRES). She served as director of CIRES from 1994 to 2004, where she facilitated interdisciplinary research spanning the geosciences and social sciences, established a Center for Science and Technology Policy Research, and a K-12 outreach program. Her research interests include studies of atmospheric circulation and precipitation, the development of new radar techniques and instruments for observing the atmosphere, and the role of climate science in decision support. She is the author or co-author of more than 80 peer-reviewed articles. She also served in interim positions at UCB as Vice Chancellor for Research and Dean of the Graduate School, as well as Provost and Executive Vice Chancellor for Academic Affairs. Avery is a fellow of the Institute of Electrical and Electronics Engineers, the American Association for the Advancement of Science, and of the American Meteorological Society, for which she also served as president. She currently serves on the US Advisory Committee to the Intergovernmental Oceanographic Commission; NRC Board on Higher Education and Workforce; the NOAA Science Advisory Board; the Consortium of Ocean Leadership Board; and the Massachusetts Global Warming Solutions Act Implementation Advisory Committee. She is active in professional societies and serves on academic and research program review committees.

**Glen Daigger** is Senior Vice President and Chief Technology Officer at CH2M HILL with responsibility for the technology function for the firm's water businesses (water resources, water supply and treatment, wastewater). He is also the first Technical Fellow for the firm, an honor which recognizes the leadership that he provides for CH2M HILL and for the profession in the development and implementation of new wastewater treatment technology. Dr. Daigger has more than 30 years of experience in wastewater treatment plant evaluation, troubleshooting, and process design. His areas of expertise include biological wastewater treatment and treatment process design, in particular biological nutrient removal (both nitrogen and phosphorus), combined trickling filter and activated sludge systems, the use of biological selectors to control activated sludge bulking, and oxygen transfer. Between 1994 and 1996 he served as professor and head of the Environmental Systems Engineering Department at Clemson University. Dr.Daigger is a member of the American Society of Civil Engineers, American Water Works Association, Association of Environmental Engineering, International Water Association, Water Environment, as well as numerous other professional societies. Dr. Daigger received his PhD in Environmental Engineering from Purdue University.

**Evan DeLucia** is the G. William Arends Professor of Biology at the University of Illinois at Urbana-Champaign; he was the founding Director of the Program in Ecology and Evolutionary Biology, served as the Head of the Department of Plant Biology, and currently he is the director of the School of Integrative Biology. DeLucia completed a PhD (1986) in plant ecology and physiology at Duke University. He joined the faculty at Illinois in 1986, where he was recognized as a University Scholar in 1997. In 1994, DeLucia was a Bullard Fellow at Harvard University and in 2002 he was a Fulbright Fellow at Landcare Research in New Zealand. DeLucia became a Fellow of the American Association for the Advancement of Science in 2005. He is a member of the American Association of Plant Physiologists, the International Union of Forest Research Organizations, the Ecological Society of America, the American Geophysical Union and the American Association for the Advancement of Science. He was elected Chair of the Physiological Ecology Section of the Ecological Society (1996-98). He currently provides editorial services for several prominent journals, including Ecology, Oecologia, Tree Physiology, and Global Change Biology. The responses of forest and agro-ecosystems to elevated carbon dioxide and other elements of global change are at the center of DeLucia's research interests. Using ecological, physiological and genomic approaches, DeLucia seeks to understand how global change affects the carbon cycle and the trophic dynamics between plants and insects. He has served in an advisory capacity to members of the US congress and the National Academy of Sciences.

**Robert Dickinson**, a Professor at The University of Texas, is a leader in dynamic meteorology and physical climatology. He first delineated the way planetary scale Rossby waves interact with the mean flow—a process central to understanding the general circulation of the atmosphere. He has also established the major role of foliage in climate dynamics and made major contributions to other problems. His areas of interest include the dynamics of atmospheric planetary waves, stratospheric dynamics, models of global structure and dynamics of terrestrial and planetary thermosphere, NLTE infrared radiative transfer in planetary mesopheres, global climate modeling and processes, the role of land processes in climate systems, the modeling role of vegetation in regional evapotranspiration, and the role of tropical forests in climate systems. His recent research has focused on how to model what land does as part of a climate system model. He earned a B.A. in Chemistry and Physics from Harvard University in 1961. He also holds a M.S. (1962) and Ph.D. (1966) in Meteorology from the Massachusetts Institute of Technology.

**Thomas Dietz** is a Professor of Environmental Science and Policy (ESPP), Sociology and Animal Studies at Michigan State University. He is also Co-Director of the Great Lakes Integrated Sciences and Assessment Center (glisa.msu.edu). He holds a Ph.D. in Ecology from the University of California, Davis, and a Bachelor of General Studies from Kent State University. At MSU he has served as Founding Director of the Environmental Science and Policy Program and Associate Dean in the Colleges of Social Science, Agriculture and Natural Resources and Natural Science. At the National Research Council he has served as chair of the U.S. National Research Council Committee on Human Dimensions of Global Change and the Panel on Public Participation in Environmental Assessment and Decision Making, and as Vice Chair of the Panel on Advancing the Science of Climate Change of the America's Climate Choices study. (americasclimatechoices.org). His research interests include the macro-comparative human ecology, environmental values and decision making, and the interplay of science and democracy in deliberative processes.

**Durland Fish** is a Professor in the Yale School of Public Health. He studies the ecology of vector-borne pathogens. Recent emphasis has been on tick-borne pathogens causing Lyme disease, human anaplasmosis and babesiosis, and on mosquito-borne West Nile virus and dengue fever. Current projects include experimental manipulation of natural transmission cycles, vaccination of wildlife reservoirs against vectors and vector-borne pathogens, interactions among multiple pathogens in vectors and hosts, vector competence for viral and bacterial pathogens, and pathogen population genetics. Spatial analysis of pathogen prevalence using satellite imagery and geographic information systems forms the basis for applied studies in landscape epidemiology. His laboratory maintains colonies of ticks and mosquitoes for experimental studies, and a network of field sites is available for ecological studies. Professor Fish is Director of the Yale Center for EcoEpidemiology, an interdisciplinary center that seeks to integrate environmental science and ecology with medical epidemiology. He is also on the Steering Committee of the Yale Climate and Energy Inst. where he coordinates campus wide research on climate and human health.

**Debra Hernandez** is a Professional Engineer and her background is in coastal management and engineering. Ms. Hernandez is currently the Executive Director of Southeast Coastal Ocean Observing Regional Association (SECOORA). She was the President of Hernandez and Company and previously worked as Director of Program and Policy Development for the South Carolina Department of Health and Environmental Control. Ms. Hernandez's expertise lies in federal and state coastal and environmental management laws, regulations, and policies. She served for six years on the Ocean Research Advisory Panel and the NRC Ocean Studies Board. Additionally, she chaired the Coastal States Organization (CSO) from 2002 to 2004. CSO represents the interests of 35 governors from coastal states on federal activities relating to coastal management. She also served on the Planning Commission and was elected to City Council for the Isle of Palms, SC.

**Haroon Kheshgi** is the Global Climate Change Science Program Leader at ExxonMobil's corporate Strategic Research. He studied chemical engineering at the University of Illinois (Urbana, B.S. 1978) and the University of Minnesota (Minneapolis, Ph.D. 1983). He pursued research at Lawrence Livermore National Laboratory (1983-1986) before joining ExxonMobil Research and Engineering Company in 1986. At ExxonMobil Corporate Strategic Research his research addresses many aspects of global climate change including carbon cycle, detection and attribution of climate change, paleoclimate implications, and the mitigation of greenhouse gas emissions. He has contributed to the Intergovernmental Panel on Climate

Change (IPCC) as lead author, contributing author, and review editor in the IPCC's last three assessment reports and it's Special Reports on Carbon Dioxide Capture and Storage, and on Land Use Change. Recent activities include participation in the International Petroleum Industry Environmental Conservation Association's Climate Change Working Group, the Engineering Founder Societies' project on carbon management, the Society on Petroleum Engineering's committee on carbon capture and storage, and the American Institute of Chemical Engineers Energy Advisory Board. He recently served as a member of the NRC's Board on Atmospheric Sciences and Climate (BASC), and before that as a member of the BASC Climate Research Committee.

**Robin Leichenko** is Associate Professor in Geography and Director of the Initiative on Climate and Society at Rutgers University. Her current research focuses on the economic and social dimensions of climate change impacts, vulnerabilities, and adaptation in U.S. coastal cities and regions. She has also conducted research on the impacts of climate change on urban areas and agricultural regions in Pakistan, India, and southern Africa. Her 2008 book, entitled, *Environmental Change and Globalization: Double Exposures* (Oxford University Press), received the Meridian Book Award for Outstanding Scholarly Contribution in Geography from the Association of American Geographers. She is currently serving as a Review Editor for Working Group II of the Fifth Assessment Report of the IPCC (Intergovernmental Panel on Climate Change). She also served on the NRC/BECS Committee on Assessing the Impacts of Climate Change on Social and Political Stresses. She has an M.A. in Economics and a Ph.D. in Geography from Penn State University.

**Maria Carmen Lemos** is Professor of Natural Resources and Environment at the University of Michigan, Ann Arbor and Senior Policy Scholar at the Udall Center for the Study of Public Policy at the University of Arizona. During 2006-2007 she was a James Martin 21st Century School Fellow at the Environmental Change Institute at Oxford University. Her research focuses on environmental public policymaking in Latin America and the U.S., especially related to the human dimensions of climate change (adaptation and adaptive capacity building); the co-production of science and policy and different means to narrow the gap between useful and usable knowledge; and the role of technoscientific knowledge and environmental governance in building adaptive capacity to climate variability and change response. She is a co-founder of Icarus (Initiative on Climate Adaptation Research and Understanding through the Social Sciences), which seeks foster collaboration and exchange between scholars focusing on vulnerability and adaptation to climate change. She is a lead author of the Intergovernmental Panel on Climate Change (IPCC-AR5) and has served in a number of the US National Research Council of the National Academies of Sciences committees including Restructuring Federal Climate Research to Meet the Challenges of Climate Change (2009), America Climate Choice Science Panel (2010) and the Board on Environmental Change and Society (2008-present). She has MSc and PhD degrees in Political Science from the Massachusetts Institute of Technology, MIT.

**Ian Noble** is an independent consultant and Chief Scientist at the Global Adaptation Institute (GAIN). Recently he retired from the World Bank where he was a Senior Advisor responsible for leading the Bank's activities in adaptation to climate change. At the Bank he also worked with the Carbon Finance Unit on the design of the BioCarbon Fund and on emissions reductions through reduced deforestation and forest degradation (REDD+). Before going to the Bank in 2002 he was Professor of Global Change Research in the Institute of Advanced Studies at the Australian National University. He has had senior roles in the IPCC process, including the current assessment, and in international cooperative research on climate change as

part of the IGBP (International Geosphere Biosphere Program) including chairing the Global Change and Terrestrial Ecosystems (GCTE) project for six years. In Australia he participated in the public and policy debate over responses to climate change and served as a Commissioner in an inquiry for the Prime Minister into the future of the Australian forests and forest industries. Ian Noble is an ecologist by training with research interests covering animal behaviour, vegetation and biodiversity management, ecosystem modeling, climate impacts and the science-policy interface. In 1999 he was elected as Fellow of the Australian Academy of Technological Sciences and Engineering.

**Camille Parmesan** is a Professor in Integrative Biology at the University of Texas at Austin (USA) and holds the National Aquarium Chair in the Public Understanding of Oceans and Human Health in the Marine Institute, Plymouth University (UK). Dr. Parmesan's research focuses on the current impacts of climate change on wildlife, from field-based work on American and European butterflies to synthetic analyses of global impacts on a broad range of species across terrestrial and marine biomes. This work has had high impact, leading to Parmesan being ranked the second most highly cited author in the field of Climate Change from 1999-2009 by Thomas Reuters Web of Science. Her analyses documenting the global extent and pervasiveness of the effects of anthropogenic climate change on biodiversity have helped support arguments in policy sectors for reduction of greenhouse gas emissions. She works actively with governmental agencies and NGOs to help develop conservation assessment and planning tools aimed at preserving biodiversity in the face of climate change. She was awarded the Conservation Achievement Award in Science by the National Wildlife Federation, named "Outstanding Woman Working on Climate Change," by IUCN, and named as a "Who's Who of Women and the Environment" by the United Nations Environment Program (UNEP). Dr. Parmesan has worked with the Intergovernmental Panel on Climate Change for more than 15 years, and is a co-recipient of the Nobel Peace Prize awarded to IPCC in 2007. Dr. Parmesan is a Professor in Integrative Biology at the University of Texas at Austin (USA) and holds the National Aquarium Chair in the Public Understanding of Oceans and Human Health in the Marine Institute, Plymouth University (UK).

**Connie Roser-Renouf** has been at the George Mason University Center for Climate Change Communication since its inception in 2007. Her research focuses on understanding how diverse publics use, interpret and respond to information on the issue of climate change. The guiding objective of her work is the identification of effective communication strategies that inform and engage audiences. Dr. Roser-Renouf earned her PhD in Communication Research at Stanford University in 1986. Prior to joining the Center at George Mason, she taught and conducted research at the University of California at Santa Barbara; the University of Denver; the University of Pittsburgh; and Humboldt State University.

**Kathleen Segerson** is a Professor of Economics at the University of Connecticut. She was the Head of the Department of Economics from 2001-2005. Dr. Segerson specializes in natural resource economics, and in particular, the economics of environmental regulation. She is currently a member of both the Chartered Executive Board of the Environmental Protection Agency's Science Advisory Board, and the Vice Chair of the Advisory Board's Committee on Valuing the Protection of Ecological Services and Systems. She was a member of the U.S. General Accounting Office's Expert Panel on Climate Change Economics from 2007-2008 and frequently serves on external review committees for the U.S. Department of Agriculture. She has also served on three National Research Council study committees: the Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems (2002-2004), the Committee on the Causes and Management of Coastal Eutrophication (1998-2000), and the Committee on Improving Principles and

Guidelines for Waste Resources Planning by the U.S. Army Corps of Engineers (2008- present). In 2008, she was named a Fellow by both the American Agricultural Economics Association and the Association of Environmental and Resource Economists. Dr. Segerson earned a Ph.D. from Cornell University in 1984. She currently serves as a member of the NRC's Board on Agriculture and Natural Resources (BANR).

**Karen Seto** is Professor of the Urban Environment at the School of Forestry and Environmental Studies at Yale University. Professor Seto studies the human transformation of land and the links between urbanization, global change, and sustainability. A geographer by training, her research includes understanding urbanization dynamics, forecasting urban growth, and examining the environmental consequences of land-use change and urban expansion. She is an expert in satellite remote sensing analysis and has pioneered methods to reconstruct historical land-use and to develop empirical models to explain and forecast the expansion of urban areas. Professor Seto is Co-Chair of the IHDP (International Human Dimensions Programme on Global Environmental Change) Urbanization and Global Environmental Change Project (UGEC), and a Coordinating Lead Author for the IPCC Fifth Assessment Report. She also serves on the U.S. Carbon Cycle Scientific Steering Group, the NRC Geographical Sciences Committee, and the NRC Committee on Needs and Requirements for Land-Change Modeling. She is the Executive Producer of "10,000 Shovels: Rapid Urban Growth in China," a documentary film that integrates satellite imagery, historical photographs, and contemporary film footage to highlight the urban changes occurring in China. Professor Seto is an Aldo Leopold Leadership Fellow and recipient of a NASA New Investigator Program Award, a NSF Career Award, and a National Geographic Research Grant. She has a Ph.D. in Geography from Boston University.

**Kathleen Tierney** is a Professor of Sociology and Director of the Natural Hazards Research and Applications Information Center at the University of Colorado. The Hazards Center is housed in the Institute of Behavioral Science, where Prof. Tierney holds a joint appointment. Dr. Tierney's research focuses on the social dimensions of hazards and disasters, including natural, technological, and human-induced extreme events. With collaborators Michael Lindell and Ronald Perry, she recently published Facing the Unexpected: Disaster Preparedness and Response in the United States (Joseph Henry Press, 2001). This influential compilation presents a wealth of information derived from theory and research on disasters over the past 25 years. Among Dr. Tierney's current and recent research projects are studies on the organizational response to the September 11, 2001 World Trade Center disaster, risk perception and risk communication, the use of new technologies in disaster management, and the impacts of disasters on businesses.

**Charles Vorosmarty** is a Professor of Civil Engineering, a Distinguished Scientist with NOAA-Cooperative Remote Sensing Science and Technology Center and Director of The City University of New York's Environmental Crossroads Initiative at The City College of New York. His research focuses on the development of computer models and geospatial data sets used in synthesis studies of the interactions among the water cycle, climate, biogeochemistry and anthropogenic activities. His studies are built around local, regional and continental to global-scale modeling of water balance, discharge, constituent fluxes in river systems and the analysis of the impacts of large-scale water engineering on the terrestrial water cycle. He is a founding member of the Global Water System Project under ICSU's Global Environmental Change Programs. He is spearheading efforts to develop global-scale indicators of water stress, to develop and apply databases of reservoir construction worldwide and to analyze coastal zone risks associated with water diversion. He also is on several national and international panels, including the U.S. Arctic Research

Commission, the NASA Earth Science Subcommittee, the NRC Committee on Hydrologic Science, the NSF's Arctic System Science Program Committee and the Arctic HYDRA International Polar Year Planning Team. He also was on an NRC panel that reviewed NASA's polar geophysical data sets, the decadal study on earth observations, and is Co-Chair of the NSF's Arctic CHAMP hydrology initiative. He has assembled regional and continental-scale hydro-meteorological data compendia, including the largest single collection, Arctic-RIMS (covering northern Eurasia and North America).

# Appendix C

# Statement of Task

Review of the National Climate Assessment 2013 Report and
Advice Regarding the Sustained Assessment Process
*[note: the dates indicated below have now shifted]*

A Panel of the NRC "Committee to Advise the U.S. Global Change Research Program" (USGCRP) will conduct an independent review of the U.S. Global Change Research Program's 2013 NCA report in three phases, as described below. Advice regarding the NCA's approach to developing a sustained assessment process is welcomed throughout this review process.

***Phase I: Discussion of the preliminary key messages of the 2013 NCA report.***

In a meeting involving USGCRP/NCA officials and lead authors, the Panel will hear about the preliminary key messages emerging from the NCA process and will discuss: critical concerns about the accuracy of those messages; any major issues that may have been omitted from the key messages and should be considered for inclusion in the NCA report. This will be considered in light of the fact that there is a limit to how many issues can be considered "key" in this synthesis report, and that in a sustained assessment process, there will be opportunities to address existing knowledge gaps in future interim/full synthesis reports. This discussion will held at the end of July, 2012; the only product of this effort will be a meeting recap based on NRC staff notes.

***Phase II: Full Review of the draft NCA Report***

The Panel will provide a written evaluation of the full draft of the 2013 NCA report and the associated supporting background material that justifies the key messages. The committee will aim to deliver this review within 90 days of receipt of the draft 2013 NCA Report, which is expected to be delivered before December 1, 2012. The review will address the following questions about the draft report:

- Does the report meet the requirements of Section 106 of the GCRA?

- Is the report responsive to the nation's needs for information on climate variability and change in a global change context, their potential implications, and the potential effects of different response options?
- Are the report's key messages and graphics clear and appropriate from a communications perspective?
- Are there any critical content areas missing from the report?
- Are the findings documented in a consistent, transparent and credible way?
- Does the research needs chapter address the most important gaps in existing knowledge?
- Does the sustained assessment chapter provide an appropriate path to support the development of a sustained assessment process within USGCRP that engages regional and sectoral communities of interest?

***Phase III: Discussion of the Revised Draft NCA Report***

Within one month of receiving a revised draft of the 2013 NCA report and associated supporting background materials, the Panel will have a meeting to discuss the draft with USGCRP/NCA officials and lead authors, to discuss the adequacy of the changes made in response to the Panel's earlier written review and to other comments from the general public. It is anticipated that this meeting will occur in May, 2013.

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