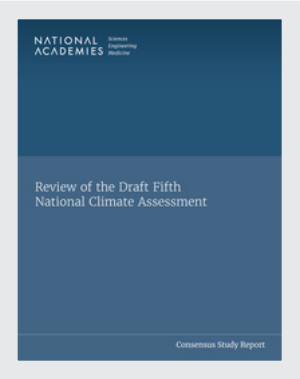

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Review of the Draft Fifth National Climate Assessment

Committee to Review the Draft Fifth National Climate Assessment

Board on Atmospheric Sciences and Climate

Division on Earth and Life Studies

Board on Environmental Change and Society

Division of Behavioral and Social Sciences and Education

Consensus Study Report

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This Consensus Study Report was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published report as sound as possible and to ensure that it meets the institutional standards for quality, 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 thank the following individuals for their review of this report:

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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations of this report, nor did they see the final draft before its release. The review of this report was overseen by **KAI LEE,** Owl of Minerva, LLC, and **ANTONIO BUSALACCHI (NAE),** University Corporation for Atmospheric Research. They were responsible for making certain that an independent examination of this report was carried out in accordance with the standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the authoring committee and the National Academies.

Contents

Summary

The US Global Change Research Program (USGCRP) is mandated to develop an assessment of global change every four years or less. The Fifth National Climate Assessment (NCA5) is the latest in a series of sustained assessments that evaluate the state of global change science and analyze the wide range of impacts of climate change in the United States. The assessments represent a consensus-based view of the state of knowledge, relevant for policy and decision making.

The draft NCA5 report reviewed here addresses a wide range of topics of high importance to the United States and society more broadly, extending from human health and community well-being to the built environment, to businesses and economies, and to ecosystems and water resources. NCA5 is a unique opportunity to examine the impacts of current and projected climate change on each region of the United States. Hundreds of experts representing federal, state, and local governments; academia; non-governmental organizations; and the private sector developed the draft NCA5 report, with further input from community engagement events and public comment. The scale of collaboration is the largest for any National Climate Assessment (NCA) to date. The impressive and rich array of perspectives introduced through the NCA5 writing process provides an opportunity to develop a foundational climate change report that informs and highlights adaptation and mitigation efforts and serves as a valuable resource for broad audiences.

The National Academies of Sciences, Engineering, and Medicine convened an ad hoc Committee to Review the Draft Fifth National Climate Assessment (the "Committee"). The Committee is charged with providing a comprehensive, independent review of the draft NCA5 report, concurrent with the public comment period. In its review, the Committee evaluated the draft NCA5 report to determine whether it meets the requirements of the federal mandate; provides accurate information grounded in the scientific literature; and effectively communicates climate science, impacts, and responses for general audiences including the public, decision makers, and other stakeholders (see Chapter 1 of this report for the Committee's complete Statement of Task). Chapter 2 of this report synthesizes the Committee's overarching comments on the draft NCA5 report and makes recommendations for improvement. Chapter 3 provides detailed comments on each individual chapter of the draft NCA5 report, and Appendix A includes detailed line-by-line comments. The Committee's approach to this review was to provide constructive comments and specific suggestions to strengthen the accuracy, consistency, credibility, and accessibility of the key messages and supporting text in the draft NCA5 report.

The Committee applauds the NCA5 authors for their outstanding job assembling, researching, and interpreting the vast knowledge of an extremely complex and rapidly changing topic—climate change impacts, adaptation, and mitigation in the United States. The Committee also commends the NCA process for its use of traceable accounts to accurately document the state of knowledge—including emerging and remaining gaps in knowledge—regarding the impacts of climate change. The draft NCA5 report gives significant attention to matters of equity and justice—a substantial and long-overdue improvement over past NCAs. The Committee appreciates the attention to evaluating climate change impacts and responses through the lens of equity and justice. The Committee also commends the NCA5 authors for identifying progress the United States has made in adapting to climate change, particularly providing examples of successful adaptations by local and tribal communities.

Clear and consistent structures support the ability of NCA5 to reach its target audiences effectively, thereby enhancing the credibility and usability of the report. In order for the draft NCA5 report to better provide a clear, thorough, and credible encapsulation of the knowledge base of the impacts of climate change on the United States, the Committee recommends that consistent structures be adopted to make the report accessible to the target audiences:

1. **Key message "labels" and "titles" should follow a common structure throughout the report.**
2. **The "message" part of each key message should have a consistent reading level, length, and voice throughout the report.**
3. **Confidence and likelihood statements should be used consistently for each claim across all key messages, and readers should be able to readily understand what is meant by confidence and likelihood.**
4. **A consistent framework for traceable accounts sections would better support the key messages and build consistency and credibility across chapters.**
5. **The introduction to each chapter should be consistent in length, depth of content, relationship to key messages, and voice; new terminology should also be introduced in a consistent manner.**

It is vital that key messages throughout the report are crafted consistently and carefully. Key messages should incorporate and express the knowledge base through the use of appropriate confidence and likelihood levels and be carefully written so that findings can be understood by broad audiences and not taken out of context. Special attention is needed to ensure confidence and likelihood statements convey important context to readers about claims made in the key messages. Similarly, traceable accounts provide credibility and transparency to each key message and associated text; thus, a framework is recommended to build consistency and credibility for this important section. While it is appropriate for the text supporting the key messages to look different from one chapter to another, consistent introductory sections would provide readers with the appropriate context and a roadmap to understand the rest of the chapter.

Overall, the Committee is impressed with the graphics throughout the draft NCA5 report. Considering that figures and boxes are opportunities to meaningfully convey information to the broadest possible audiences, the Committee recommends the following:

6. **All figures, figure captions, and figure citations should be consistent and self-contained.**
7. **Boxes within chapters should be used to highlight specific examples or to summarize or improve message accessibility.**

The Committee recommends making figures and their captions self-contained such that the reader can easily understand the key ideas related to the figure without reading the supporting chapter text. The Committee also suggests that figures adhere to basic principles of design, including through the use of consistent titles, colors, and symbols. The use and content of boxes could also be more effective if reserved for specific types of content (i.e., firsthand stories, examples, complex concepts, an important figure). When possible, boxes could be better utilized to communicate a message that is not clearly expressed in the main text or needs amplification.

In addition to the structural issues raised above, there are a number of other inconsistencies across the draft NCA5 report that pertain to the ways topics and terms are structured and discussed. While it is appropriate for chapter authors to design their chapters to meet specific topical needs, there are certain content areas that would benefit from more consistent treatment throughout the draft NCA5 report to strengthen the credibility of key messages and enhance clarity and readability:

8. **The draft NCA5 report should be revised to address inconsistencies across chapters, including treatment of adaptation and mitigation, distinction between natural variability and climate change, use of scenarios, treatment of Focus On… Features, and the use of terminology.**
9. **The draft NCA5 report should be revised to utilize and distinguish between the different use cases of sea-level rise projections and sea-level rise scenarios clearly and consistently.**
10. **Individual chapters across the draft NCA5 report—particularly national and regional chapters—should be better integrated and cross-referenced.**

Where inconsistencies in structure and content between chapters cannot otherwise be resolved, the Front Matter could explain these differences. Overall, stronger cross-referencing and integration between chapters would reduce redundancies and inconsistencies, create more space for authors to expand on certain topics, and strengthen connections between national and regional topics.

The Committee commends the NCA5 authors for incorporating equity and justice into the report; however, there are opportunities to more intentionally and consistently integrate issues related to equity and justice throughout the report to highlight systemic interconnections. To that end, the Committee makes the following recommendations:

11. **For consistency, chapter introductions should include context on equity and justice as related to the chapter topic. To move beyond general statements, different dimensions of justice, including distributional, procedural, recognitional, and intergenerational justice, should be addressed as appropriate throughout the chapter text. Related gaps in the literature should be identified in the text and traceable accounts.**
12. **A glossary of terms related to equity and justice should be adopted and/or developed to ensure consistent use of terminology across NCA5. Associated references should be provided.**
13. **To provide equitable access to climate-related information across US communities, national chapters should include all US islands and territories in their figures and assessments whenever possible.**

Finally, in reviewing the draft NCA5 report as a whole, the Committee recommends more thorough attention should be given to certain topical areas:

14. **Relatively more emphasis should be placed on the topics of: mitigation, adaptation successes and shortcomings, projected impacts of climate change, attribution of extreme events, and rural analysis.**

1
Introduction

The Global Change Research Act of 1990 mandates the US Global Change Research Program (USGCRP) develop an assessment of global change every four years or less. The Fifth National Climate Assessment (NCA5) is the latest in a series of sustained assessments that evaluate the state of global change science and analyze the wide range of impacts of climate change in the United States. The assessments represent a consensus-based view of the state of the science and, although they are relevant for policy and decision making, they do not prescribe policy interventions (Crimmins, 2022). The first National Climate Assessment (NCA) was produced in 2001 (National Assessment Synthesis Team, 2001), the second in 2009 (Karl et al., 2009), the third in 2014 (Melillo et al., 2014), and the fourth in two volumes—volume I in 2017 (USGCRP, 2017) and volume II in 2018 (USGCRP, 2018a).

The National Academies of Sciences, Engineering, and Medicine (the National Academies) have a long history of providing advice to USGCRP by conducting formal reviews of the NCAs, USGCRP strategic plans, and other USGCRP products (NASEM, 2017a). Foundational National Academies reviews of USGCRP programs include National Research Council (2003) and (2004). Recent examples of National Academies reviews include the draft Fourth National Climate Assessment (NASEM, 2018a; USGCRP, 2018a), the draft Climate Science Special Report (NASEM, 2017b; USGCRP, 2017), the draft Second State of the Carbon Cycle Report (NASEM, 2018b; USGCRP, 2018b), the draft Third National Climate Assessment (Melillo et al., 2014; NRC, 2013), and the draft assessment on the impacts of climate change on human health (NASEM, 2015; USGCRP, 2016).

These reviews are authored by ad hoc committees or by the Committee to Advise the USGCRP. Established in July 2011, the Committee to Advise the USGCRP provides broad, ongoing advice from across the National Academies to the USGCRP. It also serves as a point of contact through which USGCRP can gain access to expertise throughout the National Academies for advice on specific aspects of the program. The National Academies convened an ad hoc Committee to Review the Draft Fifth National Climate Assessment (the "Committee"). The Committee is charged with providing a comprehensive, independent review of the draft NCA5 report, concurrent with the public comment period. The complete Statement of Task for the Committee's review is provided in Box 1-1.

A number of elements are new to NCA5. Compared to the Fourth NCA, the draft NCA5 report added chapters on economics (Chapter 19) and social systems and justice (Chapter 20) and divided the physical science chapter into two chapters (Chapter 2 on Climate Trends and Chapter 3 on Earth System Processes). Also new to NCA5 are five "Focus On… Features" on topics that span multiple chapters. The NCA5 author team is larger and more diverse, with more than 500 authors and technical contributors. The NCA5 authors have also placed particular emphasis on figures, science communication, equity and justice, and the development of a web-first format for the report.

There were several opportunities for public engagement with the development of the draft NCA5 report, including engagement workshops, a call for technical input, calls for comment on the draft prospectus and the annotated outline for the draft NCA5 report, and two calls for artwork.

BOX 1-1
Statement of Task

An ad hoc committee will conduct a review of the Draft Fifth National Climate Assessment, concurrent with the public comment period. The committee will incorporate diversity, equity, inclusion, and justice principles in its review. The committee's review will address the following questions about the draft report:

1. Does the draft assessment meet the requirements of Section 106 of the Global Change Research Act?
2. Do the key messages reflect current understanding about observed and projected impacts to the United States, the challenges, opportunities, and success stories for addressing risk, and identification of emerging issues related to climate change?
3. Does the draft assessment accurately reflect the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since the last National Climate Assessment?
4. Does the draft assessment appropriately identify and provide sufficient context for embedded content, and does this content reflect current scientific understanding?
5. Are there any critical content areas missing from the draft assessment and not adequately addressed by embedded content or references?
6. Are the findings documented in a consistent, transparent, and credible way?
7. Is the draft assessment written at a technical level that is appropriate for the intended audience?
8. Are the draft assessment's key messages and graphics clear, internally consistent, and appropriate? Specifically, do they reflect supporting evidence, include an assessment of likelihood, and communicate effectively?
9. Are the data and analyses handled in a consistent, transparent, and credible manner? Are statistical methods applied appropriately?
10. What other significant improvements, if any, might be made in the draft assessment?

THE COMMITTEE'S APPROACH TO THIS REPORT

During fall 2022, the National Academies appointed the Committee, which is composed of 18 members who have expertise in climate change science, vulnerability, and adaptation in the regions and sectors covered in NCA5. Committee members were not authors of or technical contributors to the draft NCA5 report. The draft NCA5 report was released to both the Committee and the public on November 7, 2022. In addressing its tasks, the Committee met virtually three times from November to December 2022. The Committee held one open-session meeting to learn more about NCA5 and ask questions of the Director of the National Climate Assessment and other NCA5 authors. Individual chapters were reviewed by small teams of Committee members. In addition to chapter review teams, Committee members looked across the entire draft NCA5 report with particular attention to how well it addresses equity and justice and how clearly and accurately the report communicates the state of knowledge on climate change science. The Committee's review was restricted to figures that had cleared copyright by January 27, 2023, and did not include other elements not available to the Committee, including the Glossary that is currently under development. Following the standard National Academies' procedures, the Committee's draft report then underwent a rigorous process of external peer review before publication.

REPORT ROADMAP

This report serves as the Committee's comprehensive review of the draft NCA5 report. After this brief introduction (Chapter 1), Chapter 2 synthesizes the Committee's overarching comments on the draft NCA5 report and makes recommendations for improvement. These comments cover both the structure across and within chapters as well as content across the entire draft NCA5 report. Chapter 3 provides detailed comments on each individual chapter as well as the five Focus On… Features, the Front Matter, and Appendixes 3 and 4; comments closely follow the questions in the Committee's Statement of Task (Box 1-1). The individual chapter reviews use a common structure with a summary followed by comments on the introduction, key message and supporting text language, traceable accounts, graphics and boxes, equity and justice, data and analyses, literature cited, and other recommended changes, as applicable. Appendix A includes detailed line-by-line comments on each chapter in the draft NCA5 report. The Committee's approach to this review was to provide constructive comments and specific suggestions to strengthen the accuracy, consistency, credibility, and accessibility of the key messages and supporting text in the draft NCA5 report. The Committee recognizes that NCA5 authors have limitations regarding structure and length and this review is careful to suggest places to eliminate writing where the Committee also suggests adding material. In its review, the Committee uses the term "climate change" to refer to anthropogenic climate change.

The primary audiences of NCA5 are "decision makers" including federal agencies, local and state governments, tribes, health care providers, educators, business owners, and the media (Allison Crimmins, personal communication). In its review, the Committee thought carefully about the audiences for NCA5 while developing recommendations related to effective communication. Tailoring communication to specific audiences is one of the fundamental principles of strategic science communication (Besley and Dudo, 2022) and contributes to desirable audience outcomes (Bostrom et al., 2013). Considering the breadth of potential audiences and users of NCA5 requires authors to communicate findings in a way that enhances accessibility while maintaining accuracy. When assessing whether the draft NCA5 report was written at an appropriate technical level, the Committee focused on two different target audiences—a broad audience base and a more technical audience base. Specifically, the Committee assessed chapter introductions, key messages and associated text, and figures from the perspective of targeting the broadest possible audiences, while the Committee expected the traceable accounts to target more technical audiences (e.g., the scientific research community). The Committee also considered how broad audiences might use some parts of the report, such as key messages, boxes, and figures.

2
Overarching Comments and Recommendations

The Committee applauds the Fifth National Climate Assessment (NCA5) authors for an impeccably researched, assembled, and interpreted vast body of literature on an extremely complex and rapidly changing topic—climate change impacts, adaptation, and mitigation in the United States. This is no easy task and is increasingly challenging as the knowledge base on climate change (e.g., the literature, action on climate change mitigation and adaptation) has dramatically expanded in recent decades, particularly since the last National Climate Assessment (NCA) report was released in 2018. The Committee also commends the NCA process for the inclusion of traceable accounts sections at the end of each chapter to describe the process and rationale authors used to develop the chapter and reach consensus on key messages. These sections support the ability of the draft NCA5 report to accurately document the state of knowledge—including recent additions and remaining gaps in knowledge—regarding the impacts of climate change.

The Committee has many recommendations on how the draft NCA5 report can be revised to more clearly and credibly communicate its contents and add emphasis to better balance the state of knowledge on climate change. These recommendations are intended to support the overall goal of NCA5, which is to report on: the scientific understanding of climate change, how climate change already has and is expected to further affect the United States, and what can be done to mitigate and adapt to climate change. Before discussing the recommendations for revising the draft NCA5 report, the Committee outlines some of the many aspects of the report that deserve note and praise.

NOTES OF PRAISE

The draft NCA5 report gives significant attention to matters of equity and justice. This is a substantial and long-overdue improvement over past NCAs, and the Committee appreciates the attention to evaluating climate change impacts and responses through the lens of equity and justice. This attention to equity and justice is notable in many ways, including in the identification of overburdened communities, disproportionate consequences, and systemic drivers of vulnerability, particularly for tribal and other frontline communities in urban and rural areas. The Committee commends the NCA5 authors for using traditional knowledge in its assessment such as in Chapters 16 (Tribes and Indigenous Peoples), 29 (Alaska), and 30 (Hawai‘i and US-Affiliated Pacific Islands).

The Committee commends the NCA5 authors for identifying progress the United States has made in adapting to climate change, particularly at the state and local levels. The regional chapters review state-level adaptations and highlight promising examples of local-level adaptations, including actions of tribal communities. Chapter 31 (Adaptation) strikes the appropriate tone describing how adaptation measures to date appear to be insufficient to address the growing risks from climate change and that transformative adaptation as well as increased funding and technical support will be needed. Given the strong attention the report devotes to adaptation, there is an opportunity to give a similar treatment to mitigation actions, noted below.

Lastly, the draft NCA5 report has done a better job than previous NCAs of characterizing the Representative Concentration Pathway (RCP) scenarios used in recent Intergovernmental Panel on Climate Change (IPCC) assessments and NCAs. The use of terms such as "intermediate" and "very high" to characterize the RCPs better reflects the likelihood of these radiative forcing scenarios happening and makes these scenarios more accessible to general audiences. Consistent use of these more accessible terms beyond the introductory chapters would more clearly and effectively communicate the implications of each scenario throughout the report.

ADDRESSING THE MANDATE IN THE GLOBAL CHANGE RESEARCH ACT OF 1990

Overall, the Committee finds the draft NCA5 report addresses the mandate of Section 106 of the Global Change Research Act (GCRA) (Box 2-1). The draft NCA5 report integrates, evaluates, and interprets the science on climate change, and the Committee finds that the breadth of coverage of key climate change topics is impressive. The draft NCA5 report has done a masterful job pulling diverse information on the complex topic of global change together. In subsequent sections and in Chapter 3 of this report, the Committee offers specific comments on how the information base is interpreted and opportunities for improvement.

BOX 2-1
Global Change Research Act of 1990,[a] Section 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:

1. Integrates, evaluates, and interprets the findings of the Program and discusses the scientific uncertainties associated with such findings.
2. 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.
3. Analyzes current trends in global change, both human-induced and natural, and projects major trends for the subsequent 25 to 100 years.

[a] US Global Change Research Act of 1990, P.L. 101-606 (11/16/90), 104 Stat. 3096-3104.

Regarding subsection 1 of the GCRA, the draft NCA5 report addresses the state of knowledge about the science of climate change, including how climate change is already happening as a result of greenhouse gas (GHG) emissions and how the climate is projected to continue changing; impacts of climate change on sectors and regions of the United States; and how those impacts are projected to change in the future as a result of varying intensities of climate change mitigation and adaptation efforts. Although the Committee has recommendations on how to improve the draft NCA5 report, it is important to note that it is comprehensive, thorough, and well documented. In addition, although the Committee has recommendations on how to better integrate uncertainties into the text supporting key messages, overall, the NCA5

authors have made a substantial effort to assess the state of knowledge and report scientific uncertainties associated with their report findings, providing credibility and transparency to the report.

Consistent with previous NCAs, the draft NCA5 report focuses on climate change and does not focus on other global change issues. In many cases, the draft NCA5 report analyzes the interactions of climate change with other global change issues—particularly how other global changes intensify the effects of climate change. For example, Chapter 6 (Land Cover and Land-Use Change) considers how land cover and land-use change can lower the resilience of ecosystems and agriculture to climate change impacts. Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) effectively discusses the interactions of climate change with non-climate stressors including land-use change, urbanization, pollution, and overharvesting, and Chapter 7 (Forests) discusses the impact of fire and land-use change on the terrestrial carbon sink. Additionally, some regional chapters discuss other changes that have important implications for local vulnerability. Chapter 29 (Alaska) touches on non-climate stressors, including food insecurity, limited employment, and cost of living (Key Message 29.7), and Chapter 22 (Southeast) discusses urbanization in the region and how it changes exposure to climate change. However, important global change trends are not discussed in other regional and national chapters. The Focus on Compound and Complex Events defines "complex events" as those where climatic and non-climatic stressors interact in ways that exacerbate climate hazards, but these events are not addressed throughout the Focus. Other changes, such as baseline conditions, may also be important to discuss to better understand how the vulnerability of regions and sectors are changing. For example, the state of the public health system is a key factor affecting the vulnerability of the health sector to climate change but is not discussed in Chapter 15 (Human Health). Overall, the draft NCA5 report could more intentionally integrate how climate change interacts with the full suite of global changes and non-climate stressors.

The draft NCA5 report covers all of the topics enumerated in subsection 2 of the GCRA, including individual chapters on climate change impacts on natural ecosystems and biological diversity (Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity]), agriculture (Chapter 11 [Agriculture, Food Systems, and Rural Communities]), energy production and use (Chapter 5 [Energy Supply, Delivery, and Demand]), land-use (Chapter 6 [Land Cover and Land-Use Change]), water resources (Chapter 4 [Water]), transportation (Chapter 13 [Transportation]), human health (Chapter 15 [Human Health]), and social systems (Chapter 20 [Social Systems and Justice]), and many other chapters including the regional chapters touch on these issues as well. Several chapters are highly relevant to the scope of the GCRA, though not enumerated in subsection 2, including Chapter 7 (Forests), Chapter 12 (Built Environment, Urban Systems, and Cities), and Chapter 17 (Climate Effects on US International Interests).

Even though NCA5 has a chapter on climate trends (Chapter 2), projections of impacts 25 years to 100 years into the future—as noted in subsection 3 of the GCRA—are not consistently provided throughout the draft NCA5 report. For example, Chapter 15 (Human Health) says little about the projected impacts of climate change on human health. There is some discussion of projected impacts by mid-century and end of the century in most national and regional chapters. However, the Committee did not note any projections or discussions of impacts 100 years from the present (i.e., 2025), though this is likely due to the focus on estimating impacts out to the end of the 21st century in the scientific literature. This has been the case for decades (e.g., National Assessment Synthesis Team, 2001), but as time has passed, the end of the century is less than 100 years after the publication of NCAs, and therefore does not

satisfy subsection 3 of the GCRA. As described in the Committee's review of Appendix 3 and in Recommendation 8 below, there are difficulties in extending projections beyond 2100, but where this information is available, it should be included. Where there are gaps in the literature in which projections 100 years in the future have not been considered, these gaps should be noted in the "Major Uncertainties and Research Gaps" section of individual chapter traceable accounts.

Some chapters (e.g., Chapter 15 [Human Health]) present future impacts and risks as a function of global warming levels rather than tying them to specific emission scenarios and time frames; both can be effective ways to communicate projections and vulnerabilities into the future. For example, Figure 4.7 in Chapter 4 (Water) displays projected mid-21st century changes in runoff under the "intermediate" emissions scenario, while Figure 8.3 in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity), identifies increases in global mean temperature that could lead to a suite of adverse global ecological impacts. Chapters could more consistently discuss first the diagnostic state of the science on impacts (i.e., past and current, including attribution of impacts to climate change) and then the forward-looking prognostic state of science on future impacts, rather than frequently switching between discussions of historical and projected changes.

RECOMMENDATIONS FOR CONSISTENT STRUCTURES

Clear and consistent structures support NCA5 in reaching its target audiences effectively, thereby enhancing the credibility and usability of the report. In the section that follows, the Committee outlines recommendations that address the structure of chapters across the entire draft NCA5 report. Overall, the Committee recommends that consistent structures be followed for key messages, traceable accounts, chapter introductions, and figures. These recommendations considered together would improve the readability of the draft NCA5 report for the range of audiences described in Chapter 1 of this report. Additionally, this section notes a number of content inconsistencies across chapters and provides recommendations for remedies.

Key Messages

Key messages form the backbone of NCA5 and should capture the state of knowledge around climate change and identify important research gaps and possible next steps for advancing the knowledge base. Therefore, it is vital that key messages throughout the report are crafted consistently and carefully. Key messages provide an opportunity for NCA5 to provide credible, salient, and tailored information to audiences in ways that are not policy prescriptive (Farrell and Jäger, 2006). While challenging to write, key messages should incorporate and express the knowledge base through the use of appropriate confidence and likelihood levels and careful writing of findings that can be understood by broad audiences and not taken out of context. As they are currently written, there is significant variation in the structure of the key messages throughout the draft NCA5 report. NCA5 authors may consider the key messages as having three parts: the label (i.e., Key Message 2.1); title (i.e., Climate Is Changing and Scientists Understand Why); and message (see Box 2-2).

BOX 2-2
Anatomy of the Fifth National Climate Assessment (NCA5) Key Message

This box shows an example key message from Chapter 5 (Energy Supply, Delivery, and Demand) of the draft NCA5 report to illustrate the different components of an effective key message. Colors indicate different components of the key message and the terminology the Committee will use to discuss how to improve the format and content of the key messages throughout this report.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities
Interconnected effects of changes in technologies, policies, and markets increase the potential vulnerabilities of energy systems and communities to climate change and extreme weather (*likely*, *high confidence*). Compounding and cascading hazards related to energy systems and additional stressors such as cyberthreats and pandemics create risks for all but disproportionately affect underserved and overburdened communities (*likely*, *high confidence*).

Expanded mitigation and adaptation activities for energy systems include upgraded grid design, hardening of energy infrastructure, and vegetation management to reduce wildfire risk (Moreno et al. 2022; Vazquez et al. 2022) …

Orange = label
Green = title
Blue = key message
Purple = confidence/likelihood rating
Red = supporting text

Recommendation 1: Key message "labels" and "titles" should follow a common structure throughout the report.

Key message titles should communicate enough information to engage readers and use a consistent hierarchy for the information presented, following best practices in design (Seddon and Waterhouse, 2009). Therefore, the titles would be more effective if written as short, informative statements—instead of just one or two words—that convey a simplified but accurate message. Key message titles in Chapter 5 (Energy Supply, Delivery, and Demand) all convey information—for example, Key Message 5.2, "Compounding Factors Affect Energy System and Community Vulnerabilities." In contrast, in Chapter 17 (Climate Effects on US International Interests), the title of Key Message 17.2 could be rephrased from "National Security" to "Destabilization of Other Countries by Climate Change Affects US National Security." Additionally, the Committee appreciates that authors include the words "Key Message" in each label to cue to audiences of what they are reading and its importance. If the authors write titles as brief statements, they should be carefully written to be consistent with the knowledge base in the key message and traceable accounts. The Committee provides more specific suggestions for many of the key message titles in Chapter 3 of this report.

Recommendation 2: The "message" part of each key message should have a consistent reading level, length, and voice throughout the report.

The message part of each key message (see Box 2-2) varies significantly across the draft NCA5 report. The messages are the text that will be read and quoted the most by a wide range of audiences, including those that lack familiarity with the jargon and technical language of climate change; thus, the messages should be the most accessible parts of the report. Each message should be written simply and clearly, using short, uncomplicated sentences, omitting as much specialized jargon or needlessly complex language as possible (e.g., choose a word like "use" over "utilize") (Somerville and Hassol, 2011; van der Linden et al., 2015). This practice will ensure comprehension by broad audiences. It is similarly recommended by major medical associations that health communication materials target their intended audiences and use appropriate language for broad comprehension (Badarudeen and Subharwal, 2010). The messages also vary in length, ranging from one sentence to more than five sentences. The NCA5 authors may consider selecting a range for a number of words or sentences to standardize key messages so that they are a consistent length. Because of the web-first format, the authors could consider consulting with designers on the best length.

The messages would be more effectively communicated if they were more balanced; some are very broad, and some are very specific. On the one hand, broad messages can seem unclear or not specific enough (e.g., Key Message 4.1, 15.3, 17.1, 18.1, 21.1, 25.4, 28.1). For example, Key Message 28.2 includes "disproportionate" with no explanation of its meaning in the context of the key message. On the other hand, specific messages often have too much jargon and technical language. For example, Key Message 6.3 uses technical phrases such as "crop yield improvements," "animal-sourced foods," "agriculture system resilience," and "biomass crop cultivation" that could be simplified to language that could be more easily understood by general audiences (Somerville and Hassol, 2011). Key Message 28.4[1] is an example of a key message that says a lot but successfully uses plain language. The authors should also carefully consider the use of terms that can be imprecise, such as "historically," "already," and "currently," ensuring that they are used in consistent, accurate ways across key messages. Many language issues occur across multiple chapters, and NCA5 authors may find it useful to look at the full list of key messages together to ensure that terms are being used harmoniously.

When possible, messages and titles should use the active voice (i.e., subject followed by a verb followed by the object of the verb) over the passive voice (i.e., object followed by a verb with or without a subject). Passive voice can be hard for a reader to understand because there is a less clear relationship between the subject and verb, making the relationship between the confidence/likelihood rating and climate impact unclear.[2] For example, in Chapter 1 (Overview), the section 1.5 header, "Deep cuts in emissions would be required to meet national commitments" could be re-phrased to demonstrate who or what is making deep cuts in emissions

[1] Key Message 28.4. Demographics and Human Health. Increases in extreme heat, drought, and wildfire activity are negatively impacting the physical health Southwest residents (*high confidence*). Climate change is also shaping the demographics of the region by spurring the migration of people, primarily from Central America to the Southwest (*medium confidence*). Individuals particularly vulnerable to increasing climate change impacts include the elderly, outdoor workers, and people with low income (*high confidence*). Local, state, and federal adaptation initiatives are working to respond to these climatic and demographic changes and help people and communities become more resilient (*medium confidence*).

[2] See https://owl.purdue.edu/owl/general_writing/academic_writing/active_and_passive_voice/active_versus_passive_voice.html.

using active voice. For example, the section header could be revised to: "Local, state, federal, tribal, and Indigenous communities are pursuing mitigation actions that reduce emissions across the country." However, in using an active voice, NCA5 authors should be careful not to make statements policy prescriptive.

Additionally, some messages use a first-person voice (e.g., "Our Future," Key Message 29.7; "We Know How to Drastically Reduce Emissions," Key Message 32.2). In writing, the first-person point of view is used to tell a story from the author's perspective. Because this is an assessment and review of the state of knowledge rather than original research where the authors could use the first-person to explain their results (i.e., "our findings suggest"), the Committee suggests NCA5 authors avoid first-person language. The Committee also encourages authors to avoid first-person language because it is unclear who the "our" or "we" refers to. It is also important to carefully replace first person language when rewriting these statements rather than simply using encompassing phrases such as "people in the US," because that can also be inaccurate. Instead of using first-person language, where social science is available to support the key message, references to specific groups of people may be an acceptable replacement. Otherwise, the authors may consider selecting a more generic term such as "people" or "Americans," but this should be defined in the beginning of the report (i.e., Americans could reference anyone living in the United States or may only refer to citizens, problematically excluding some people who also live in the United States but who are not citizens, such as undocumented immigrants).

Additionally, authors should pay special attention to statements that may be perceived as policy prescriptive or advocating for a specific position, such as declarative statements that may not be adequately supported. In general, evidence that is policy relevant should be emphasized and statements that are normative should be deemphasized. For example, in Chapter 2 (Climate Trends), a subsection in Key Message 2.3 is titled, "The Nation Has No Choice But to Adapt to a Changing Climate" and Key Message 31.3 states "To minimize the potential for adaptation actions to benefit some at the expense of others, adaptation processes must emphasize collaboration, centralize equity and justice, and incorporate a wide range of values and knowledge sources." These statements should be rephrased so as not to be perceived as recommending certain policies or conveying a level of certainty not reflective of US policy. For example, the subsection in Chapter 2 (Climate Trends) could be re-phrased: "Adaptation can offset the adverse effects of climate change."

Regarding the text supporting the key messages, the key message should drive the supporting discussion, not the other way around. Many key messages read as though they were distilled after the supporting text was drafted. Instead, the key message should include the key points that reflect the most important or new findings for each chapter. The supporting text should support the entire key message, including providing context and noting uncertainties, as appropriate, that can be elaborated on in the traceable accounts. Attention is needed to ensure text supporting the key messages adequately achieves these goals consistently across NCA5.

Recommendation 3: Confidence and likelihood statements should be used consistently for each claim across all key messages, and readers should be able to readily understand what is meant by confidence and likelihood.

Confidence and likelihood statements convey important context to readers about the claim being made. Confidence is intended to be a *qualitative* statement based on the amount and

consistency of information available (i.e., the weight of evidence). Likelihood is intended to be a *quantitative* statement based on observations and model projections or an assessment of such *quantitative* information across sources (i.e., the probability that an impact has happened, is happening, or will happen). It is often unclear whether the NCA5 authors distinguish between the qualitative versus quantitative natures of the two types of assessments.

In general, confidence and likelihood definitions should be provided for general audiences in the Front Matter, in both written and numerical format (Budescu et al., 2014) and consistently assigned in each key message across NCA5. Each claim in the key message should include confidence at minimum and likelihood if—and only if—a quantitative assessment of probability can be made from the source material. Presently, some messages make multiple claims, but do not include confidence and likelihood at all or only include one statement of confidence/likelihood at the end of the message. This leaves the reader to wonder if the rating is applied to one claim, all claims, or just the most recent claim in the message. The draft NCA5 report in general seldom includes likelihood statements—these should be consistently considered across the document so that the lack of likelihood statements reflects the threshold defined in the Front Matter rather than an oversight. Box 2-3 provides an example of a successful use of confidence/likelihood statements and an example of a key message where the use of confidence/likelihood statements could be improved.

Additionally, likelihood statements are often provided without a corresponding explanation of quantitative support in traceable accounts sections. The likelihood statements correspond to specific probability ranges per the definitions provided in the Front Matter, which require care to justify the difference between levels of likelihood (e.g., *very likely* at >90% probability versus *likely* at >66% probability). Expert judgment can be part of the likelihood assessment, but the assessment should be based on more than belief, and the basis for such quantitative judgments should be adequately described in the traceable accounts. When quantitative likelihood assessment is not possible, it is preferable to provide only a confidence statement consistent with the knowledge base. In some cases, the knowledge base is limited or emerging, and this should be reflected in the confidence language and further expounded on in the traceable accounts. Because general audiences may only read the main text and not the more technical traceable accounts, it may also be appropriate to highlight key uncertainties briefly in the text supporting the key messages. Specifically, providing uncertainty or knowledge gaps with scientific claims makes the information more useful to decision makers and increases transparency, which can contribute to trustworthiness.

In some cases, the draft NCA5 report ascribes likelihood language to findings that are not in dispute (i.e., where the likelihood probability, based on the knowledge base, is greater than 99%). In such cases, the Committee suggests NCA5 authors follow the IPCC Sixth Assessment Report (AR6) language to classify these findings as “unequivocal” or “established fact” rather than “very high confidence.” For example, Key Message 2.1 states, “It is virtually certain that human activities have increased atmospheric levels of carbon dioxide and other greenhouse gases (*very high confidence*)” whereas IPCC AR6 states: “Observed increases in well-mixed greenhouse gas (GHG) concentrations since around 1750 are unequivocally caused by human activities” (IPCC, 2021a). The use of term “unequivocal” is appropriate when discussing facts where there is no doubt regarding the findings.

The language that scientists use to describe uncertainty, including the words “confidence” and “likelihood,” is jargon. It is the specialized language of science and the words confidence and likelihood have different meanings and interpretations in everyday use (Somerville and

BOX 2-3
Example Confidence and Likelihood Statements from Key Messages

Good Example: Each claim includes an associated confidence/likelihood statement:

> The Northern Great Plains is experiencing unprecedented extremes related to changes in climate, including severe droughts (*likely*, *high confidence*), increases in hail frequency and size (*medium confidence*), floods (*very likely*, *high confidence*), and wildfire (*likely*, *high confidence*), with alterations in plant community and crop growth (*very likely*, *very high confidence*). (Key Message 25.1)

Needs Improvement: Multiple claims are listed in the first sentence, but there is no confidence/likelihood associated with the claims. The reader is left to determine if *Very Likely*, *Very High Confidence* relates to all claims in the key message or only the last claim:

> Climate change is already harming human physical, mental, and spiritual health through increasing frequency and intensity of extreme events, increasing cases of infectious and vector-borne diseases, and declines in food and water security. Climate-related hazards will continue to grow, increasing morbidity and mortality across all regions of the United States. (*Very Likely*, *Very High Confidence*) (Key Message 15.1)

Hassol, 2011). In the Front Matter, the concepts of confidence and likelihood could be expanded somewhat to make them more accessible to readers unfamiliar with this language based on results from Budescu et al. (2014). The authors may also consider including a visual representation of confidence and likelihood, to supplement the text and numerical definitions in the Front Matter (Kause et al., 2022; Mastrandrea et al., 2010). The IPCC report is a similarly technical report, so simply presenting these terms and definitions with reference to the IPCC report is insufficient. Authors may consider a brief explanation about the nature of science, and how a single study or finding may advance understandings, that repeated replications of that work, scrutiny by the community of experts, and the convergence of expert agreement of particular findings and claims increase confidence in those understandings (Oreskes, 2021). This need not be extensive because that work has been done elsewhere, but this brief context is important for a less technical reader. In the web design, NCA5 authors may consider including definitions of confidence or likelihood ratings when the mouse arrow hovers over the phrase to remind readers of the meaning of these terms or navigate back to the Front Matter. Additionally, authors may consider including the standard definitions of confidence and likelihood at the beginning of each chapter as a standalone section. Many readers may never read the Front Matter where these terms are defined.

Traceable Accounts

Recommendation 4: A consistent framework for traceable accounts sections would better support the key messages and build consistency and credibility across chapters.

Traceable accounts written for each key message are an essential component of NCA5, providing both credibility and transparency to each key message and associated text and, therefore, the report. Overall, the traceable accounts include information about the state of knowledge and uncertainties that strengthen the quality of NCA5. The Committee's review of the traceable accounts emphasized, to the extent possible, whether the evidence presented for each key message consistently and adequately supported the assigned confidence and likelihood designations and the associated text rather than rigorously assessing the credibility of the determinations made by the authors. The Committee commends the use of confidence and likelihood statements consistent with the IPCC Fifth Assessment Report (AR5) definitions; however, there are significant inconsistencies in the traceable accounts sections across chapters, both in structure and how the evidence is presented. Chapter-specific comments are presented in Chapter 3 of this report, but here the Committee notes some of the major inconsistencies and provides recommendations to build a framework for NCA5 authors as they revise the traceable accounts sections.

Overall, the traceable accounts are appropriately written at a more technical level than the rest of the report and summarily discuss the literature base for their key messages. However, traceable accounts sections inconsistently satisfy their intended purpose, as defined by USGCRP (2018a): to detail *how* the authors arrived at their confidence and likelihood statements, and *what* evidence was used. The process for writing the traceable accounts is an analytical one about the state of the science in which authors should apply robust evidence (i.e., literature cited) to justify both the confidence and *likelihood* assigned to each statement within each key message. Thus, within the traceable accounts section, broad statements about the literature do not suffice and should be removed, citations should be included, and the substantive scope of the traceable accounts should be limited to the scope of the main text of the chapter. Additionally, where in the supporting text, authors are only able to make brief statements with a citation due to chapter word limits, they may provide greater depth in the traceable accounts, expanding on the main text to include additional context and discussion, specifically describing how that detail, nuance, or gap in understanding factored into the confidence and likelihood rating. For example, a discussion of which projections were and were not available for the chapter authors to consider and an explanation of model uncertainties are appropriate to include in the traceable accounts. There are many dense and technical passages in the text supporting the key messages that may be better suited for traceable accounts sections to enhance the readability of the main text (e.g., the text describing advances in the understanding of equilibrium climate sensitivity in Chapter 3 [Earth System Processes], pages 3-9 to 3-10).

There are many instances across the draft NCA5 report where traceable accounts sections do not provide any citations to support their statements (e.g., Chapters 4 [Water], 21 [Northeast], and 23 [US Caribbean]) and/or use broad statements such as "authors used their collective expertise and weighed the overall literature" to reach conclusions (e.g., Chapters 17 [Climate Effects on US International Interests], 23 [US Caribbean], and 25 [Northern Great Plains]). This kind of broad statement is descriptive of the process used to synthesize the literature and is not a substitute for identifying the literature (and should, likewise, be removed), nor does it provide sufficient detail required or support for the key messages. Section 106 of the GCRA does not require a summary report of the authors' collective expertise but rather an integration, evaluation, and assessment of the credible scientific base. It is appropriate for process details to be included; however, this should be done in a consistent way (e.g., some chapters provide a list of authors' expertise while others do not). Traceable accounts sections should be revised to

demonstrate *which* references support *each* confidence and likelihood statement under each key message. Examples of thoroughly written traceable accounts can be found in Chapter 5 of the Climate and Health Assessment, Vector-Borne Diseases (Beard et al., 2016) or the Energy Chapter of the Fourth National Climate Assessment (NCA4) (USGCRP, 2018a). In the draft NCA5 report, the traceable accounts for Chapter 19 (Economics) are strong overall, though there is room for improvement in the use of citations, described in Chapter 3 of this report.

The Committee recommends the following structure for traceable accounts that could be used throughout NCA5:

- Provide the full key message at the start of each traceable account.
- Summarize *which* references support each confidence and likelihood claim.
    - Include citations in "Description of Evidence Base."
    - Include citations to "Major Uncertainties and Research Gaps."
- Include a "therefore" statement describing *why* authors designated confidence and likelihood findings. Authors should describe *why* the confidence is not lessened due to research gaps *and* cite literature that supports this decision *only* if that literature is cited in the main text.
    - Include citations to "Description of Confidence and Likelihood," if relevant.

Chapter Introductions

Recommendation 5: The introduction to each chapter should be consistent in length, depth of content, relationship to key messages, and voice; new terminology should also be introduced in a consistent manner.

NCA5 authors should assume that readers will read chapters that they are interested in without reading the Front Matter, Chapter 1 (Overview), or other introductory material. In general, the introduction section of the chapter should provide the reader with a brief background and context on the chapter theme and its relevance to climate change, a brief statement about what was covered in NCA4 and what new knowledge is being added in NCA5—including the key messages—and what the chapter will not cover. While it is appropriate for the text supporting the key messages to look different from one chapter to another, consistent introductory sections would provide readers with the appropriate context and a roadmap to understand the rest of the chapter. The consistent inclusion of sub-headers throughout chapters could also help to support this goal.

Many of the chapter introductions would benefit from a high-level introductory sentence to explain why climate change is relevant to the chapter's topic or themes. In most introductory paragraphs, it is not explicit how the introduction section is related to the key messages. In introducing a chapter's contents, the introduction should not read as an abstract of the chapter (e.g., Chapters 2 [Climate Trends], 4 [Water], and 28 [Southwest]). Chapter authors could consider using a model like Chapter 17 (Climate Effects on US International Interests) where the introduction is directly related to the key messages and key message titles are in parenthesis. Chapter 29 (Alaska) also provides a successful example that includes a table of the key messages with examples of climate drivers/impacts and responses; this type of summary or roadmap could be replicated in other chapters. In addition, chapter introductions should explicitly note what

topics are covered in the chapter and what topics are not. For example, Chapter 19 (Economics) does not discuss the economics of mitigation, and Chapter 17 (Climate Effects on US International Interests) does not review the international impacts of climate change—these choices should be explained in the introductions.

Introductory sections vary widely with respect to the use of technical language and could better engage the target audiences if they were less technical. The Committee highlights chapter-specific instances where jargon is used in Chapter 3 of this report. Similarly, when introducing new or complicated terms, authors should assume readers are encountering them for the first time, including seemingly basic terms (e.g., adaptation, mitigation). For commonly used terms across the whole report, a consistent definition should be selected and used throughout and referenced in the glossary currently under development for the final report but not available in the draft NCA5 report. For example, Chapter 31 (Adaptation) details the choice of "adaptation" over the commonly used "resilience" whereas "resilience" is used in many other chapters. Chapter 20 (Social Systems and Justice) uses "overburdened communities" over other terms frequently used in the report, such as "marginalized" or "underrepresented." The NCA5 authors should make decisions about commonly used terms and use them consistently throughout the report. In the web design, rollover definitions could be provided for common phrases or words that are defined in the glossary.

The introductions to each chapter also use in-text citations and figures inconsistently. While figures may be more appropriate for some chapter introductions over others, there are opportunities to build consistency—for example, all regional chapters could include a map of the region with place names and locations referenced throughout the chapter. Introductions that use figures could consistently place them at the end of the section rather than in the middle because they are typically short sections. The NCA5 authors may also consider a word range for the introduction sections so that they are all roughly the same length throughout the report. The NCA5 authors should expand upon the glossary definitions in the chapter when the additional context or an expanded definition is needed to present a more precise definition tailored to the chapter readers.

Graphics and Boxes

Recommendation 6: All figures, figure captions, and figure citations should be consistent and self-contained.

Overall, the Committee is impressed with the graphics throughout the draft NCA5 report and understands that many graphics are still being designed or were unavailable to review due to the timing of copyright clearances. As the NCA5 authors make revisions, the Committee suggests they consider that many readers will only look at the figures and read the captions and may download and use the figures for a range of uses (e.g., reports, power points, lectures). Therefore, the Committee recommends making graphics self-contained such that the reader can easily understand the key ideas related to the figure without looking in the text. On the other hand, many figures are not adequately discussed in the body of the chapters and are at most pointed to in a parenthetical or not at all. All figures should be integrated meaningfully into the text to justify their inclusion in the chapter.

Based on recommendations by Gerst et al. (2021), Harold et al. (2016), and Rougier et al. (2014), the Committee encourages authors to ensure that each figure adheres to some basic principles of design and include at a minimum:

- Consistent use of titles;
- Legible text;
- Use of color and contrast, accessible to people who have colorblindness;
- Legend, if applicable;
- Sufficiently detailed caption; and
- Reference to the figure source(s), if applicable

To expand on the checklist above, there are many opportunities to introduce more consistency across the figures throughout the report. Furthermore, Gerst et al. (2021) explains how to improve many NCA figures based on experimental studies. Regarding embedded figure titles, NCA5 authors could consider choosing a consistent format for titles and making sure titles above and embedded in figures match. Regarding the color palette, the NCA5 authors could consider a consistent palette across the report figures, and if possible, use colors consistently to communicate particular ideas (i.e., ensure icons related to water are the same shade of blue). Regarding symbols and icons, NCA5 authors could consider adopting a similar style of icons across the report, and use them consistently (e.g., a fish icon representing fisheries in one figure will be the same fish icon representing fisheries in another graphic) and define these icons using legends in individual figures, where appropriate.

Figure caption length and amount of detail varies greatly across the report. Captions should sufficiently communicate the key ideas in the figure, explaining to the reader the important trends, takeaway points, data sources, or other information to inform readers on how the figure was created and how it should be read (Rougier et al., 2014). Captions should begin with a nontechnical explanation of what the figure shows and then, to a limited extent, the technical underpinnings of the figure. Especially in the case of a schematic illustration—a type of figure that presents a scene or story with text boxes or callouts of important facts—the captions should have sufficient references to the source material used to create the figure (Perra and Brinkman, 2021). Many (e.g., Figures 10.5, 11.5) only list the agencies or organizations that created the data or figure, making it difficult for audiences to identify the source for a claim communicated by, or data used, to generate a figure. In addition, captions should always include dates of the data or information being presented. The web version of the report could use hover-over popups to include more technical underpinnings of the figure.

The draft NCA5 report uses maps throughout to communicate a lot of information. Consistent with the recommendation about icons, the Committee suggests the report use consistent map features (e.g., colors and symbols) so that readers can easily understand any map they see in the report. Special attention is needed to establish a consistent arrangement of the contiguous states, Alaska, Hawai‘i and the US-Affiliated Pacific Islands, and the US Caribbean (Puerto Rico and the US Virgin Islands) on maps to ensure the full geographic domain of NCA5 is depicted. In the draft NCA5 report, Alaska and Hawai‘i are placed on maps in various locations (e.g., sometimes in their geographically accurate locations and sometimes below Florida), and in some cases, are not included at all. The US Caribbean is rarely included. If a geographic region is omitted, there should be an explanation in the caption as to why (e.g., no data). Additionally, there are issues related to scale with Alaska, Hawai‘i, the US-Affiliated

Pacific Islands, and the US Caribbean, and when that is the case, appendixes could be used for maps that are too small or out of scale. Gerst et al. (2021) should also be referenced for guidance on developing maps.

Recommendation 7: Boxes within chapters should be used to highlight specific examples or to summarize or improve message accessibility.

The use and content of boxes in chapters varies considerably across the draft NCA5 report. Boxes could be more effective if reserved for specific types of content (e.g., firsthand stories, examples, complex concepts, an important figure, or to summarize or otherwise improve message accessibility) in order to highlight specific items and/or deliver content more rapidly. Assessments of this nature inevitably provide a high-level summary of the state of the science, which can be rather abstract. Boxes are an opportunity to provide specific examples that can help readers connect the material to their everyday lives or policies and decisions they may hear about on the news, thus reducing the psychological distance (van der Linden et al., 2015). At the same time, boxes should at least mention their connection to climate change and related discussions in the chapters—for example, Boxes 28.2 and 4.3 do not mention the role of climate change.

When possible, boxes could be better utilized to communicate a message that is not clearly expressed in the main text or needs amplification. Boxes should include the relevant who, what, when, where, why, and how to provide a more tangible connection for readers. For example, Boxes 14.1 and 18.1 both tell compelling stories with data. Chapter 29 (Alaska) has many boxes with firsthand accounts from residents, which are excellent for making abstract phenomena more concrete and integrating Indigenous knowledge, but could be enhanced with some additional information (i.e., a description or graph showing the climate trend) and context (i.e., a few introductory sentences to describe the setting).

ADDITIONAL INCONSISTENCIES BETWEEN CHAPTERS

In addition to the structural issues raised above, there are a number of other inconsistencies across the draft NCA5 report that pertain to the ways topics and terms are structured and discussed. As a web-first report, it is unlikely NCA5 will be read by audiences cover-to-cover; thus, it is appropriate for chapter authors to design their chapters to meet their specific topical needs. However, there are certain content areas, described below, that would benefit from more consistent treatment throughout the draft NCA5 report to strengthen the credibility of key messages and enhance clarity and readability. Where inconsistencies in structure and content between chapters cannot otherwise be resolved, the Front Matter could explain these differences (e.g., the structure of each chapter was decided by the chapter authors). In the section below, the Committee outlines specific inconsistencies that stood out and, if resolved, would improve the draft NCA5 report.

Recommendation 8: The draft NCA5 report should be revised to address inconsistencies across chapters, including treatment of adaptation and mitigation, distinction between natural variability and climate change, use of scenarios, treatment of Focus On… Features, and the use of terminology.

Treatment of Adaptation and Mitigation

Adaptation and mitigation are not treated consistently across chapters. Adaptation is a major topic in all chapters, except in Chapter 32 (Mitigation), but it is not addressed in a consistent manner (e.g., sometimes together with mitigation). For example, in Chapter 7 (Forests), Key Message 7.3 focuses on adaptation, while Chapter 12 (Built Environment, Urban Systems, and Cities) has Key Message 12.3 on mitigation and adaptation measures in the built environment. Both sectors have GHG emissions or removals and are affected by climate change and thus address both mitigation and adaptation. Regional chapters in particular inconsistently include mitigation in key messages. There are also inconsistencies in how the regional chapters describe adaptation efforts or obscure what adaptation means by using examples such as forest management. Some chapters, such as Chapters 21 (Northeast) and 25 (Northern Great Plains), have key messages on adaptation, while most other regional chapters discuss adaptation within sectors and themes. Mitigation is sometimes mentioned together with adaptation, but examples used are typically only related to adaptation (e.g., Chapters 15 [Human Health], 21 [Northeast]). Often, chapter key messages include adaptation but omit discussions of mitigation entirely (e.g., Chapters 25 [Northern Great Plains], 16 [Tribes and Indigenous Peoples]).

In addition to emphasizing mitigation more prominently, GHG emissions and removals should be described in a consistent way across the report. Specifically, total emissions and net-zero emissions are often blurred together, as are removals and carbon sequestration (e.g., Figure 32.1 in Chapter 32 [Mitigation]). Furthermore, Figure 32.1. is confusing in this regard. The historical record is shown as gross emissions, with net-zero in 2050 shown as these emissions trending to zero emissions. Should the forest sink be included and continued, 2050 would be net negative, while "net-zero" would be reached around 2040. The statement that forests are a sink of 0.8 is not consistent with Chapter 7 (Forests), which reports the sink as 0.4. This confusion extends from what appears to be the absence of a standard inventory of emissions and removals across the entirety of the report. For example, NCA5 authors could select a consistent US emissions dataset and time frame based on the latest EPA national GHG inventory for 1990-2020 (EPA, 2022) with a standard benchmark year. Likewise, "key categories" should consistently refer to the chosen dataset. Such a dataset should be introduced to the reader (e.g., in the Front Matter or Chapter 2 [Climate Trends]), including appropriate caveats and limitations, and consistently cross-referenced throughout.

A key area of advancement since NCA4 is in negative emission technologies (e.g., carbon dioxide removal). Relevant to the discussions of adaptation and mitigation, these technologies should also be discussed as part of the broader portfolio of options to achieve net-zero GHG emissions, including relevant references (e.g., NASEM, 2019, 2021, 2022a).

Distinction Between Natural Variability and Climate Change

The draft NCA5 report frequently describes "change" but does not consistently distinguish between natural variability and climate change. This lack of clarity can be misleading for the reader by creating the misconception that some impacts that are the result of the combination of natural variability and climate change are instead solely due to climate change (e.g., Chapters 4 [Water], 6 [Land Cover and Land-Use Change], 9 [Coastal Effects], 28 [Southwest], 30 [Hawai‘i and US-Affiliated Pacific Islands]). Consistent with the mandate of the

GCRA, it is important for NCA5 authors to accurately identify the multiple drivers of change (including global change), in addition to climate change, and accurately attribute impacts. Clearly describing impacts due to natural variability, climate change, or a combination of the two is important not only for informing policy decisions, but also for building public understand and trust in the report's messages. Climate change and natural variability should be clearly defined in the glossary and natural variability could be introduced in chapter introductions when the concept is important for understanding key messages.

Use of Scenarios

Where projections from multiple climate change scenarios are available, (e.g., RCPs 4.5 and 8.5), NCA5 should strive to report results from multiple scenarios. This is particularly important because the divergence between projected climate impacts based on different scenarios becomes more pronounced decades from now, especially after mid-century. Projections of sea-level rise from different climate models should also be included when such results are available. Specifically, regional chapters should utilize results from multiple emission scenarios (e.g., RCPs), sea-level rise scenarios, and climate models where such results are available. The Committee recognizes that many studies of climate change impacts only use the "Very High Scenario" (RCP 8.5). In such cases, only the projections from that scenario can be reported in NCA5, but the limited use of emissions or sea-level rise scenarios and climate models should be clearly reflected in confidence and likelihood levels and explained in the traceable accounts. Findings based on a single scenario and one or a few models should, all else being equal, receive lower confidence and likelihood than findings based on the application of multiple scenarios and models.

Data, models, and projections used to formulate likelihood statements should be standardized across the chapters. Appendix 3 describes the standard datasets provided to the NCA5 authors: downscaled model-based projections of temperature and precipitation and sea-level rise scenarios. However, the individual chapters deviate from these standard datasets in many cases, drawing from a variety of sources, including local assessments and past NCAs. Each chapter should, at minimum, provide statements based on the standard sources meant to be common across NCA5. If other sources provide different or more nuanced information then these sources can be utilized as well—but always as a supplement to the standard sources in Appendix 3, not in place of the standard sources.

Treatment of Focus On… Features

The Focus On… Features are topics chosen because of their cross-cutting importance but could be better integrated into the national and regional chapters. These features address interesting topics, and the Committee applauds their inclusion in the draft NCA5 report. However, they are only mentioned in passing in some relevant chapters (e.g., Focus on Western Wildfire in Chapter 7 [Forests], Focus on Risks to Supply Chains in Chapter 19 [Economics]). More importantly, the relevant chapters do not substantively integrate the Focus On… Features (e.g., Chapter 16 [Tribes and Indigenous Peoples] discusses COVID-19 and does not cite to the Focus on COVID-19 and Climate Change; Chapter 8 [Ecosystems, Ecosystem Services, and

Biodiversity] discusses wildfires but does not cite the Focus On Western Wildfires; Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems] does not mention the Focus on Compound and Complex Events), and there are opportunities to use these features to reduce redundancies and point the reader to sections, and vice versa, with more detail. For example, Chapter 30 (Hawai‘i and US-Affiliated Pacific Islands) contains an entire box on Blue Carbon Ecosystems (Box 30.4). The chapter may more effectively reference the Focus on Blue Carbon and devote that box space to another relevant example.

Additionally, the Focus On… Features should reflect a structure similar to that of the national and regional chapters to effectively communicate the chosen topics. The bolded statements in each Focus On… Feature should be treated as key messages, be clearly and carefully written in concise, accurate sentences, and they should include confidence and likelihood statements. The traceable accounts should include a brief discussion of authorship, discuss the knowledge base, include references, and detail the rationale for confidence and likelihood statements, in line with the recommendations on traceable accounts above.

Use of Terminology

In general, careful attention to consistent terminology and precision of language is needed. The draft NCA5 report does not consistently use the metric or Imperial system between and within chapters. Chapter 1 (Overview) introduces the convention of Fahrenheit (Celsius) but does not use this convention consistently, which causes reader confusion. There are even inconsistencies within sentences, for example, in Chapter 2 (Climate Trends): “For every additional 1°C of global warming, the average US temperature is projected to increase by around 2.5°F.” Terminology for similar concepts is also used differently from chapter to chapter—for example, adaptation versus resilience, ocean economy versus marine economy, citizen versus resident, nature-based solutions versus natural climate solutions, carbon sequestration versus carbon removal, and land-use change versus land system change. The Committee acknowledges the challenges in coming to a consensus on acceptable definitions for terms used commonly and interchangeably across scientific disciplines. The Committee suggests defining terms where they are meant to have a distinct meaning in the report text and the glossary currently under development (e.g., explain the difference between carbon dioxide removal, carbon sequestration, and carbon capture use and sequestration/storage) and consistently use one of the terms (e.g., use adaptation instead of resilience) across the report where multiple terms convey the same meaning. Throughout the report, imprecise language is also frequently used—for example, “significantly,” “will,” and “driving.” This language makes assumptions about decision making, and in some cases, may suggest levels of scientific confidence that are not supported by the text, citations, and traceable accounts.

Recommendation 9: The draft NCA5 report should be revised to utilize and distinguish between the different use cases of sea-level rise projections and sea-level rise scenarios clearly and consistently.

Projected sea-level rise (SLR) is not treated consistently across national and regional chapters and is often inconsistent with confidence and likelihood levels defined in the Front Matter. Some regional chapters (e.g., Chapter 22 [Southeast]) utilize only discrete SLR scenarios

from the Sea-Level Rise Technical Report (Sweet et al., 2022), while others use projections from emissions scenarios in IPCC AR6 (e.g., Chapter 23 [US Caribbean]), and still others attempt to relate the two but do so incorrectly (e.g., Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands], 28 [Southwest], 27 [Northwest]). An underlying cause of this inconsistency is the overlapping naming conventions between the SLR and emissions scenarios. For example, the Intermediate Scenario for SLR from Sweet et al. (2022) most closely corresponds to IPCC SSP5-8.5, which is the Very High Emissions Scenario, while the Intermediate Emissions Scenario corresponds to IPCC SSP2-4.5. Additional confusion arises from the discrete nature of the SLR scenarios, which contrasts with the ensemble-based IPCC projections used for all other climate indicators; misunderstanding these differences leads to inaccurate and poorly formed likelihood statements that cannot be appropriately derived from a discrete trajectory.

In general, NCA5 should utilize and distinguish between the different use cases of SLR projections versus SLR scenarios. Projections offer information about the range of possible SLR outcomes for a specific emissions scenario, while the scenarios provide a range of discrete decision-relevant timelines for the purpose of developing adaptation approaches. It is not good practice—nor is it necessary—to utilize only one type of SLR information to satisfy the dual needs of making likelihood statements and providing decision-relevant information. The Committee suggests two possible ways the draft NCA5 report can be improved in this regard. The first (and preferred) option is to standardize the use of the ensemble-based IPCC SLR projections to make likelihood statements—similar to how temperature and precipitation are handled—and to standardize the use of the Sweet et al. (2022) scenarios for use in discussing decision-relevant timelines. In this case, statements such as the one made on Page 9-20 Lines 7-8 would be formulated similar to those in IPCC AR6 Chapter 9—for example, “Considering only processes for which projections can be made with at least medium confidence, global mean sea-level will increase from 2020 to 2050 by Y [X to Z, likely range] meters for SSP1-1.9 and by B [A to C, likely range] meters for SSP5-8.5.” The second option is for NCA5 authors to narrowly focus on the Sweet et al. (2022) scenarios. In this case, clear guidance should be provided to chapter authors for how to formulate reasonable likelihood statements around these discrete timelines. One way to do this is to emphasize the use of Table 2.4 in Sweet et al. (2022), whereby a possible likelihood statement made using the scenarios in combination with NCA5 confidence/likelihood language could be, “The Intermediate SLR Scenario is *unlikely* to be exceeded for 3ºC of global average surface warming by 2100 and is *about as likely as not* to be exceeded under Very High Emissions (SSP5-8.5) when including Low-Confidence Processes.” Regardless of which of the above options is chosen, Appendix 3 detailing the relationship between IPCC projections and the Sweet et al. (2022) SLR scenarios should be expanded as it does not adequately explain the relationship, nor does it adequately detail the difference between the framing and appropriate use cases of each source of information. Additional comments regarding the handling of SLR projections and scenarios are provided in Chapter 3 of this report.

Recommendation 10: Individual chapters across the draft NCA5 report—particularly national and regional chapters—should be better integrated and cross-referenced.

The structure of the draft NCA5 report begins with the physical science chapters (Chapters 2-3) that provide a foundation for the national chapters (Chapters 4-20), which support the regional (Chapters 21-30) and responses chapters (Chapters 31 and 32). The national chapters lay out foundational concepts and the regional chapters build on that information to explore

specific regional impacts. Better integration of sector and regional chapters would lead to a more coherent NCA5 that more clearly highlights the integrated complexities associated with climate change.

The national chapters appropriately cover issues at the scale of the United States. Some regional chapters raise topics that are not necessarily specific to that region but could be covered in appropriate national chapters. For example, Key Message 21.5 in Chapter 21 (Northeast) discusses whether finance for climate action plans is adequate. The text in this key message addresses both national and regional concerns, and the matter of adequacy of finance for mitigation and adaptation is certainly not limited to the Northeast region. Rather, this issue is of national importance, and it may be more appropriate to address the adequacy of finance in Chapters 31 (Adaptation) and 32 (Mitigation) and, if appropriate, have the regional chapters cover finance issues specific to the respective regions.

Cross-referencing chapters across the report demonstrates the inherent interconnections and complexities of climate change and its impacts. Overall, stronger cross-referencing between chapters would reduce redundancies and inconsistencies, create more space for authors to expand on certain topics, and strengthen connections between topics. For example, some regional chapters (e.g., Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]) appear siloed from the rest of the report and would benefit from comprehensive two-way cross-referencing with relevant national chapters. While all chapters may not have been available to authors at the time the draft NCA5 report was developed, there is an opportunity for authors to leverage information included in different chapters as the draft NCA5 report is revised.

Relatedly, regional authors should be mindful when citing studies that cover the nation rather than the region (e.g., Chapter 25 [Northern Great Plains] discussion of mental health) not to create an ecological fallacy when national analyses are downscaled to regions. Similarly, national chapters should be mindful when citing global studies (e.g., Figure 8.3). The NCA5 authors should identify global or national-level studies as such and use appropriate confidence levels when applying results to smaller geographic scales. Each chapter should discuss these limitations in the literature (as mentioned above) in their traceable accounts sections.

RECOMMENDATIONS ON EQUITY AND JUSTICE

Recommendation 11: For consistency, chapter introductions should include context on equity and justice as related to the chapter topic. To move beyond general statements, different dimensions of justice, including distributional, procedural, recognitional, and intergenerational justice, should be addressed as appropriate throughout the chapter text. Related gaps in the literature should be identified in the text and traceable accounts.

The Committee commends the NCA5 authors for incorporating equity and justice into the report; however, there are opportunities to highlight related issues more intentionally and consistently across the chapters. Notions of “equity” and “justice,” along with their related dimensions, are critical when considering climate change impacts, mitigation, and adaptation. Acknowledgment emphasizes the rights and interests of populations that have traditionally been excluded due to gender, age, race/ethnicity, poverty, or other social factors, and helps to identify key questions and indicators that can be used to assess progress, issues of access, the distribution of costs and benefits, competing interests, as well as just transitions. Though these and related

terms will take on different meanings depending on the context, they can be applied in an appropriate manner across all chapters for consistency and cohesiveness.

Dimensions to consider include distributional, procedural, and recognitional justice, as described in Chapter 1 (Overview) (page 1-40). As the dimensional overview on page 1-40 is critical for consistent integration across the report, the Committee suggests a citation for the definitions provided. In addition, the concept of intergenerational justice should be added. For consistency in term usage, NCA5 authors may reference the definitions in the Chapter 1 (Overview) (page 1-40) or develop and reference a more robust glossary with cited definitions (see Recommendation 12 below). To address different dimensions of justice, authors may highlight how resources, impacts, vulnerabilities, benefits, and burdens vary across populations or geographies; recognize who is typically involved in the decision-making processes; highlight historical norms regarding inclusion and representation; and identify who is typically left out of such processes. "Intergenerational" equity considers fairness or justice between present and future generations, including the burdens and costs that will be incurred by future generations as a result of action taken (or not taken) at present. Issues of access, including appropriate data and governance are also important to consider to support inclusiveness and equity. As climate change impacts, mitigation, and adaptation sometimes expose competing priorities, recognition of trade-offs, including equity and justice concerns, should be addressed when applicable.

Overall, there is substantial variation in how equity and justice issues are integrated across chapters. Some chapters, for example Chapter 9 (Coastal Effects), use the introduction to strongly frame the chapter in the context of equity and justice, while other chapters such as Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity) make no mention of equity or justice in the introductions. Chapter 15 (Human Health) frames health in the context of equity and justice in the introduction and goes on to consistently integrate related issues throughout the chapter, including systemic connections, depth of reporting on disproportionate impacts (rather than a blanket statement), and related dimensions of equity. Chapter 18 (Sector Interactions, Multiple Stressors, and Complex Systems) strongly illustrates the systemic interconnections relating climate change to equity and justice, and uniquely—but importantly—integrates governance and data justice issues. Other chapters would benefit from following these examples. The Committee recommends including equity and justice framing in chapter introductions and prioritizing the integration of related issues throughout the chapters where possible, rather than stand-alone sections addressing the topic. Doing so would highlight systemic interconnections and help avoid the appearance of addressing the topic as an afterthought. Additional considerations for addressing equity and justice throughout NCA5 are outlined in Box 2-4.

Recommendation 12: A glossary of terms related to equity and justice should be adopted and/or developed to ensure consistent use of terminology across NCA5. Associated references should be provided.

To ensure consistency throughout the report, the Committee recommends the development or adoption of a glossary of terms related to equity and justice. Care should be taken to avoid terminology that is harmful to impacted communities, particularly the use of deficit language. For example, many chapters use the phrase "marginalized communities," but referring to people as "marginalized" can perpetuate perceptions of inadequacy and lack of autonomy within the communities being discussed. Generally, it is best to be as specific as

BOX 2-4
Equity and Justice Considerations

The following aspects of equity and justice should be considered across all contexts and chapters:

- Who is vulnerable in this context, and why? Be as specific as possible (i.e., historically overburdened communities, geographically vulnerable, occupationally vulnerable, age-related vulnerability, medical vulnerability) and make connections with systemic factors that may lead to, contribute to, or perpetuate vulnerability;
- Intersectionality and its relationship with climate vulnerability, mitigation, and adaptation (Amorim-Maia et al., 2022);
- Questions of "for whom," "by whom," "where," and "how" (which address just transitions and dimensions of equity including distributional, recognitional, procedural, and intergenerational);
- The role of environmental data justice/availability and accessibility to relevant data and information;
- The role of governance, particularly how the integration of local context and perspectives helps to address the different dimensions of equity;
- Knowledge sources outside of peer-reviewed literature, including grey literature, white papers, storytelling, and Indigenous knowledges;
- Name inequity/injustice as such;
- Highlight concerns that have been raised by traditionally underrepresented communities;
- Avoid deficit framing language, emphasize leadership and innovation;
- Recognize social and structural components when considering the compounding/cascading/complex impacts and risks;
- Identify trade-offs as they relate to equity and justice; and
- Present mitigation/adaptation solutions, case studies, and/or stories from diverse geographies, or populations that integrate equity and justice issues.

possible when describing equity-and justice-related issues—including populations—rather than relying on jargon and terms. The Committee recommends following a similar process as was used in the New York State Climate Impact Assessment[3] process, in which a glossary of terms related to equity and justice was developed from respected information sources. In the draft NCA5 report, there is inconsistent use of terminology around climate and gentrification (e.g., eco-gentrification, green gentrification, environmental gentrification) and terminology on race and socioeconomic status (e.g., minority, racialized minority, BIPOC, low income, low wealth). For example, Chapter 15 (Human Health) uses both "low-income" and "low-wealth," while most of the other chapters use "low-income." These two terms are distinct and should be used appropriately based on the intended meaning. Agreement on one respected reference for each term, such as "low-income" and "low-wealth," would help to ensure consistent use of terminology across the report.

Recommendation 13: To provide equitable access to climate-related information across US communities, national chapters should include all US islands and territories in their figures and assessments whenever possible.

[3] See https://nysclimateimpacts.org.

Access to climate observations, projections, and assessments is not equitable across US territories, particularly for US-affiliated islands in the Pacific and Caribbean, which is noted in the respective regional chapters. NCA5 provides an opportunity to increase equity in this area, and every effort should be made to do so. Many figures in national chapters do not include the US Caribbean, and while many figures do include Hawai‘i, virtually no figures include the other US-Affiliated Pacific Islands despite the availability of information to do so. Whenever satellite data or global model output is used to generate national figures (e.g., Figures 2.4, 2.5, 3.7, 4.3), NCA5 should include a complete map of all island territories. If no data are available for these regions, the figure caption should state this to be the case (e.g., Figure 2.10). The Committee recognizes that including all island territories is not always optimal when attempting to produce legible figures for the contiguous United States due to the geographic extent of the US-Affiliated Pacific Islands. In such cases, the Committee recommends that separate figures be created for regions that are not included, that these figures be aggregated in an appendix, and that figure captions in national chapters point to this appendix for maps of regions not shown. Finally, the national chapters should strive to be more inclusive of island territories in textual statements and assessments of climate-related impacts and risks.

AREAS TO ADD EMPHASIS

Recommendation 14: Relatively more emphasis should be placed on the topics of: mitigation, adaptation successes and shortcomings, projected impacts of climate change, attribution of extreme events, and rural analysis.

In reviewing the draft NCA5 report as a whole, the Committee identified a number of topical areas where relatively more emphasis could be placed. In this section, the Committee outlines topics that should receive more complete attention across the report and identifies specific examples or inconsistencies across the report.

Mitigation

The treatment of GHG mitigation is uneven across the draft NCA5 report and should receive more attention in many of the chapters, consistent with its treatment in Chapter 1 (Overview). On the one hand, Chapter 32 of the draft NCA5 report is devoted to mitigation. In contrast, national chapters do not consistently emphasize mitigation or draw connections to Chapter 32 (Mitigation). Most notably, chapters on sectors that have significant GHG emissions or removals treat mitigation inconsistently. For example, Chapters 12 (Built Environment, Urban Systems, and Cities) and 13 (Transportation) have key messages on mitigation (i.e., Key Message 12.3, Key Message 13.1). On the other hand, Chapters 7 (Forests) and 11 (Agriculture, Food Systems, and Rural Communities) address GHG emissions with a focus on removals in text boxes, and Chapter 5 (Energy Supply, Delivery, and Demand) addresses GHG mitigation together with adaptation but does not include emissions or mitigation in any of the key messages. Some chapters discuss adaptation and mitigation as a grouped topic (e.g., Chapter 16 [Tribes and Indigenous Peoples], Chapter 15 [Human Health]), but then only examples of adaptation are provided with no specific discussion on mitigation. The inconsistent attention to mitigation

extends to the regional chapters. While Chapter 21 (Northeast) summarizes state GHG mitigation plans in a box and Chapters 26 (Southern Great Plains) and 28 (Southwest) summarize mitigation actions in the regions in figures, the other regional chapters say very little or nothing, or may discuss emissions reductions but do not refer to the actions as "mitigation" (e.g., Chapter 25 [Northern Great Plains]). Given the importance of mitigation in the consideration of climate change impacts in the future and the substantial knowledge base on mitigation, a greater emphasis on mitigation in the United States is appropriate.

Adaptation Successes and Shortcomings

Significant adaptation efforts are happening across the United States at all different scales. Summarizing the breadth of adaptation efforts is difficult because the United States lacks transparent and credible mechanisms to aggregate and assess the combined effectiveness of these measures regionally and nationally. The draft NCA5 report provides a competing dual analysis of adaptation. Many chapters describe specific adaptations, such as Chapter 21 (Northeast), that lists state and tribal adaptation plans. While recent work on adaptation is impressive, the recitation of adaptations does not assess whether and to what extent these measures will be successful in reducing risks from climate change. In contrast, Chapter 31 (Adaptation) finds that without a more dedicated effort toward transformation, the current trajectory of adaptations will be inadequate to fully mitigate the increasing risks from climate change and examines the need for transformative adaptation. Both views provide important insights—adaptations are being made but appear inadequate to fully adapt to how the climate may change. Chapter 31 (Adaptation) should better integrate these two points, and the synthesis of these two approaches to assessing adaptation should be carefully reflected in Chapter 1 (Overview). It would be appropriate for national and regional chapters to coordinate their discussions of adaptation to be consistent with the framework outlined in Chapter 31 (Adaptation). It may also be appropriate for NCA5 authors to acknowledge that adaptation actions related to infrastructure, human health, local economies, ecosystems, and emergency management are often about changing an element of a larger project that is already scheduled to occur, making projects challenging to assess as standalone adaptation actions.

Projected Impacts of Climate Change

The impacts of climate change are increasing, resulting in greater impacts on health, the built environment, and natural systems. However, the focus of many key messages across the draft NCA5 report is on recent observed changes and impacts. As noted above, a key requirement of the GCRA is to report on projected climate change impacts, specifically 25 to 100 years into the future, and relatively more emphasis on projected impacts is needed. For example, some sector chapters, such as Chapter 12 (Built Environment) and Chapter 13 (Transportation) devote little attention to projected climate change impacts. Many regional chapters focus only on recent impacts and would benefit from discussing projections and key uncertainties (e.g., Chapters 27 [Northwest], 29 [Alaska]). Furthermore, there is a tendency in some key messages (e.g., Key Message 4.1) to conflate or switch between current and projected changes in a confusing way. Care should be given not to intermix statements about observed and projected

changes in key messages. Recommendation 8 above details the suggested use of scenarios when projections are included.

Attribution of Extreme Events

The Committee commends the discussion in the draft NCA5 report on recent observed extreme events that identify how vulnerable society and nature are to climate change. Attribution of such events is an emerging field of research (e.g., NASEM, 2016). In many cases in the draft NCA5 report, extreme climate or weather are discussed (e.g., Chapters 4 [Water], 11 [Agriculture, Food Systems, and Rural Communities], 12 [Built Environment, Urban Systems, and Cities], 28 [Southwest]) but there is little or no discussion disentangling natural variability from climate change as causes of extreme events, as discussed above. For example, Chapter 28 (Southwest) discusses the current mega-drought affecting the entire region and cites Williams et al. (2022) but does not mention the causes of the drought or that the reference concludes that while climate change is making the drought more severe and long-lasting, natural variability has a relatively greater contribution to the severity of the drought than does climate change. As another example, the text in Chapter 1 (Overview) and Figure 1.4 are misleading because they imply the increase in the number of billion-dollar disasters is solely due to more intense weather and climate events. However, societal exposure to such events caused by population and property increases in hazardous areas also plays a significant role (see Figure 1.4 and explanatory text; Figure 2.6 and accompanying text; and Appendix 4, Figure A4.5). Chapters should be carefully written to emphasize that many extreme events have a higher likelihood of occurring due to climate change, rather than directly attributing extreme events to climate change, unless there is evidence to support the statement. Without precise attribution of extreme events, readers could be left with the impression that these events are entirely the result of climate change. There is an opportunity to expand the discussion of attribution of extreme events in the main text of Chapter 3 (Earth System Processes) to describe the concept in a more accessible way, the use of attribution studies and their limitations, and progress in the knowledge base since NCA4.

Rural Analysis

Rural communities are covered in Chapter 11 (Agriculture, Food Systems, and Rural Communities) and urban communities are covered in Chapter 12 (Built Environment, Urban Systems, and Cities). Impacts on urban communities are also addressed in other chapters of the draft NCA5 report, but the unique challenges and opportunities for rural communities are not adequately addressed. A more balanced discussion of rural communities would support the framework recommended for equity and justice, provided above. For example, Chapter 13 (Transportation) focuses on transportation networks in cities and omits discussions of rural mobility. Chapter 14 (Air Quality) covers environmental justice and air pollution risks in urban areas, with little attention to such risks in rural areas. Chapter 15 (Human Health) makes passing mention of rural farmers but does not discuss issues specific to rural communities (e.g., access to health care). Even though Chapter 12 (Built Environment, Urban Systems, and Cities) is focused on the built environment in urban areas, the built environment in rural areas is not covered in the

draft NCA5 report. The regional chapters generally do a better job of commenting on rural areas, though there are opportunities, for example, in Chapter 28 (Southwest), to place more emphasis on rural areas.

3
Chapter Comments

This chapter provides comprehensive reviews of each draft Fifth National Climate Assessment (NCA5) report chapter followed by the five Focus On… Features. Chapter comments respond to the questions outlined in the Committee's Statement of Task (see Chapter 1 of this report). For each chapter, the Committee provides comments following a consistent structure: summary of the Committee's comments; comments on the chapter introduction; comments on key messages, supporting information, and traceable accounts; comments on graphics and boxes; comments on equity and justice; comments on data and analyses; comments on literature cited; and other recommended changes. Reviews of the draft NCA5 report chapters with different structures (i.e., Front Matter, Chapter 1 [Overview], Appendixes) deviate from this general structure. Appendix A of this report provides detailed line-by-line comments for each draft NCA5 report chapter, as appropriate, and the References chapter includes a complete list of references for all suggested additions to the literature cited in the draft NCA5 report.

CHAPTER 0: FRONT MATTER

The Front Matter is well written and provides an accessible guide to the organization of the draft NCA5 report and guidance to readers on how to read it. The draft NCA5 report has a single Overview chapter (Chapter 1) focused on the report's findings, thus, the Front Matter could better introduce concepts and metrics that are relied upon throughout NCA5. The Committee suggests expanding the current discussion to elaborate on elements critical to understanding NCA5. For example, as discussed in detail in Chapter 2 of this report, the discussion of confidence and likelihood could be expanded on for general audiences.

In addition, the Front Matter states that "NCA5 authors were advised to assess the full range of scenarios available" (page 0-11, line 16), but some projections in the subsequent chapters report on just one scenario. There is some inconsistency throughout the report when projections are presented, and additional information could be provided in the Front Matter for clarification. For example: Were authors given any direction on which scenario to use when presenting future climate change impacts? Did authors consider consistently presenting more than one scenario (i.e., Low and High)? The Committee suggests including an explanation on the use of scenarios throughout the report. Consistent with the recommendation in Chapter 2 of this report to place relatively more emphasis on mitigation, it may also be useful as part of the introduction of scenarios in the Front Matter to include indicators of current policy scenarios to help audiences make the connection between often abstract emission scenarios and current policy.

The Front Matter of the draft NCA5 report does not currently comment on its intended audiences. Overall, the key messages and main text are appropriate for the intended audiences; however, there are instances in which the text is too technical or uses jargon, as detailed in the individual chapter reviews. The Front Matter may benefit from an explanation of the NCA5 authors' target audiences, as well as the intended audiences and use of the more technical traceable accounts sections.

The Committee suggests the Front Matter include a definition of the term "risk," which is widely used throughout the draft NCA5 report but is never clearly defined. For example, the Front Matter could adopt a definition that is closely aligned with the Intergovernmental Panel on Climate Change (IPCC) definition of risk as the confluence of hazard, exposure, and vulnerability (IPCC, 2021b), if that is consistent with its use throughout NCA5.

Chapter 2 of this report notes that chapters throughout the draft NCA5 report use different structures to meet their topical needs. While these differences are appropriate, the Committee suggests the Front Matter note where different structures are used, and if possible, explain the process that led to their development.

Additionally, the map of NCA5 regions in Figure 1 could be improved. Authors should consider using boxes or lines to separate the different geographic domains being represented. In addition, because it is the first map readers will see when they start the report from the beginning, it would be useful to design the map in such a way to show oceans and connected countries.

Table 3 would be more useful if it presented projected carbon dioxide (CO_2) concentrations and levels of increases in global mean temperature at a particular point in time. To be consistent with the Global Change Research Act (GCRA), the Committee suggests presenting projections 25 to100 years into the future.

Box 1 provides useful information on projected levels of warming and how to interpret them.

CHAPTER 1: OVERVIEW

Summary

Chapter 1 (Overview) is well organized and presents a set of findings that overall reflect the key themes from the underlying chapters in the draft NCA5 report. For the most part, this chapter is clear and written at a technical level appropriate for broad audiences. The Committee has the following main suggestions for improvement, and specific line-by-line comments are included in Appendix A:

1. Chapter 1 (Overview) should better cover the breadth of key messages and related information in the draft NCA5 report to accurately present a comprehensive synthesis of the report related to observed and projected climate change impacts, mitigation, and adaptation. While quite broad in its summary of the draft NCA5 report, this chapter does not discuss some important topics that are covered in the report such as the role of greenhouse gas (GHG) sequestration; low-carbon power sources for mitigation; the limited and, in many cases, transient climate change benefits in some sectors and regions; and geographic coverage of the entire United States, including territories.
2. In some instances, Chapter 1 (Overview) makes statements that could be perceived as policy prescriptive, including preferences for particular policy outcomes such as levels of mitigation or expressing a desire for certain forms of transformative mitigation or adaptation. It is appropriate for NCA5 to provide information that is policy relevant but not to express policy preferences or prescriptions.

3. In a few cases, based on what is presented in the draft NCA5 report chapters, the Committee is concerned that the confidence findings are misrepresented in Chapter 1 (Overview). This discrepancy is most noticeable where projections are stated using "will," but the underlying state of knowledge as expressed in traceable accounts does not justify such a high level of confidence.
4. In many cases, Chapter 1 (Overview) does not put impacts or extreme events in appropriate context, thus potentially creating the misleading impression that impacts are solely caused by climate change. This includes sectors and impacts that are affected by other global changes or societal changes and weather and climate events that may be affected by natural variability as well as climate change.
5. Chapter 1 (Overview) does not address whether adaptation has the potential to offset projected adverse impacts of climate change or whether there are limits to adaptation, particularly at higher levels of warming.

Chapter 1 (Overview) is a comprehensive assessment of the state of knowledge on climate change and addresses all the topics specified in the GCRA. However, Chapter 1 (Overview) does not specifically identify projected impacts of climate change 25 to 100 years in the future as required by the GCRA, reflecting the lack of projections particularly 100 years in the future throughout the draft NCA5 report, identified in Chapter 2 of this report. In some cases, projected impacts are provided for mid-century or for a given level of warming, but many are expressed without a time frame or specific increase in average global temperature.

Review Comments Related to the Statement of Task

Comments on Chapter Organization

The Committee commends the NCA5 authors for developing a single chapter to summarize and synthesize the report, rather than including both a Summary and an Overview as was done in the Fourth National Climate Assessment (NCA4). This change helps make the introductory information clearer and more concise in the draft NCA5 report. Chapter 1 (Overview) generally synthesizes key messages from the draft NCA5 report into broader cross-cutting messages well, and accurately summarizes new science on climate change and key findings on observed and projected impacts of climate change since NCA4. Overall, Chapter 1 (Overview) is well structured and appropriately written for broad audiences. Specifically, the Committee commends the emphasis on mitigation and adaptation efforts by noting in Section 1 both that progress is occurring to advance these efforts and that more is needed to meet stated emissions goals. However, while Chapter 1 (Overview) does discuss mitigation, often mitigation efforts are discussed in conjunction with adaptation measures. The Committee suggests that Chapter 1 (Overview) provide definitions and context to facilitate a greater understanding by broad audiences. For example, the text in Chapter 1 (Overview) should provide clear definitions for adaptation and mitigation that include answers to the following: what is mitigation; how does mitigation differ from adaptation; what time frames matter for mitigation efforts, and why. This context, which is presently omitted, will take up only a small amount of text, vastly increase accessibility to all audiences, and better set the stage for the rest of the chapters in NCA5. Additionally, since the draft NCA5 report utilizes an iterative risk management approach,

chapter authors may point out that mitigation is the primary tool to reduce likelihood broadly, while adaptation reduces consequence locally.

Comments on Consistency with Report Text

The Committee recognizes that it is challenging to decide which messages and supporting information are important to include in Chapter 1 (Overview) of such a comprehensive report. However, in some cases, the chapter is not consistent with the body of the report. For example, in the Chapter 1 (Overview) discussion on the specific needs to meet stated emissions goals in the coming years, there is a focus on renewable energy without any discussion of other options for reducing net GHG emissions or radiative forcing. However, several other chapters discuss the importance of options such as carbon capture and carbon sequestration (e.g., Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity], Chapter 11 [Agriculture, Foods Systems, and Rural Communities], and Chapter 32 [Mitigation]), and energy conservation, nuclear power, or new technologies such as hydrogen fuels (e.g., Chapter 32 [Mitigation]).

Additionally, in summarizing sector and regional impacts, Chapter 1 (Overview) only mentions adverse impacts of climate change and does not mention the mix of impacts reported for some sectors and in some regions. This is most notable in Table 1.2 (see Appendix A for specific comments). Specifically, chapters such as Chapter 25 (Northern Great Plains) and 19 (Economics) describe a mix of impacts—often where there are some beneficial effects associated with trade-offs. For example, energy use and recreation are estimated to have a mix of impacts. Chapter 19 (Economics) shows in Figure 19.1 that expenses for electricity are projected to increase while expenses for fossil fuel use are projected to decrease. Additionally, the draft NCA5 report points out in many cases that cold weather recreation is expected to decrease due to warming temperatures and changing precipitation patterns, but it does not fully address how warm weather recreation could change. The Committee suggests that Chapter 1 (Overview) more accurately and transparently represent a mix of impacts associated with climate change as reported in some national and regional chapters, while highlighting that the knowledge base consistently finds that the net effect of climate change is projected to be negative, and increasingly negative with additional levels of warming.

Care is needed to ensure that Chapter 1 (Overview) accurately reflects confidence and likelihood statements in sector and regional key messages and their supporting traceable accounts. For example, Chapter 1 (Overview) appears to overstate levels of confidence and likelihood in its statements on agriculture and the relationship between incremental increases in temperature and damages compared to the levels of confidence and likelihood that are expressed in Chapters 11 (Agriculture, Food Systems, and Rural Communities) and 19 (Economics). To state an outcome "will" happen can be interpreted as having the same as finding the outcome is *virtually certain* with *high confidence*. Chapter 1 (Overview) states that climate change "will" make food less accessible and more expensive (Section 3.2, page 1-18, lines 14-15). Key Message 11.2 states that, based on projections, the outcome is *likely* with *medium confidence* because there are relatively few studies, in addition to other factors such as adaptation and baseline changes that can have an important effect on vulnerability. Thus, these qualifications provided in Chapter 11 (Agriculture, Food Systems, and Rural Communities) do not support attaching "will" to findings on climate change and food production.

Chapter 1 (Overview) also states, "Each additional increment of warming will cause more damage and greater economic losses than previous warming, while the risk of catastrophic

or unforeseen consequences also increases" (Section 1.1, page 1-4, lines 14-15). The Committee agrees that the evidence presented in the draft NCA5 report and the broader knowledge base supports the expectation that with increasing changes in warming, there will be increasing net damages. However, the Committee questions whether the use of the word "will" is appropriate for this finding. There are important uncertainties regarding climate change, impacts, adaptation, and baseline changes that justify less than complete certainty in this finding. The traceable account for Key Message 19.1, for example, points out many important uncertainties regarding the relationship between increased warming and damages. An indication of some uncertainty in this finding would be more consistent with the state of knowledge expressed in Chapter 19 (Economics) and could be addressed by substituting language from Chapter 19, "with every additional degree of warming, the United States overall is expected to see increasingly adverse consequences." The second clause of the sentence is appropriate and should remain as written.

Comments on Top-Line Messages

Most of the top-line messages in Chapter 1 (Overview) are clearly stated and supported by subsequent chapters. However, Section 5 ("How We Move Forward") has some findings that may be perceived as policy prescriptive. For example, statements that transformative adaptation reduces inequalities is not a statement of fact (Section 5.3, page 1-39, lines 1-24). While transformative adaptation can reduce inequalities, some transformative adaptations may not reduce or could even exacerbate inequalities if not carefully pursued through an equity lens, as noted in Chapter 31 (Adaptation). The Committee suggests carefully rewording statements like these that state values to be policy informative without being policy prescriptive.

Additionally, some of the subsection headers need clarification. For example, the headers for subsections 1.3 ("Adaptation is moving forward across the country") and 1.4 ("Communities are taking action to strengthen resilience") are similar and authors should clarify the distinction between the two and consider an alternative header for subsection 1.4 such as "Communities are acting on climate change." The header for subsection 4.2 ("Rising emissions are driving rapid global warming") is also ambiguous given that the rate that emissions rise depends on the timescale considered and should be rephrased. Furthermore, many headers in Section 3 ("The Risks We Are Facing") are overly broad. For example, in Section 3.8 ("Regional economies and livelihoods"), while many livelihoods, cultures, heritages, and traditions are being adversely affected by climate change, the section title can be read to imply that all of the components of these categories are adversely affected. Some rephrasing could address this concern—for example, use "many livelihoods" or state "cultures, heritages, and traditions" are being affected.

Comments on Documentation from Other Chapters

In general, the individual chapters are appropriately addressed and referenced in Chapter 1 (Overview); however, there are several exceptions. For example, page 1-20, lines 31-33, states that sea-level rise (SLR), fire, and flooding are expected to displace millions of Americans, but it is not clear where the magnitude of displacement (i.e., millions of people) is stated in the chapters or in the underlying literature. Furthermore, Chapter 19 (Economics) discusses migration but states that specific impacts, such as levels of migration, are uncertain (page 19-12, lines 7-8). Appendix A identifies additional discrepancies between the draft NCA5 report

chapters and Chapter 1 (Overview) and makes suggestions for cross-referencing specific chapters.

Comments on Graphics and Boxes

While some figures in Chapter 1 (Overview) were not available for the Committee to review, the figures that are displayed were generally clear and informative.

The title of Figure 1.2 should indicate the time period of the data portrayed. The caption should address the geographic areas where warming has not appeared to have occurred or, if appropriate, point out where in the report this topic is addressed.

The text and Figure 1.4 are misleading because they imply the increase in number of billion-dollar disasters is solely due to more intense weather and climate events. Non-climate stressors also contribute to the increase in such disasters, such as population growth, particularly in areas most exposed to climate hazards, and property values, which have increased faster than the general rate of inflation. Figure 2.6 in Chapter 2 (Climate Trends) displays billion-dollar disasters in 2021 but does not address how the number of such disasters has changed over time. Thus, Figure 1.4 appears to be presenting information not found in the body of the draft NCA5 report. Additional comments are provided in Appendix A.

The titles and labeling of Figure 1.18 are confusing. The figure appears to display the relative cost effectiveness of emissions reduction options, not how much carbon will not be emitted. While the figure is still under development, as depicted, it is unclear based on the multiple titles and labels on the figure whether the figure is showing emissions reduction potential by abatement measure, savings per abatement measure, cost per million metric tons (MMT) of CO_2-equivalent offset by each abatement measure, incremental cost per MMT of CO_2-equivalent offset by each abatement measure, or some combination. The figure title and label of the x-axis should be rewritten to make it clear that the figure is displaying dollar per ton of net emission reduction. Additionally, the Committee suggests that the figure be modified to use more distinct color gradients (blues and yellows are tough to discern). Finally, in the caption, the term “marginal costs” should be explained, as well as the key take aways from the figure.

Table 1.1 provides good examples of adaptation, but the examples are limited. While it is challenging to portray comprehensive examples of promising adaptations, one option would be to include broader efforts such as federal and state adaptation measures along with local measures.

The structure of Table 1.2 is useful. However, the title of Table 1.2, “All Regions Are Experiencing a Mix of Adverse Impacts” is not clear on what a “mix of adverse impacts” means. In addition, the table does not reflect the mix impacts presented in some chapters of the draft NCA5 report. For example, entries for the Northeast, Midwest, and Northern Great Plains focus on adverse impacts; not all livelihoods will be harmed, and some could benefit.

Comments on Equity and Justice

Overall, equity and justice issues are appropriately addressed and well-integrated in Chapter 1 (Overview). The chapter authors provide important historical drivers of inequity and include present-day implications. Systemic interconnections are well addressed and provide strong framing across the chapter. The chapter authors do not focus on only race/ethnicity and economic status when addressing inequity and vulnerability, but also highlight other historically

overburdened communities as well as geographic vulnerabilities (i.e., rural areas) and occupational vulnerabilities (i.e., small fisheries).

However, the Committee suggests several minor improvements. Consistent with the recommendation in Chapter 2 of this report, Chapter 1 (Overview) should use more consistent terminology; for example, "under-resourced," "overburdened," and "frontline" seem to be used interchangeably in the chapter. Chapter 1 (Overview) should adopt consistent terminology that will be used throughout NCA5. Chapter authors may consider including the concept of intersectionality and its relationship to climate vulnerability. Some attention to data justice, or the availability and accessibility of relevant data to communities, may be warranted in some contexts; for example, it is a broad and unbacked assumption that "communities are now equipped with a stronger understanding of the risks they face" (page 1-4, lines 4-5) as accessibility to relevant climate data is highly variable. Finally, the Committee also suggests including "intergenerational justice" in the list of relevant forms of justice in subsection 5.5 ("Transformative change is an opportunity for a more just Nation"). Additional specific suggestions are identified in Appendix A.

Comments on Data and Analyses

This chapter presents some data from underlying chapters and in general, these are presented well. The Committee notes concerns above about figure titles and captions that could be clearer and should present appropriate caveats about the data being presented. The chapter should adopt a standard dataset framework (e.g., GHG emissions), consistent with the recommendation in Chapter 2 of this report, so that references to data are always consistent and correct.

Other Recommended Changes

In many cases, Chapter 1 (Overview) does not put impacts in the appropriate context, which could create the misleading impression that impacts, including some changes in extreme events, are entirely caused by climate change. For example, regarding impacts on ecosystems, Chapter 1 (Overview) should state that ecosystems are also being degraded by other global changes such as land-use, habitat fragmentation, pollution, and overfishing. The chapter should point out that some extreme events are partly the result of natural variability, as well as climate change.

In general, the chapter does not address whether adaptation has the potential to offset projected adverse impacts of climate change, nor does it examine limits to adaptation. While Chapter 31 (Adaptation) discusses limits to incremental adaptation and the need for transformative adaptation, evaluating both the possibilities and limitations of adaptation is essential to every sector for future planning, and should be addressed in the chapter. The Committee notes that this is a challenging topic to assess; however, some discussion is warranted either highlighting the knowledge gap or explaining why these topics were not addressed.

The implications of international impacts of a changing climate on the United States, including possible effects on national security and the opening of the Arctic to shipping and resource extraction, are not addressed in the chapter, except for migration.

Finally, the Committee questions the citation of global economic damages that is drawn from Chapter 17 (Climate Effects on US International Interests). Since the draft NCA5 report

focuses on impacts on the United States, the Committee suggests Chapter 1 (Overview) cite findings from Chapter 19 (Economics) on estimated impacts of climate change on US gross domestic product (GDP) (e.g., US GDP is projected to fall by 0.13% per degree Fahrenheit increase; page 19-12, lines 25-27).

CHAPTER 2: CLIMATE TRENDS

Summary

This chapter summarizes the observed climate trends in the United States and their causes and impacts, providing a foundation for the rest of NCA5. The chapter is written in a consistent, transparent, and credible way and does a great job of using accessible language and not assuming knowledge of scientific terms and jargon. While the chapter covers a wide range of topics, including temperature, rainfall, and sea-level, among others, the discussion and references regarding the role of natural climate variability and its regional differences are missing. The key messages are well stated and supported by the details provided. The chapter meets the requirements of Section 106 of the GCRA. This chapter and Chapter 3 (Earth System Processes) should be better coordinated, described below and in the Committee's review of Chapter 3 (Earth System Processes).

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is generally well written. It not only provides a useful background for the subsequent three key messages, but also discusses connections to other chapters. The introduction could be improved by adding more discussion of the connection to Chapter 3 (Earth System Processes)—specifically, to explain the overlap between the two chapters and distinguish each chapter's focus. Highlighting these connections is especially important as these two chapters provide foundational information for the following national and regional chapters; thus, later chapters should be able to clearly reference pertinent physical science in each of these chapters. Because this chapter relies on IPCC reports, it would be useful to make clearer when references are being made to that source, and more attention could be given to what is new in this chapter compared to NCA4. Additionally, "climate trends" is an incredibly broad topic that cannot fully be covered within this chapter; therefore, it is important for the introduction to include a statement about the information that is not included in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages are generally well written, at the appropriate technical level. They reflect current understanding about observed and projected impacts to the United States, the challenges, opportunities, and success stories for addressing risk; and identification of emerging issues related to climate change. Assessments of confidence and likelihood are included, though chapter authors could consider always putting confidence/likelihood language in parentheses for

clarity. In the key message titles and subsection headers, authors should avoid using personal pronouns because they lack clarity and should also exercise caution when making declarative statements in headers that are not supported by the corresponding text.

One major issue missing from this chapter is a comprehensive discussion of the issue of ocean acidification, which is likely to have profound impacts on natural ecosystems, as well as ocean resources such as fisheries. There are currently a few mentions of this topic, but the discussion should be expanded.

Comments on Specific Key Message Language

> **Key Message 2.1. Climate Is Changing, and Scientists Understand Why**
> It is *virtually certain* that human activities have increased atmospheric levels of carbon dioxide and other greenhouse gases (*very high confidence*). Global average temperature has risen in response, with even more warming experienced in the continental United States and Alaska (*virtually certain*, *very high confidence*). Long-term changes have been observed in many other aspects of the climate system (*very high confidence*). The Earth system is complex and interconnected, which means changes in faraway regions also affect the United States (*high confidence*).

Key Message 2.1 is well written and sets the foundation for the other two key messages by emphasizing the fact that the climate has already been changing. This key message also provides a single location where almost all of the climate changes discussed and expanded upon elsewhere are introduced for use by the other chapters.

> **Key Message 2.2. The Risk of Extreme Events Is Increasing**
> Observations show an increase in the severity, extent, and/or frequency of multiple types of extreme events (*very high confidence*). Heatwaves have become more common since the 1980s (*very high confidence*). Drought risk has been increasing in the Southwest over the past century (*very high confidence*) and decreasing elsewhere (*medium confidence*). Rainfall has become more extreme in recent decades, especially east of the Rockies (*very high confidence*). Hurricanes are intensifying more rapidly (*high confidence*) and causing heavier rainfall and higher storm surges (*high confidence*). More frequent and larger wildfires have been burning in the West in the past few decades due to a combination of climate factors and policy (*high confidence*).

Suggested title: "Extreme Events Are Becoming More Frequent and Severe."

Key Message 2.2 is another generally well written key message. However, while the title of this key message includes the word "risk," the key message is exclusively about hazard. The Committee suggests rewriting the key message title to more accurately reflect the discussion on hazards.

> **Key Message 2.3. The Future Is in Our Hands**
> The more the planet warms, the greater the impacts—and the greater the risk of unforeseen consequences (*very high confidence*). Scientists understand much about the Earth system, but there are still uncertainties about how the planet will react to rapid warming. Risks increase with warming, and warming increases with emissions (*very high*

confidence). Reducing emissions would limit future warming (*very high confidence*) and the associated increases in risks (*medium confidence*). While worst-case scenarios cannot be ruled out, the future is largely in our hands.

This key message title is not scientific and seems to ignore equity and justice concerns on the very question of who has the power in the United States to shape climate and energy policy. The title does not describe the information included in the supporting text well—the audiences would expect the text supporting this key message to be about policy actions, but a more appropriate title would have to do with climate impacts. Additionally, this key message could be more direct if it began with the third sentence and the first two sentences were removed. Furthermore, the Committee suggests that authors avoid using first person language in the title and key message.

Comments on Text Supporting the Key Messages

The text supporting the key messages is generally well written and contains sufficient details that provide further context. Detailed comments on the text are provided in Appendix A. Some of the statements, including section headers, however, should be clarified. For example, the section header, "The Nation Has No Choice But to Adapt to a Changing Climate" is unclear because "the Nation" can refer to both the people of the United States and the government, and the supporting text in the section only makes broad statements about "the Nation." The Committee suggests rephrasing the section header to be more precise, for example, "Adaptation can address climate change impacts."

When discussing regional differences in climate trends across the United States, the impact of natural climate variability is mostly ignored with a few exceptions. The role of natural climate variability and its interaction with human-induced climate trends in temperature, precipitation, and sea-level is documented widely in the scientific literature and is essential for proper interpretation of observations. It is important to point out that locations where natural climate variability is currently suppressing the impact of climate change can expect to experience rapid increase in the suppressed variable if/when the natural variability changes phase (e.g., sea-level rise [SLR] along the west coast of North America). It is also important to point out that the influence of natural climate variability becomes particularly strong when the climate trend is computed based on short periods of time or small geographic areas.

The title of the subsection "Sea Level Rise Will Continue to Accelerate" implies too much certainty. For example, global SLR under Shared Socioeconomic Pathway (SSP) 1-1.9 does not continue to accelerate. Even though this is the Very Low Emissions scenario, and even though a case could be made that the probability of a very low emissions future is low, the title of this key message is "The future is in our hands." If emissions were drastically curbed emissions starting now, SLR may not continue to accelerate. The Committee suggests changing the title to "Sea Level Rise Is Expected to Continue Accelerating." Within this subsection, it should be noted under what conditions (i.e., emissions scenarios excluding Very Low) SLR is expected to accelerate. However, even within a higher emissions scenario, there may be individual ensemble members for which SLR does not accelerate, and herein lies an important distinction between projections and scenarios. Likelihood statements (including the word "expected") can be made using projections based on emissions scenarios. Likelihood statements should not be made based on SLR scenarios. In general, a distinction should be made between

projections and scenarios here and throughout NCA5. Also in this section, the word "likely" is used often. Is this word used in the context of NCA5 confidence/likelihood language? If not, a different word should be used. If so, the word should be italicized, and the justification for these likelihood statements should be based on projections (not scenarios) and added to the traceable accounts.

Comments on Traceable Accounts

This chapter could better identify and provide sufficient context for embedded content and explain how the chapter content reflects current scientific understanding by following the recommended framework for traceable accounts sections in Chapter 2 of this report. In addition to the introduction, relevant connections to Chapter 3 may also be appropriate. The "Major Uncertainties and Research Gaps" section listed under Key Message 2.1 seems arbitrary. Chapter authors should remove subtitles and add discussion of other sources of uncertainties and gaps. The Committee suggests referencing the recommendation in Chapter 2 of this report for more guidance on enhancing traceable accounts.

Comments on Graphics and Boxes

Graphics in this chapter are generally effective and appropriate, though improvements would increase accessibility for the intended audiences. Several figures (e.g., Figures 2.2, 2.7) are highly technical and could be better presented for general audiences. Figure captions should be expanded to discuss what the figures mean rather than just what exactly they show. Many figures in this chapter could be made larger or broken out into separate figures to enhance readability.

Figure 2.4 is informative, and the first sentence of the caption is a good example of explaining what the figure means, although even "obvious" points like "With differences from region to region and season to season" might be useful additions for general audiences. In general, figure captions should be as much about what the reader should learn from the figure as about its technical sources (e.g., the caption for Figure 2.4 is one line of "what it shows" and six lines about where it comes from). In addition, showing how temperature and precipitation changes (in degrees and by percent from the average) compared to the natural variabilities (e.g., masking by T test) would be helpful.

The US-Affiliated Pacific Islands (USAPI) and in most cases the US Virgin Islands (USVI) are missing from figures (Figures 2.2, 2.4, 2.5, 2.7, 2.8, 2.9, 2.12) and text. If NCA5 is to be equitable, it should support and provide relevant climate information equally across all United States lands and territories. If the USAPI and USVI do not fit nicely into the current figure formats (it is understandable if they do not), then additional figures should be made and provided in an appendix of figures specifically for USAPI and USVI locations, which can be referenced in the text to point interested readers and decision makers to the relevant information for these locations. This should be possible for any maps based on satellite data or global models (e.g., Coupled Model Intercomparison Project Phase 6 [CMIP6]).

Comments on Equity and Justice

The introduction merely mentions that "Black Americans die from heat-related diseases at a rate twice that of the general population (EPA 2022b)." The Committee suggests highlighting how climate trends relate to equity and justice in the introduction and integrating associated dimensions (distribution of benefits and burdens, recognitional, procedural, intergenerational justice) in the chapter body as appropriate. Adding references to other chapters that discuss related equity and justice issues (e.g., disproportionate impacts from climate change) would help build consistency with the rest of the report.

Within the text, more effort should be made to assess the literature and make statements regarding observed and projected trends for the USAPI and US Caribbean. Not only would this support Chapters 23 (US Caribbean) and 30 (Hawai'i and US-Affiliated Pacific Islands), but these regions are the most lacking in climate information. This report is an important opportunity to support climate information and decision making in these vulnerable territories.

Comments on Data and Analyses

Data and analysis adopted from other sources and presented in this chapter are appropriate. However, this chapter frequently switches between the Imperial and metric systems (e.g., Fahrenheit and Celsius, feet and meters) in both the text and figures. Consistent units should be used both across this chapter and in accordance with unit conventions adopted in other chapters of the report (i.e., Chapter 1 [Overview]).

Comments on Literature Cited

Overall, appropriate literature is cited. Some suggestions are listed below, and others can be found in Appendix A.

It is unclear how the reported amounts of averaged SLR along the continental United States (CONUS) coasts were obtained on page 2-24 lines 32-34. Assuming the source is Sweet et al. (2022), the values reported here are not provided explicitly in that reference. One could look at Table 2.4 in Sweet et al. (2022) and see that 2ºC warming most closely corresponds to the Intermediate Low Scenario (50%), while the Low and Intermediate scenarios correspond to the tails of the probability distribution (98% and 2%, respectively). Chapter authors could then look at Table 2.3 in Sweet et al. (2022) and find a Low to Intermediate range for CONUS average sea-level of 0.6-1.2 m (2-4 ft) in 2100 and 0.8-2.2 m (2.5-7 ft) in 2150. Both ranges differ from the ranges given in the draft NCA5 report. For page 2-24, lines 36-37, the Committee assumes this statement is based on the Intermediate scenario, but the Intermediate scenario is just as likely from a probability standpoint as the Low scenario for 2ºC warming. So, if it is very unlikely that CONUS SLR will exceed 4 feet in 2100 for 2ºC warming, then it is also very unlikely it will be as low as 2 feet, which is reported as the lower bound of what appears to be a likely range two sentences prior. This section needs work to be internally consistent with the draft NCA5 report likelihood ranges, as well as Sweet et al. (2022) on which it is based.

Other Recommended Changes

On page 2-14, lines 12-13 state, "The number and cost of weather-related disasters has increased dramatically over the past four decades, in part due to the increasing frequency and severity of extreme events." The statement is technically correct because increases in extreme events are "in part" the cause of increases in billion-dollar disasters. However, this section should also acknowledge the important trends in baseline socioeconomic conditions that have resulted in a significant increase in exposure to such events. Three contributing factors are (1) increased population—United States population rose from 226 million in 1980 to 331 million in 2020, a 46 percent increase[1]; (2) the Consumer Price Index has been lower than increases in property values[2,3]; and (3) there is evidence that there is more development in hazardous areas than in relatively safer areas and that development in hazardous areas is increasing more than in less hazardous areas in the United States (e.g., Iglesias et al., 2021). It is important that the draft NCA5 report put such data as change in billion-dollar disasters in appropriate context.

CHAPTER 3: EARTH SYSTEM PROCESSES

Summary

Overall, Chapter 3 (Earth System Processes) adequately identifies and supports the key findings, and the authors should be commended for putting together a nice chapter on a short deadline. The chapter largely meets the requirements of Section 106 of the GCRA. Most of this chapter is a summary of the relevant IPCC chapters. This is an appropriate way to bridge between the IPCC, which represents 4 years of synthesis of the science from a 1,000-page document of global scope, and this document focused on the United States, especially in terms of impacts and mitigation. The language and confidence limits are in general well done. Below, the Committee focuses on issues that can be improved.

The first issue is the number of key messages: 12 for this chapter, while most other chapters have three to five. Consistency between chapters would improve the readability and usability of the document. The four "methods" key messages, and especially the descriptions of the scenarios and ensembles, could be better presented as subsections in the text supporting the key messages, appendixes, or perhaps boxes. Some of the scenario descriptions are in the Front Matter and in Appendix 3, which may be more appropriate instead of in Chapter 3 (Earth System Processes). Regardless, these scenario sections should be consistent and refer to each other. Some other key messages could be combined—for example, Key Messages 3.1 and 3.5 could be combined; Key Message 3.6 and 3.12 could be combined; and Key Messages 3.3 and 3.8 through 3.11 could be combined.

Second, there is substantial overlap in key message titles between this chapter and Chapter 2 (Climate Trends). The Committee notes that the separation of the physical science chapter into two is new in NCA5, so authors are working this out for the first time. Chapters 2 (Climate Trends) and 3 (Earth System Processes) should complement each other and be carefully balanced to have enough similar—but not entirely duplicated—information, designing the

[1] See https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html.
[2] See https://www.whitehouse.gov/cea/written-materials/2021/09/09/housing-prices-and-inflation.
[3] See https://anytimeestimate.com/research/housing-prices-vs-inflation.

separation of information to serve different purposes or audiences. It may help if the authors of these two chapters coordinate with each other to work out the best way to minimize the overlap while maintaining the completeness of discussion. It would help the reader if there was an explanation in the chapter introductions about what material is covered in each chapter, as well as some information in the Front Matter. In addition, Chapter 2 (Climate Trends) and Chapter 3 (Earth System Processes) should cross-reference each other frequently.

Third, one important role that this chapter could play is to provide technical background information (in service of the other chapters) at a level that general audiences could understand. Presenting a few introductory topics in clear language—for example, explaining how and why the odds of some extreme events are increasing, and how they are attributed to climate change—could make important topics accessible to general audiences, and would be particularly useful for many of the other chapters to reference. Attribution of extreme events is being reported in the newspapers all the time; explaining what readers should look for in such reporting and why attribution is important would provide a service to all NCA5 audiences.

Lastly, key message titles should be rewritten to be messages themselves. For example, "Key Message 3.2. Climate Sensitivity and Climate Feedback" could be replaced with "Climate sensitivity and climate feedbacks will determine future changes and impacts" or some other title that provides meaningful information.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction is nicely written but reads as more of a summary. Chapter 3 is one of the most technical chapters in the draft NCA5 report, so the authors should emphasize in an accessible way why the topics are important for the audiences. In the spirit of focusing on knowledge gains since NCA4, the introduction should explain that this chapter is a new addition since previous NCAs. An additional sentence or two on the following should also be incorporated: (1) what is described in this chapter versus Chapter 2 and (2) frame the chapter topics in the context of equity and justice.

Comments on Key Messages, Supporting Information, and Traceable Accounts

In general, the key messages are well written and present appropriate information. The number of key messages should be reduced to be consistent with other chapters, as suggested above. The key messages are short, so combining them should not be too difficult. There is also overlap with Chapter 2 on some topics, for example, climate drivers (e.g., GHGs, aerosols), extreme events (e.g., temperature and precipitation), the cryosphere, and SLR as well as the role of natural variability. Additionally, focusing on fewer topics (e.g., attribution of extreme events) and explaining them in a less technical way would be valuable. Finally, the key message titles themselves should contain information, not just be headers. There are confidence statements but no likelihood statements; these should consistently be provided across all chapters, consistent with recommendations in Chapter 2 of this report.

Comments on Key Messages and Supporting Information

Key Message 3.1. Drivers of Climate Change
Human activities—primarily emissions of greenhouse gases—have caused nearly all global warming observed over the industrial era (*very high confidence*). Changes in natural climate drivers had globally small and regionally variable long-term effects over that period (*high confidence*).

This is a well-written section, although there is some duplication with Chapter 2 that could be removed by adding cross-references.

Key Message 3.2. Climate Sensitivity and Climate Feedback
Recent improvements in the understanding of how climate feedbacks vary across timescales have narrowed the estimated *likely* range of warming expected from a doubling of atmospheric carbon dioxide by 50% to between 4.5°F and 7.2°F (*high confidence*).

This is a well written section; however, because it is a technical subject and consistent with suggestions above to combine key messages, this key message could be combined with others.

Key Message 3.3. Changes at Regional Scales
Changes in regional climate can differ substantially from changes in global-scale averages, and natural variability in the climate system limits the precision of regional-scale projections. Thus, it is important to account for regional differences as well as natural variability when providing climate change information. (*Very High Confidence*)

Key Message 3.3 is a solid key message, but all the references are to model studies. Referencing some observational papers or Chapter 2 (Climate Trends) would improve the flow, authority, and cohesiveness of this key message.

Key Message 3.4. New Scenarios and Climate Projections
A new generation of Earth system models has produced an updated set of projections under a number of newly developed policy-relevant scenarios. A number of Earth system models have been run at significantly higher resolution (about 20-50 km) than the previous standard (abut 100-200 km) for focused experiments to explore particular aspects of climatic changes, like tropical cyclones, that cannot be simulated by coarser-resolution models.

Key Message 3.5. Large Ensemble Simulations
New experiments from multiple climate models that capture both natural variability uncertainty and model uncertainty have improved our ability to understand and quantify expected climatic changes and the relative contributions of human-caused climate change and natural climate variability at regional scales (*high confidence*).

Key Message 3.7. Observations for Improving Process Understanding and Modeling
Recently deployed observing systems have reduced uncertainty in climate projections and improved our understanding of the climate system. Important advances in understanding stem from the application of new techniques that synthesize information from models and both new and existing observation networks and new data on past climatic conditions. (*High Confidence*).

Key Messages 3.4, 3.5, and 3.7 are framed differently from the rest; they are simply introductions and are about methods rather than impacts, adaptations, or mitigation. It may be more appropriate to move them to Front Matter (under the "Scenarios" section) or to Appendix 3 or merge them into the other key messages (e.g., Key Message 3.4 into 3.1, Key Message 3.5 into 3.2 or 3.3, Key Message 3.6 into 3.12). For Key Message 3.5, multi-model ensembles should be emphasized, as within-model ensembles can contain structural biases.

Additionally, Key Message 3.7 may be more appropriate for Chapter 2 (Climate Trends) or may not be necessary for NCA5. The explanation for emergent constraints is technically difficult, not well motivated, and ultimately not clear enough for the broader audiences. Because this section would have to be expanded considerably to be readable for general audiences, and this information is not used often in the report, chapter authors could consider eliminating this section.

Key Message 3.6. Extreme Event Attribution
The science of evaluating the effects of human-caused climate change on extreme weather and climate events has advanced significantly. Human influence has changed the frequency and intensity of some types of extreme events, and it is now possible to quantify climate change effects on specific extreme events. (*High Confidence*).

In Key Message 3.6, page 3-18, lines 9-11 indicate that advancements in methods that allow for the almost immediate attribution of extreme events is important. "Almost in real time" could be added to the last sentence of Key Message 3.6. Such rapid attribution has become almost commonplace in the popular media since NCA4. As discussed above, because of its importance, this section could be expanded and written more clearly for broader audiences.

Key Message 3.8. Water Cycle Changes
Many processes relevant to the water cycle have already begun to change and are projected to continue changing as the planet warms, including atmospheric moisture (*high confidence*), atmospheric circulation, patterns of natural variability (*medium confidence*), and the modulating role of vegetation on evaporation (*low confidence*). These drive changes in the intensity of precipitation in extreme events; snowfall, snowpack, snow melt; and the seasonal cycles of average precipitation and evaporation.

Key Message 3.8 is an overall important topic that is well written but should be better coordinated with Chapter 4 (Water). There are some specific comments on this section in Appendix A, but a general point that should be made is that if natural variability increases in the future, it will be more difficult to separate natural from forced variability.

> **Key Message 3.9. Changes in the Carbon and Biogeochemical Cycles**
> Understanding of the biogeochemical responses to human-caused greenhouse gas emissions has increased due to expanded observations and improvements in models, but uncertainty in the future evolution of the global carbon cycle remains high (*high confidence*).

Key Message 3.9 is well done in general, but the carbon cycle could be emphasized in the title rather than biogeochemistry, which may be too technical a term. This key message is not discussed in Chapter 1 (Overview). Chapter authors should consider how to make this key message relevant to the Chapter 1 (Overview) (as an indication of its relevance to the report as a whole) or remove it as it is too technical.

> **Key Message 3.10. Changes in Ocean and Cryosphere and Sea Level Rise**
> New observations, models and reconstructions have improved understanding of the drivers of regional sea level rise (*high confidence*) and how processes combine to cause sea level change at the coast (*medium confidence*).

Key Message 3.10 is a good introduction to the global problem, but the regional variability in SLR should also be emphasized.

> **Key Message 3.11. Atmospheric Circulation Changes**
> Atmospheric circulations that affect US regional climate are influenced by the global warming–induced expansion of the tropics (*medium confidence*). However, identifying the relative contributions of natural variability and human-induced climate change to changes in regional atmospheric circulation remains challenging.

Key Message 3.11 could be incorporated into another key message, as it does not directly describe a hazard that impacts humans or ecosystems. It is also another highly technical message, largely beyond broader audiences as presented. If more space is needed, this message may be the most dispensable in this chapter.

> **Key Message 3.12. Changes in Extreme Events**
> Human activities are affecting climate system processes in ways that are expected to increase the frequency and intensity of many, but not all, climate extremes, including heat waves, wildfires, drought, heavy rainfall, and coastal flooding (*medium* to *high confidence*).

Key Message 3.12 is important and could contribute to a stronger report if it were more often referenced. This key message could be expanded to be clearer for broader audiences.

Comments on Traceable Accounts

Chapter 2 of this report provides recommendations for traceable accounts and approaches to ensure consistency across NCA5. There are a number of specific issues with the traceable accounts section in Chapter 3.

First, this chapter's traceable accounts include a list of the expertise of the scientists writing the report, which is a good idea but inconsistent with other chapters. As recommended in Chapter 2, the NCA5 authors should decide whether such a description will be consistently included in all chapters. Additionally, other chapters describe the data gathering process that authors used to develop the chapter—stakeholder engagements, how authors communicated amongst one another, and frequency of author meetings—a section that is omitted in this chapter.

Second, the knowledge base should emphasize data sources and papers rather than the opinion of scientists. There are many examples in the traceable accounts of this chapter where opinions of scientists are emphasized. As an illustration of the problem, the traceable account for Key Message 3.1 states "Scientists have known the potential for climate change due to CO_2 emitted from human activities since the early 20th century and identified other human drivers, including non-CO_2 GHGs, land-use change, and aerosols by the 1970s (Ramaswamy et al. 2019)." "Scientists" should be replaced with references to scientific studies and note that studies start in the 1800s. The traceable account for Key Message 3.3 states "Because of the widespread agreement across generations of climate scientists that the local climate change response in a particular variable can differ substantially from the globally averaged response in that same variable since the earliest climate change assessments, there is very high confidence in this statement." Per the confidence/likelihood language definitions presented in the Front Matter, the widespread agreement in the entire available knowledge base, not scientists, should determine the confidence intervals.

Third, traceable accounts should include many citations and can be more technical. For example, in the traceable account for Key Message 3.1, the paragraph on the methane sources (page 3-34, lines 22-29) does not include any citations. Traceable accounts on major uncertainties in regional variability (page 3-38, lines 27-35) should also include citations. Traceable accounts for Key Messages 3.8 and 3.9 do not include many citations. Traceable accounts should use the references in the body of the chapter to explain the evidence for the statements made in the key messages. Notably, because the traceable accounts are intended to be more technical than the body of the text, the traceable accounts are a good place to present many of the complexities and caveats that currently make sections of the text difficult for broad audiences.

Likelihood statements should be consistently used where quantitative evidence exists to support statements. For example, the description of confidence in Key Message 3.1 only mentions confidence for anthropogenic warming, when likelihoods are available from the literature. The traceable account for Key Message 3.2 also does not include likelihood, although well-vetted likelihoods are available from the IPCC. Most of the key messages in this chapter could include likelihoods and provide supporting evidence for the likelihood statement in the corresponding traceable account.

In the traceable account for Key Messages 3.4 and 3.5, it is not clear that it is necessary to say that there are new scenarios and large ensembles exist and are useful. The traceable accounts section could be reduced to focus on the parts of the chapter that have confidence and likelihoods that impact hazards.

The traceable accounts for Key Messages 3.2, 3.6, 3.11, and 3.12 are good examples and consistent with the recommended method; however, the key messages do not include likelihood statements. The traceable accounts for Key Message 3.8 should be similar in scope as the other traceable accounts. The key gaps section is informative but lacks citations.

Comments on Graphics and Boxes

Overall, the graphics are clear and well chosen. Most of the figure captions should be expanded; all figure captions should be self-contained and explain where the information comes from, rather than just provide a citation. Additionally, chapter authors should make sure that each figure is referenced in the text, and there are opportunities to better integrate figures into the supporting text.

It is not clear why there is an elephant in Figure 3.3. The figure appears to be taken from a PowerPoint slide. Consider cropping and moving the text to the caption so that the actual data presented is easier to read.

Figure 3.4 is extremely similar (and should be identical) to Figure 2.4. Both figures may not be needed.

Comments on Equity and Justice

Chapter 3 contains no reference to equity and justice. The introduction to this chapter should discuss the importance of hazards from climate change and how they might adversely affect already overburdened communities more than others. Some of the topics, especially regional changes and short-lived climate forcers, could be framed through an equity and justice lens.

Comments on Data and Analyses

Overall, the chapter does a good job of describing data and analyses in a consistent way. All the figures should have figure captions that are more thorough so that they are self-contained and clearly state what the figure means and why the reader should care.

Comments on Literature Cited

Overall, appropriate literature is cited. In some places, more citations should be included. Details are included in Appendix A.

CHAPTER 4: WATER

Summary

Overall, the chapter meets the requirements of Section 106 of the GCRA, with exception of the requirement of special attention to projected changes and challenges 25 to 100 years in the future. The chapter covers an admirably wide range of water topics. However, the chapter neglects to discuss or at least make clear ties to several key issues and chapters: mitigation (despite important carbon footprints of water management), blue carbon, energy (beyond hydropower), human health, economics, urban water, transportation, and agriculture. The key findings are reasonably well stated and supported (with some exceptions discussed below) and the subject matter covered within each key message follows a logical order. However, the key message titles should be rephrased into short, informative statements (see examples below),

rather than headers, to more clearly portray the key message. Additionally, the traceable accounts do not document the key findings in a consistent, transparent, and credible way and require significant revisions.

The chapter is, in parts, written at too high a technical level. For instance, the explanatory text should include more references to "climate change." The reader is sometimes required to assume or infer that phenomena listed are due to climate change, which may be confusing for broad audiences, as defined in Chapter 2 of this review.

The chapter also tends to focus only on "bad news," even where the figures themselves illustrate broad regions where some areas may fare better than others. For example, Figure 4.3 shows broad swaths of the US where precipitation changes are projected to be small, and Figures 4.6 and 4.7 show a swath of the desert Southwest where increases in soil moisture and runoff are expected. Even-handedness in NCA5 will be necessary for credibility and to provide a basis for realistic adaptation planning. Therefore, where relevant, this chapter should address both the many challenges posed by climate change as well as opportunities (see Chapter 29 [Alaska] for examples) or areas where climate change may have the least impact. There is somewhat uneven attention to the inclusion of both confidence and likelihood levels for many statements, with only one or the other or neither listed for many statements.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Notably, the introduction is a summary of the chapter, though not necessarily with the same citations or emphases. It does not attempt to motivate the chapter (e.g., "we all need water"), nor does it set the stage for the chapter by discussing the state of knowledge in NCA4. A revision to at least touch on both of those introductory topics would benefit readers of this chapter. References to NCA4 should be used in this introduction and liberally throughout the chapter to better focus on knowledge gains since the previous NCA.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages in this chapter reflect current knowledge about observed and projected impacts of climate change to water in the United States, followed by the challenges, opportunities, and methods to prepare for and address these impacts. They also identify emerging issues related to climate change. To help emphasize the key messages, the Committee suggests rewriting the titles as statements, rather than phrases, consistent with recommendations outlined in Chapter 2 of this report.

The text is written in a technical manner that, for the most part, communicates its findings effectively. However, some revisions may be needed to ensure comprehension by broad audiences. For example, "increasing the rates at which water is transferred to the atmosphere from open water, soil, and plants (Key Message 4.1)" is an unnecessarily opaque way of referencing what broad audiences will better understand as "increasing evaporation (and water use by plants)." As another example, in Key Message 4.2, "frontline of climate change" is a bit vague and might be replaced by "(particularly) vulnerable." Beyond vocabulary, context needed by broad audiences is often missing—for example, the evapotranspiration (ET) discussion lacks

a relevant explanation. While it is helpful that ET is defined and climate impacts are discussed, the topic is missing the "so what" factor. Why should one care about ET when climate is discussed? Is ET good or bad? The chapter should not leave these questions up for interpretation, but instead ensure the text is clear and explanatory.

Adaptation and, especially, mitigation should be more fully discussed, specifically regarding water management (e.g., in Key Message 4.3). Adding a few sentences, along with references to other chapters where these issues are addressed more fully, might be all the chapter needs to introduce these important questions that policy makers are grappling with.

Comments on Specific Key Message Language

> **Key Message 4.1. Profound Changes to the Water Cycle**
> Climate change has caused profound shifts in the water cycle, creating risks for both people and nature (*high confidence*). Many regions of the United States are expected to see more precipitation and heavier rainfall (*likely*, *medium confidence*), resulting in increasing flood damage. However, warming will also increase the rates at which water is transferred to the atmosphere from open water, soil, and plants, increasing aridity and drought risk and threatening surface and groundwater supplies (*very likely*, *high confidence*). In many locations, snow cover is decreasing and melting earlier (*very likely*, *high confidence*), posing risks to agriculture and municipal water supplies, and natural systems (*high confidence*).

Suggested title: "The Water Cycle Is Changing, and Will Change, Profoundly."

This key message provides a quick and generally readable synopsis of the range of water-cycle changes projected in terms of which water-cycle components will change or have already experienced change. The key message itself switches between changes already experienced (first sentence), projected changes (second and third sentences), and changes already experienced (fourth sentence), which weakens its impact. In each case (precipitation, evaporation, and snow), changes are already being experienced and are projected to increase, and the Committee suggests stating it as such.

The chapter opens with an infographic describing climate change threats to water quality. However, the key message does not touch on many of the issues presented nor does the supporting text.

> **Key Message 4.2. Rising Risks, Disproportionate Impacts**
> Natural and human systems have evolved under the water cycle's historical patterns and cannot adapt quickly to rapid changes in patterns of droughts and floods (*high confidence*). Communities on the frontline of climate change—including many Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities—are particularly at risk from changes to water quantity and quality due to the proximity of their homes and workplaces to hazards, limited access to resources and infrastructure, and cultural connections to water (*very likely*, *high confidence*).

Suggested title: "Water Changes Will Cause Different Impacts on Different Communities."

This key message and its supporting discussion move immediately from the natural science focus of Key Message 4.1 to important issues of equity and justice disparities. Thus, this key message and its supporting discussion interject the issue of equity and justice disparities right from the start, elevating equity and justice issues. Notably, a reader could conclude from the wording of this key message that only the vulnerable and historically overburdened communities are at risk; the Committee suggests adding a few words in the first sentence to clarify that everyone will be impacted, but (second sentence) these communities face enhanced risks. Sanders et al. (2023) could be added as a reference to support this latter point.

Additionally, the first statement in the key message regarding the inability of human systems to adapt quickly to rapid changes in floods and droughts is an overstatement, belied by a hundred years of water-resources and flood-management activities. It is also likely contradicted by Indigenous knowledges. The Committee suggests the phrasing "struggle to adapt quickly" instead of "cannot adapt quickly." As in Key Message 4.1, more attention to historical experience and responses to variability and extremes context in the supporting text would be useful for tempering or supporting this first sentence.

> **Key Message 4.3. Slow Progress Toward Adaptation**
> The ability of water managers to adapt to changes has improved with better data, advances in decision-making, and steps toward cooperation. However, infrastructure standards and water allocation institutions have been slow to adapt (*high confidence*), and efforts are confounded by wet and dry cycles driven by natural climate variability (*high confidence*). Frontline, tribal, and Indigenous communities are heavily impacted but lack resources to adapt effectively, and they are not fully represented in decision-making (*high confidence*).

Suggested title: "Progress Toward Adaptation Has Been Slow."

This key message is well written and referenced, albeit limited somewhat by a few successful experiences thus far in overcoming barriers to planning and limited implementation of major adaptations. Both this key message and Key Message 4.2 highlight the observation that "adaptation is slow," but it is unclear how this is measured. The Committee suggests providing an explanation for how adaptation is being measured either in the key message or in the traceable accounts. Also, Chapter 31 (Adaptation) should be referenced here for more detailed considerations of adaptation.

Comments on Text Supporting Key Messages

Key Message 4.1. Profound Changes to the Water Cycle. *Nuances of the projected changes often neglected:* Broadly speaking, the supporting discussion tends to list changes and impacts in geographically overbroad terms. For example, "many regions expected to see more precipitation" directly ignores the 25 to 30 percent of the country where declines are projected (Figure 4.3); the Committee suggests that slight wording changes such as "northern and eastern states will see more precipitation and southern states will see less" would make these statements more accurate and effective. Additionally, more significant rewording or cross-referencing relevant chapters would highlight more of the nuances or regional differences rather than implying that single projection applies to all regions equally. The overbroad descriptions also tend to discuss only the ensemble-means of projections (in Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9)

with no mentions of the ranges of outcomes indicated by the upper and lower percentile maps for each water-cycle variable shown in these same figures. If space allows, it would be helpful to include a discussion of these ranges in the supporting discussion for Key Message 4.1; at the very least, these ranges should be discussed in the corresponding traceable accounts. The Committee also suggests replacing "means" with "averages" throughout the chapter to enhance accessibility, and if medians are being used, they should include a brief explanation. Finally, it would be helpful throughout to clarify which changes (historical or projected) are precipitation-driven versus temperature-driven; uncertainties are larger regarding the former than the latter.

Reports of observed changes versus reporting of projected changes are intermingled and confusing: In several places—for example, the paragraph at top of page 4-12—the text switches between references to projections and already-observed changes in ways that confuse the audiences; more care should be given to distinguish the time frames (now or future) and basis (observations versus model projections) of the changes discussed throughout. Similarly, clarification of the distinction between projected climate changes (i.e., changes in climate) versus changes in terrestrial parts of the water cycle (i.e., groundwater recharge) induced by climate change would be useful.

Climate and water-cycle variability almost entirely neglected: This key message and supporting discussion largely neglects to mention either the natural variability that the trending and projected changes are embedded in, or the projections that variability is in many cases, projected to increase. Both aspects of variability are important context for interpreting the past and future changes reported and for understanding their likely practical impacts.

Flood non-stationarity treated as an "open question": The large uncertainty suggested on page 4-11, lines 5-7, is either an overstatement of the cited work in the face of scientific consensus or is not accurately summarized. There is little doubt or lack of consensus that historical records of floods are an increasingly unreliable representation of current or future probabilities and magnitudes under climate change. The Committee suggests clarifying the meaning or the literature basis for this conclusion and bringing this statement and the key message assertion that there are major changes in flood damages to come into better agreement. The key message also frames its projection of increased flood "damages" in a way that appears to attribute that increase strictly to heavier precipitation. Flood damages, however, will depend on the success or failure of flood-risk management provisions and adaptations; flood risks are projected to increase in many places, but that is not the same as flood damages. Even flood risks are not entirely determined by the fate of heavy precipitation. Conversion of precipitation from snowfall to rainfall, increased durations and numbers of storms, and other non-climatic changes may contribute as much to increased flood risks and increased droughts as precipitation does. Additionally, the general tendencies of landscape drying may reduce flood risks in some locales. The Committee suggests that more care be given to connecting how the precipitation change projections translate to flood risks and then eventually to flood damages.

Changes in duration of extremes not mentioned: Future storms (and droughts) are described in terms of increasing frequencies and magnitudes; changes in storm durations are also projected and will have equally significant impacts (e.g., Gutmann et al., 2018; Kossin, 2018; Lamjiri et al., 2017; van Oldenborgh et al., 2018). In many settings, it is the duration that increases mortality (in the case of heat waves) or results in the largest precipitation totals. More discussion of drought durations and even multiple drought types might be warranted in this discussion.

Key Message 4.2. Rising Risks, Disproportionate Impacts. *Limited attention to causes and consequences of disparities:* As noted in the discussion of equity and justice issues below, this section rarely progresses beyond acknowledging that certain communities will be worse off and focuses even less on why and how to address the disparities than the key message itself. In this regard, the key message and this discussion should be brought into better agreement.

Current Colorado River issues provide useful examples that could be included here: This section should also include a discussion of drought-stricken Colorado River basin areas and tribes with water rights that have yet to be quantified as pressing examples of impacts and disparities. The issue of past (natural) megadroughts (most pressingly, in the Colorado River basin) is extremely important in a key message addressing extremes and impacts, and the discussion (e.g., on page 4-16) should explicitly point at the later discussion around Figure 4.19 or move the discussion and figure up to this key message, or even Key Message 4.1.

Key Message 4.3. Slow Progress Toward Adaptation. *Discussion of water disputes is oversimplified:* Not all water disputes are handled with litigation; this suggestion (page 4-21) is overly simplistic. It is especially not accurate when the statement is followed up with a statement about the Colorado River. The Colorado River has had many legal tools used to allocate water; this body of law is known as "the Law of the River" and is largely made up of a combination of agreements between states, nations, and smaller entities. It is true that climate change has stressed the capacity of the Law of the River to work as intended and there are problems with the body of law as well. For example, tribal rights to the water have, in several cases, not been quantified. The Law of the River was designed to provide and allocate water using assumptions based on pre-industrial times when flows were above average and tribal rights were unaccounted for. Now, given the historic megadrought-induced water shortages and snowpack reductions, the system is stressed and is in rapid and continuing decline. A more accurate sentence here might read (see suggested citation, Garofalo, 2019):

> Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River Basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued sustained flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes....

Natural variability context scarcely mentioned until end of chapter: The discussion of natural variability in context of the Colorado River Compact (page 4-23) is an important addition but appears very late in the long list of chapter-specific trends. The final sentence (page 4-23, lines 17-19), with its allusion to the crucial mix between natural variability of "wetness" versus warming-induced flow reductions, is a key problem that was ignored throughout the earlier parts of the chapter and that will be faced in most parts of the country. The Committee suggests the chapter authors highlight and expand on this issue earlier under either Key Message 4.1 or Key Message 4.2.

Other equity- and justice-impacted communities are largely ignored: The subsection on tribal and Indigenous communities (page 4-25) is a good start, albeit drawing mostly from a

single reference (Fillmore and Singletary, 2021). As noted below, this use of a separate subsection to address these issues means that tribal issues that are shared by other nontribal communities are highlighted, which is laudable, but without acknowledgment of issues and barriers shared by other communities.

Water quality issues under-addressed: The finding (from Fillmore and Singletary, 2021) that water quality information is the most pressing need (page 4-25, line 5) among the western tribes they polled suggests that perhaps more discussion and attention to water quality issues, following Figure 4-2, is in order in the chapter.

Lack of technical capacity is the real limitation on adaptation: The lack of access to downscaled projections on page 4-25, lines 19-20, is less of an issue since past NCAs with the advent of high-resolution national coverage and modern internet resources in most areas; it is not the case that such projections are "rarely" available now or are the limiting factor on adaptation planning and activities (Findlater et al., 2021). What is insufficiently available now are the technical skills, expertise, and computing resources necessary to put those available projections to use in non-research institutions. Furthermore, rather than access, there is a lack of consistent guidance on whether and how projections should be incorporated into planning.

Comments on Traceable Accounts

The Chapter 4 (Water) traceable accounts do not include citations. Additionally, the traceable accounts make some stronger and different assertions, and express more confidence in some instances, than the text in the body of the chapter. Additionally, the purpose of traceable accounts is to support *how* the authors arrived at their confidence and likelihood statements. While the traceable accounts are well written, they *should include* citations to adequately support the claims made in the text. Because the traceable accounts are lacking citations, the chapter does not identify and provide sufficient context for embedded content in the traceable accounts section. Thus, the traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement.

As noted above, water quality, especially the mechanisms by which it will be affected by climate change, is neglected in this chapter. Figure 4.2 nicely summarizes many of these mechanisms, but this figure is inadequately discussed and only referenced in passing in the chapter. Some of this missing attention to water quality may reflect the relatively thin literature on the topic, but this relative lack of research on water quality with relevance to the impacts of climate change should be highlighted in the traceable accounts.

The summary (on page 4-9) of projected western United States groundwater-recharge changes, "decreas(ing) natural recharge across much of the West," which is stated without a confidence level, is an inaccurate depiction of the projections. The statement is contradicted by the key figure (6) in the primary citation (Niraulta et al., 2017), which shows different outcomes in different regions, over different time frames, and from different climate models. Thus, confidence should be relatively modest at present, indicating that this is an important research gap.

The list of ways that warming will influence snow processes and implied snow-fed runoff processes is missing one of the more important and straightforward changes to come: the fractions of many historically snow-dominated river basins that receive rainfall (and generate rapid rainfall runoff in large amounts) instead of snowfall will increase dramatically, thus increasing the flood flows and early runoff. The regions that will be impacted are more pressing

than the changes in rates and frequencies of rainfall versus snowfall in determining these enhanced volumes of runoff and winter floods.

Finally, regarding the continued discussion of snow processes on page 4-27, several important articles should be included (also in Key Message 4.1) to bring this discussion up to date: the excellent up-to-date literature review by Siirila-Woodburn et al. (2021), and a wide-ranging evaluation of snowmelt sensitivities by Ban and Lettenmaier (2022), Gordon et al. (2022), and Harpold and Brooks (2018).

Comments on Graphics and Boxes

The figures are generally effective and appropriate. For the most part they are simple, captioned well, and useful to wide audiences. In most cases, though, the figures should be better integrated into the body of the text (as most are dispatched therein with a single sentence each or less) to further motivate or expand on points made in the text. The Committee highlights more specific suggestions below.

Figure 4.2 is an effective and accessible infographic that presents primary pathways by which climate can impact water quality. If possible, the Committee suggests constructing a corresponding infographic for water quantity and/or supply.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 are an excellent sequence of similarly formatted graphics showing projected midcentury ensemble mean, 20th percentile, and 80th percentile changes in various water-cycle components. The captions include a wide range of useful "examples" but are stated strictly in terms of Representative Concentration Pathway (RCP) 4.5 conditions. However, this is inconsistent with what the map labeling implies is shown in the maps. Additionally, the text states, "average of all projections" and "average of 10 projections," but does not define how many are included in the "all" referenced. The Committee suggests fixing the labeling or the captions to make sure they are aligned.

Figures should be able to stand alone, and the captions should both tell the reader the meaning of the figures and describe what the figures show. The ensemble-average projections are covered in the text but treated as the projections; it would be better to acknowledge and at least allude to the ranges of changes indicated by the 20th and 80th percentiles shown. (In the caption of Figure 4.4, "the projections … are expected to decrease" is an odd and redundant phrasing.)

Comments on Equity and Justice

The authors include some attention to equity and justice in the chapter; however, it would benefit from stronger framing of equity- and justice-related issues in the introduction, including a definition of water justice. The Committee also suggests integrating historical and systemic drivers of preexisting inequalities that may be entrenched or exacerbated by climate change (i.e., describe how the changes to water quality, accessibility, reliability, and availability are related to the social context of water justice (i.e., resource distribution, decision-making dynamics, power relations). The Committee appreciates the attention to the importance of data access.

Currently, the chapter authors focus primarily on Black, Hispanic, tribal, Indigenous, and socioeconomically disadvantaged communities, and occasionally on distinctions between rural and urban communities and settings. Key Message 4.2 could benefit from a discussion on the disproportionate impacts to drought-stricken Colorado River basin areas and tribes with water

rights that have yet to be quantified. Additionally, many of the discussions of equity and justice issues would be improved by pointing to other chapters and sections where the issues are more fully addressed.

Notably, there is no mention of gender issues regarding water availability, despite the glaring fact that, from as recently as the November 25, 2022, *Eos*: "according to the United Nations, climate change and its effects are not gender neutral: Women and girls are hit the hardest, as the climate crisis deepens already existing gender inequalities," with even more acute disparities across the range of LGBTQ+ communities (e.g., Goldsmith and Bell, 2022; Goldsmith et al., 2022; Vinyeta et al., 2016). Pacific Island communities are also not mentioned in this chapter. In fact, the word Hawai'i appears once, and only to explain that it is not in a specific image. There is no mention of equity issues likely associated with examples like Figure 4.14.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Data and Analyses

The chapter summarizes existing literature rather than employing data and statistics, and so few comments on data and analyses are applicable.

Figures 4.3, 4.4, 4.5, 4.6, 4.7, and 4.9 map ensemble average and 20th/80th percentile projected changes in selected water-cycle variables. Unfortunately, only the average changes are discussed and sometimes in the context of projected outcomes. The ranges of projections indicated by the 20th and 80th percentile maps should be incorporated into the discussions, and into the uncertainties and likelihoods as described in the chapter.

Comments on Literature Cited

Many references cited throughout this chapter are older than ten years and thus predate NCA4. Where possible, older references should be replaced with newer literature, or, better still, selective lists of references building from the earlier reference should be used to demonstrate the growing body of literature on the topic. Additionally, much of the discussion and literature cited is noticeably western US-oriented, and additional newer references for eastern US issues should be included.

Occasionally, the literature cited does not reflect as broad a statement as it is cited to support; examples are offered above (e.g., the use of the Niraulta et al., 2017 paper in Key Message 4.1) and in Appendix A. Another example is from the discussion on drought (page 4-17, lines 14-16): "Drought conditions have historically resulted in increased groundwater pumping, a practice projected to increase with climate change (Bloomfield 2019; Hanson et al. 2012; Scanlon et al. 2012)." The Bloomfield article is based on case studies in the United Kingdom and the other references are focused on specific regions, rather than the United States as a whole. The chapter should reflect this nuance in its summary of the literature.

CHAPTER 5: ENERGY SUPPLY, DELIVERY, AND DEMAND

Summary

The Committee found Chapter 5 (Energy Supply, Delivery, and Demand) to be strong overall. The chapter largely meets the requirements of Section 106 of the GCRA. The key messages are clearly stated and are thoroughly supported by the detail provided within the chapter, and the findings are mostly documented in a consistent, transparent, and credible way. However, the traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the knowledge base. The chapter could also better integrate issues of equity and justice inherent in the US energy system. Additionally, the chapter does contain some technical language that may be difficult for the broadest possible audiences to follow; however, this is hard to avoid and still maintain clarity and accuracy for a technical topic like energy. The Committee provides suggested additions for topics and citations below.

The standout advancements in energy since NCA4 include improvements in clean and smart energy technology deployment, progress in climate modeling and planning methodologies, and increased equitable access to clean energy. These are clearly noted by the authors. However, reductions in coal use in the United States since NCA4 deserve mention as well.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Although the introductory text provides appropriate context, the Committee has three suggestions for additional context that could be added. First, chapter authors could consider discussing energy subsidies and other relevant government interventions including the recently passed Bipartisan Infrastructure Law and Inflation Reduction Act, mentioned in two other chapters (Chapters 25 [Northern Great Plains] and 32 [Mitigation]). Another important development is the use of litigation, particularly against the fossil fuel industry (Setzer and Higham, 2021). Similarly, natural gas bans in cities and bans on electricity produced with coal by some states (e.g., California, Oregon) should also be mentioned (Stevens and Lamberrmont, 2021). Second, the introduction should mention fossil fuels by name and relevant expectations for the fossil fuel industry such as reducing methane leakage/venting. Third, the chapter would benefit from a discussion of international topics related to energy such as the global energy supply chain and a more pointed discussion of critical minerals and supply chain concerns, as these topics are important in the context of both climate change and global change. Other international tensions relevant to US energy worth mentioning include nuclear energy (e.g., instability of Russian reactors); use and international trade of coal (i.e., among the United States, Germany, China, and Russia); production, demand, and trade of natural gas and oil; and imports, exports, and scaling up of solar panels. Topics not included in the chapter should also be mentioned in the introduction.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in this chapter reflect the current knowledge base of observed and projected impacts on energy systems in the United States as well as the challenges, opportunities, and ways to address the risk in the energy systems. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, it is not always clear to which clauses of individual sentences the confidence and likelihood rankings apply. To provide credibility, it is important that each assertion includes a confidence and, if applicable, likelihood ranking (see Key Message 25.1 for an example). The chapter prioritizes newer literature (since NCA4) and appropriately includes citations after each assertion.

Overall, the label, title, and message for each key message are appropriate, and consistently use both confidence and likelihood language. Key Message 5.3 should convey whether current progress is sufficient to address the current and future impacts of climate change.

Comments on Specific Key Message Language

> **Key Message 5.1. Climate Change Threatens Energy Systems**
> Energy supply and delivery are at risk from climate-driven changes, which are also shifting demand (*likely*, *high confidence*). Effects on energy systems are expected to increase with projected increases in the frequency, intensity, duration, and variability of extreme weather events (*likely, high confidence*). Potential impacts include damages to infrastructure and operations and resulting effects on human lives and livelihoods from extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires (*likely*, *high confidence*).

Key Message 5.1 summarizes the observed and projected impacts and disruptions on energy systems including energy supply, energy delivery, and energy demand. The key message is concise, appropriate, and consistently uses assessments of both confidence and likelihood. In the text supporting the key message, there are great examples and citations throughout, including noting positive impacts of climate change (e.g., Alaska offshore production). The citations and logical order of topics support the confidence and likelihood statements.

> **Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities**
> Interconnected effects of changes in technologies, policies, and markets increase the potential vulnerabilities of energy systems and communities to climate change and extreme weather (*likely*, *high confidence*). Compounding and cascading hazards related to energy systems and additional stressors such as cyberthreats and pandemics create risks for all but disproportionately affect underserved and overburdened communities (*likely*, *high confidence*).

Key Message 5.2 summarizes the observed and projected impacts from compounding factors such as resource constraints (material and workforce, supply chain, siting new infrastructure), cybersecurity threats to the power grid, vulnerable communities and equity, and cascading hazards. The title of this key message is informative, the message is well written, and

the topics discussed flow logically. In the text supporting the key message, citations are recent and support the overall findings (confidence and likelihood statements). Terms are defined in the text where necessary to help all readers understand.

> **Key Message 5.3. Progress Continues on Enhancing Energy System Resilience** Investments are being made to increase the resilience of the energy system, and opportunities exist to build upon these efforts (*likely, high confidence*). Progress includes improvements in energy-efficient buildings; technology to decarbonize the energy system; advanced automation and communication and artificial intelligence technologies to optimize operations; climate modeling and planning methodologies; and efforts to increase equitable access to clean energy (*likely*, *high confidence*). An energy system transition emphasizing decarbonization and electrification would require significant investment in new generation, transmission, distribution, and fuel delivery (*likely*, *high confidence*).
>
> *Suggested title:* "Efforts to Build Energy System Resilience Are Under Way."

Key Message 5.3 summarizes the existing investments to increase the resilience of the energy system and highlights the opportunities to further strengthen these efforts and resilience. The analysis is supported by recent literature. However, the term "resilience" given its central role in this key message should be clearly defined. Additionally, this key message should also indicate whether current progress and trajectories are sufficient to enhance energy system resilience to deal with future potential damages from climate change. The Committee suggests the key message title not use "continues on," which is not clear. The Committee provides a suggestion for an alternative title above. Lastly, the second sentence includes many claims, and it is unclear if the confidence and likelihood statement pertains to only some or all of these claims.

Comments on Text Supporting the Key Messages

Key Message 5.1. Climate Change Threatens Energy Systems. This chapter describes several impacts of climate change on the United States energy system, but it omits how the total demand for energy could change. There is a detailed analysis of the electricity system but there are not similar details for "primary" energy resources like coal, oil, and gas demand.

The key message is about climate change but most of the examples are about the effects of weather and weather-driven events like wildfires under current conditions (or projections) without a clear message about changes in recent decades. This key message is also missing the distinction between natural variability and climate changes; clarity could be added by modifying a few sentences throughout the chapter. Examples could be more clearly communicated by discussing them separately from the projections as well as by creating an additional section for examples associated with climate change. Permafrost impacts in Alaska are not discussed, including issues like methane leakage, a key challenge in the oil and gas industry.

The text supporting this key message should also note the impact of policy responses to climate change on the energy system. An example could be price changes due to imposing a price on carbon, or higher overall energy costs as the infrastructure and makeup of the energy system changes. The Committee suggests adding a discussion about what oil and gas are used for besides electricity to clarify that even in a "transitioned" world their development and delivery is still relevant, and therefore the inclusion here makes sense to audiences. It is also important to

note where regional differences exist across the country—for example, electricity generation and water availability is a topic that may be more relevant in the west and mountain west than in the east—and there should be cross-references to those relevant regional chapters. Given limitations of the word count, the Committee suggests that the technical details for the section of "Oil and Gas Delivery" be moved to the traceable accounts.

Key Message 5.2. Compounding Factors Affect Energy System and Community Vulnerabilities. Regarding vulnerable communities and equity, there is a lack of discussion about the distributional impact to those who used to work in the traditional fossil fuel sector but have been displaced due to the energy transition. Other compounding factors that are missing include inflation and geopolitics, which can impact energy prices. The Committee suggests adding cross-references to other chapters (e.g., Chapter 19 [Economics]). In addition, consumer behaviors are not discussed, which may impact the adoption of new energy technologies and influence the actual performance of these technologies. The text supporting Key Message 5.2 may be slightly technical for broad audiences, so the Committee suggests defining terms specific to the energy industry in the introduction. This section is also an important opportunity to note the emerging evidence that CO_2 affects human cognition at levels observed in buildings in cities, including school classrooms (Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). This addition may not involve much text, but instead could mention the topic and reference Chapter 15 (Human Health). The impact of CO_2 on human cognition levels has been missed in previous reviews and even in IPCC AR6.

Additionally, the Committee suggests touching on the causes of resource constraints, particularly regarding the critical minerals supply chain and the implications for the energy sector (Ballinger et al., 2019; Li et al., 2020). The section could also use more detail and citations. Similar comments are made in Chapter 32 (Mitigation) review, and therefore, there may be an opportunity for both of these chapters to cross-reference one another on this topic rather than duplicating information, which should help minimize the number of additional words. Given limitations of the word count, the Committee also suggests that the technical details for the section "Compounding and Cascading Hazards" can be moved to the traceable accounts.

Key Message 5.3. Progress Continues on Enhancing Energy System Resilience. Reductions in coal use in this country since NCA4 deserves mention. It is a great story of mitigation in action but should be couched in the context of the fuel switching driven by natural gas price advantage and not just renewables. Related issues of equity and their effects on communities deserve attention as does the differing approaches of states (e.g., Righetti and Stoellinger, 2021). The text in this section would also benefit from adding a few sentences detailing the Inflation Reduction Act changes to the tax credit scheme that emphasize worker protections and vulnerable population protections. The short discussion of energy storage in this section omits developments of alternative materials beyond lithium. Similarly, the idea of recycling battery materials or the circular economy should be explored. Given the limitations of the word count, the Committee suggests that the technical details for the section "Automation, Information Technologies, and Grid-interactive Efficient Buildings" can be moved to the traceable accounts.

Comments on Traceable Accounts

Generally, the chapter does a decent job in its traceable accounts section. Literature citations are highly variable, and the Committee suggests consistently adding citations after

sentences that assert that there is literature, policy, or law supporting a claim. For example, the statement, "The impact of climate change on global warming and sea-level rise is well established in the peer-reviewed research and supporting publications…" (page 5-19, lines 28-29) should include references. Overall, literature citations are lacking in the traceable account for Key Message 5.1, rare for Key Message 5.2, not uncommon in Key Message 5.3. This is primarily an issue in the "Description of the Evidence" sections for each key message. Adding appropriate citations would help appropriately identify and provide sufficient context for the embedded content.

The traceable account for Key Message 5.2 is quite long, though it is effective in describing the omissions in the literature and the lack of available data due to classified information. The traceable account for Key Message 5.3 should describe how authors arrived at their prescribed likelihood statements, as is done for the other key messages.

Comments on Graphics and Boxes

The graphics are effective and appropriate but could be better integrated into the text. Some are too busy and try to do too much without enough explanation in the captions, making them somewhat inaccessible. Specific suggestions are described below.

The title of Figure 5.1 is different than the title embedded in the image. The Committee suggests making them the same or omitting one. Additionally, the text in the small boxes is hard to read and there are too many boxes, which is distracting. The Committee suggests reducing words if possible or organizing the text in a table under the image with numbers to identify where the "pipelines," "thermoelectric power plants," etc. appear in the image. Figure 5.1 should also be updated to reflect permafrost changes, such as on pipelines.

For Figure 5.2, the Committee suggests using "electricity demand" instead of "energy demand" in the titles because this figure is only about electricity. Authors should also clarify the word "hot" in the figure where it describes the scenario.

In Figure 5.7, the Committee suggests explaining in the caption the difference between the two images, and why the "renewable" electricity generation graph (b) shows coal—is it biofuels and carbon capture utilization and storage?

Comments on Equity and Justice

Equity and justice principles are somewhat addressed throughout the chapter, however, given the inherent environmental injustices in the energy sector, the chapter should more clearly emphasize these principles. Below, the Committee identifies several equity and justice issues that could be expanded or discussed to enhance the chapter.

The chapter would benefit from defining "energy justice," including distributional (distribution of benefits and burdens across populations), procedural (who is included in energy decision-making processes to ensure that energy procedures are fair, equitable, and inclusive), and contextual (understanding of historic and ongoing inequalities) aspects. The key energy justice-related terms should be integrated, including energy insecurity, energy burden, energy equity, heat equity, and just transition. There are additional equity and justice issues relevant to this chapter. For example, in the context of energy, race is the primary indicator for the placement of toxic facilities in the United States (Mohai and Saha, 2015). The chapter should

also include a discussion on energy lifecycles as they relate to environmental justice, including extraction, production, consumption, and waste.

The chapter lacks an important discussion on energy industry workers who have based their generational livelihoods on fossil industries (e.g., coal and mining industries) and will likely face a lack of work or the need for training to move into new industries or technologies. A related discussion of public acceptance could be included (e.g., Armstrong, 2021; Sharpton et al., 2020). The issue of how expertise in the oil and gas community is relevant to many challenges in the renewable energy sector is not explored. Considerations of the workforce are the intertwined health issues. The Inflation Reduction Act emphasizes worker and vulnerable populations protections through a new two-tiered tax credit system that could be mentioned in Key Message 5.3. There should also be a discussion of inequitable adoption of new energy technologies among groups of consumers (e.g., adoption mainly happens in wealthy neighborhoods).

More focus is needed on the just transition literature and related equity complications. For example, there should be a discussion on the transition to lower-carbon sources of energy without specific efforts to ensure an equitable transition; as a result, everyone will not benefit equally (Carley and Konisky, 2020). Also, the chapter could mention that frontline communities of a just transition are diverse and, in addition to race and ethnicity, include those who work in legacy energy industries; non-extractive communities that rely on fossil fuels (i.e., those that host power plants or manufacture combustion engines); those who face enhanced short-to medium-term energy insecurity; as well as those who will lack access to new employment opportunities, involvement in decision making, and advanced technologies.

Finally, there should be a review of efforts to address disparities and build adaptive capacity including workforce and economic development, energy assistance programs, access to technology, community engagement in decision-making processes, and identification of barriers to a just transition. Associated data gaps should also be pointed out, such as who is on the frontline of a just transition, as well as the effectiveness and design of technology access, workforce, and economic development programs.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Literature Cited

This chapter cites literature from well-respected journals and agencies, most of which were published since NCA4. However, the Committee suggests also including other sources of information and literature that make up the knowledge base.

Other Recommended Changes

The Committee suggests discussing regulatory barriers that impede the commercial build-out of new technologies—for instance, the unclear regulatory framework for CO_2 or hydrogen pipelines (e.g., Garofalo and Lewis, 2020). This chapter is primarily focused on impacts on the energy systems and energy system resilience but lacks a detailed discussion on mitigation and adaptation moving into the future. The Committee suggests adding the role of mitigation

measures in addressing climate change to Key Message 5.3, as well as referencing Chapter 32 (Mitigation) where these efforts are discussed.

CHAPTER 6: LAND COVER AND LAND-USE CHANGE

Summary

This chapter reviews climate change impacts related to land cover and land-use change (LCLUC). The chapter is strong and essential for the framing of the broad objectives of NCA5 and meets the requirements of Section 106 of the GCRA but could be improved with a few key modifications. This chapter is important because LCLUC is an important element of global change research, though the chapter could more explicitly include projections of trends 25 to 100 years in the future. This chapter is written at an appropriate technical level, especially for decision makers, and supports an appropriate balance of evidence against scientific uncertainties. A chapter on LCLUC was also included in NCA4 and the chapter in the draft NCA5 report brings new materials, especially an interesting focus in Key Message 6.3 on constraints to the array of available land-use choices resulting from future land-based mitigation needs.

The chapter provides a working definition of land systems, which encompasses both land cover and land-use. However, the text frequently departs from a disciplined use of the definition in favor of generally referring to land-use or ecosystems. The chapter would benefit from a discussion that is explicitly framed around land cover and land-use. There is a focus on developed land as an important focal point, which is useful since this land cover class is less well addressed in other chapters. However, it is misleading to emphasize its importance by referencing its rate of increase, when in terms of total area change, developed land may be less important than other land cover changes, such as agriculture and forests. NCA4 suggested the developed land category is far less important than emphasized in this chapter. The precise analysis of LCLUC statistics should be reviewed here and cross-checked with other chapters. Similarly, estimates of emissions and removals should be reviewed, made consistent with other chapters, and standardized using an established source such as the US National Inventory (EPA, 2022). The chapter could be improved with additional text on rangelands and grasslands, particularly given their importance in NCA4. Revisions are needed to better integrate equity and justice into the chapter. The examination of future LCLUC projections is useful, but the chapter uses outdated Special Report on Emissions Scenarios (SRES) emissions scenarios. Lastly, the chapter could benefit from more reference to, and use of, emerging concepts and literature of land change science.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction presents several figures; however, it should also introduce the key message themes. It would also be useful to expand the discussion on the importance of LCLUC in analysis of climate change and climate change mitigation and adaptation. Other chapters note that climate change impacts are complicated and exacerbated by land management; it would be

appropriate in this chapter to go into more detail about the nuance interactions of climate change and LCLUC. There is an emerging field of land science with references that could be added (e.g., Chowdhury and Turner 2019; Gutman et al., 2004; Rindfuss et al., 2004; Turner et al., 2007, 2020). One potential area of discussion is the concept that LCLUC influences both the radiative aspects of climate change (i.e., GHG emissions and removals) and the water-energy balance through surface conditions change (i.e., albedo, latent and sensible heat flux). These dynamics and their interactions and feedbacks with climate are complex and not always obvious—for example, in some conditions, biotic carbon sequestration can lead to additional warming. It is important to distinguish this chapter on LCLUC from other chapters on forests, ecosystems, and agriculture, and by drawing on the land change science literature. Reference to, and drawing from, Chowdhury and Turner (2019) and Turner et al. (2007, 2020) may be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter discusses climate change impacts on LCLUC. The chapter authors outline the definition of land systems, which is comprised of two components: land cover and the way land covers are used by humans, or land-use. The chapter does a good job outlining the importance of land systems because it generally covers the most important domains of impact as well as where most mitigation and adaptation will take place. Although the chapter introduction starts with a defined framework for analysis (i.e., land cover and land-use), the key messages and the discussion on potential future options for adaptation does not adhere to this framework. While the emphasis of this chapter is to examine climate change impacts on land cover, with a focus on domestic concerns, it would be useful to include a brief discussion of how land cover changes in turn drive climate change, such as when deforestation results in GHG emissions or changes in water or energy balance. Furthermore, briefly discussing the idea of global teleconnections between land cover changes in other parts of the world and climate change impacts here in the United States would provide the audiences a better understanding of the complexities of interactions between land cover and climate change. A good example of these teleconnections is the hydroclimatological teleconnection between deforestation in the Amazon and domestic climate change impacts. Among other facets, this would help give the audiences a better understanding of the global context for land cover change mitigation.

There are some early conceptualization issues as well—for example, representing important land cover changes based on percent change rather than absolute magnitude gives a false impression that expansion of developed land cover is most important, which is not accurate. The key messages are appropriate and presented in a logical way, especially Key Message 6.3 on future projections. However, it would also be useful to note that LCLUC is by itself an important global change, which will interact with climate change to exacerbate, or perhaps ameliorate, the impacts. This chapter focuses on climate change influences on infrastructure, which is a good message for audiences because of its obvious economic impact. Key Message 6.3 on restricting future decision options is very important, and perhaps could be given more emphasis overall. Key messages are often missing likelihood statements, and it is not clear that the chapter authors approached confidence and likelihood in the same way as other chapters, nor as specified in the Front Matter.

The chapter could be improved by adding more on grasslands, rangelands, and pastures concerning recent increases in fire. One of the dominant land covers in the United States, rangelands, has important climate impacts, such as fire and new evidence on invasive species

from climate change. Relatedly, there should be more discussion on the wildland-urban interface (as well as other land cover/land-use interfaces), which would help frame this chapter in a way that is distinct from other "land cover" chapters.

Similarly, with other chapters, land cover changes are driven by both climate change and natural variability, which should be attributed separately. Early in the discussion of Key Messages 6.1, there is a statement that the United States sink for carbon is dominated by increased CO_2 concentrations in the atmosphere over the influence of LCLUC. The next sentence cites Pugh et al. (2019), which comes to a different conclusion, unless the CO_2 fertilization influence on regrowth is taken into account. This idea contradicts Chapter 7 (Forests), which attributes the sink to harvested wood products and regrowth. All references to carbon budgets and GHG inventories should be reconciled, standardized, and consistent with current literature, common terminology, and other chapters. In addition, the chapter does not acknowledge the role of natural variability in the key messages. At local levels, natural variability may play a larger role than climate change.

Comments on Specific Key Message Language

> **Key Message 6.1. Land System Goods and Services**
> Climate change has increased the intensity and frequency of extreme rain, droughts, fires (*high confidence*), and floods (*low* to *medium confidence*), posing increased risks for roads and other infrastructure, agricultural production, forests and biodiversity, and human health (*high confidence*). The role of forestlands as carbon sinks is at risk from climate-driven wildfire (*high confidence*). Climate change has disrupted the ways that people interact with the landscape for spiritual practices, recreation, and subsistence (*high confidence*).

Suggested title: "Climate Change Will Increase the Threat to Infrastructure and Loss of Important Land-Based Goods and Services."

In order to acknowledge the role of natural variability discussed above, Key Message 6.1 should include "in some places and times" to recognize that climate change does not cause these hazards everywhere, all the time.

> **Key Message 6.2. Land System Resilience**
> Resilience allows natural and built systems to maintain their basic character and functions in the face of change, supporting the continued delivery of goods and services. Changes in climate and land use affect the resilience of land ecosystems and thus the fate of the services they provide (*high confidence*); for example, increasing drought reduces the ability of forests to store carbon. Climate and land-use change interact, and these interactions present challenges as well as opportunities for maintaining ecosystem resilience (*high confidence*).

Suggested title: "The Combination of Climate Change and Land-Use Change Will Lower the Resilience of Land Systems to Floods, Droughts, and Other Challenges."

Given that the term "resilience" plays a central role in this key message, the Committee suggests including a clear definition of the term.

Key Message 6.3. Future Land-Use Options
The future of land use in the United States will depend on how energy and agricultural technology evolves, how the climate changes, and the degree to which we prioritize climate mitigation and adaptation in land-use decisions (*very high confidence*). Continued crop yield improvements and reductions in demand for animal-sourced foods could free agricultural land for other uses, depending on the ability to maintain agricultural system resilience (*low confidence*). Decarbonization will require a large expansion of solar and wind energy generation and transmission infrastructure (*high confidence*) and may involve large land-use changes toward reforestation or biomass crop cultivation (*low confidence*).

Suggested title: "Future Land-Use Decisions and Options Will Increasingly Focus on Climate Mitigation and Adaptation at the Exclusion of Other Considerations."

This is an important key message, and it has been framed well by the authors. To distinguish this chapter from others on individual land covers and sectors, it may be useful to bring in the concept of nature-based solutions, or natural climate solutions, which will heavily focus on the land base. The chapter authors could use literature such as from Seddon et al. (2021).

Comments on Text Supporting the Key Messages

The supporting text is written well and cites references well. However, the Committee has two major concerns. First, the chapter provides the land systems framework in the introduction, but the text supporting the key messages reviews individual sectors or land covers (e.g., forest, agriculture, developed land). It would improve the chapter and distinguish it from other chapters if the text adhered to the overall land systems framework or as noted, a land change science perspective (see references above). Laying out the broader framework of LCLUC importance overall, the changes observed in land cover and land-use separately, and the drivers and impacts of LCLUC would improve the usefulness of the chapter. A few cogent examples would then be useful to demonstrate ideas discussed without having to cover all cases of specific LCLUCs.

Second, it is critically important to accurately report numbers and data and use a standard source consistently across all chapters. It is important to adhere to one type of statistical unit (e.g., square miles or acres but not both) and perhaps consider change metrics expressed as absolute values (not percentages) with specificity on whether the change is net or gross.

Key Message 6.1. Land System Goods and Services. The section lays out some important considerations. The land system is important for the provision of goods and services and economic vitality. This key message could provide more background for Key Message 6.3, which is the most important component of this chapter. This key message does well to point out the economic implications of climate destabilization of built infrastructure, and it may be useful to examine the same for other infrastructure aspects such as agriculture—for example, excessively wet spring conditions prevent planting.

The impact on goods and services is noted, but the range of specific examples of impacts across various sectors would be too numerous to delineate them all in this chapter (e.g., agriculture, forests). Thus, the chapter should present a few cases as examples, perhaps using a

box. It would be useful to report on studies that have looked at the economy from a larger perspective; for example, see Kubiszewski et al. (2020) and Weiskopf et al. (2020).

Key Message 6.2. Land System Resilience. This key message demonstrates how climate change will influence the ability of all land systems to mediate impacts, which is useful. This framing is helpful for this chapter because there are other chapters that treat ecosystems, forests, and agriculture individually. It would be useful if there were more cross- references to other chapters. The discussion of economic impacts is useful. There is also a discussion on how multiple interactions between land cover and use are important. However, Figure 6.7 is bulky and defeats its purpose. Perhaps some case studies or examples would be a better substitute.

The emphasis on the importance of development needs reconsideration because although it is a rapidly changing land cover, its overall magnitude is less than some other land cover types. The discussion of interactions in the land system is useful. However, it is reduced to a few examples of ecosystem dynamics. It would be useful to elaborate on climate interactions in the context of a land systems framework, or through the lens of land change science, which would focus on LCLUC-specific issues. This is also a place to discuss nature-based solutions or natural climate solution frameworks, offering insights on the value and characteristics of land-based adaptation and mitigation.

Key Message 6.3. Future Land-Use Options. It is important for the chapter authors to carefully discuss current trends and status of LCLUC; some studies suggest the rate of land conversion is diminishing and will continue to decrease into the future. The current data on land cover in the United States suggests that pasture is the largest category and urban is the lowest, yet the draft NCA5 report emphasizes urban development and barely discusses pasture. This chapter seems to suggest that developed land is the cover category with the greatest net change in area. However, because change can be an increase or a decrease in area, this is misleading because combined area changes in forest, agriculture, and pasture far exceed developed, as well as the net change, according to NCA4 and Auch et al. (2022) since 2016. Therefore, either something has changed recently or the draft NCA5 report is inconsistent with past assessments and recent literature. Moreover, there appears to be evidence that these vegetative cover classes also declined in *use*, which would be an important observation to explore and project into the future. Auch et al. (2022) notes that the percentage of land in CONUS undergoing cover change each year has been declining. The two most prominent patterns of land-cover change were natural resource cycles and increases in urban and built-up land. Natural resource cycles accounted for 80 percent of all annual gross change, with these processes mostly involving the loss and gain of tree cover though harvest, wildfire, other natural events, and its regrowth, as well as fluxes between cropland and grass/shrub. Gurgel et al. (2021) uses a multidimensional econometric model and suggest no major shifts in land-use change trajectories, with most future changes in agriculture, not developed land (urban). The emphasis on developed land conversion diminishes other land-use changes of importance, such as conversion of grasslands to croplands for biofuels (Lark et al., 2022).

Comments on Traceable Accounts

Traceable accounts are done well but lack citations in some places, except for Key Message 6.3. However, due to the lack of projections and forecasts on specific important climate change impacts related to LCLUC, the connection between the literature and the statements in the key messages is weak. The chapter does an adequate job using confidence and likelihood in

its key messages, but the statements are not adequately justified in the traceable accounts. Consideration of literature on land system drivers, such as economic or production factors, and how they are influenced by climate change should be added. Also, traceable accounts could be improved by organizing them by human system and natural system drivers and factors. In the context of this chapter, LCLUCs are largely driven by human decision making rather than natural events, which are better described in other chapters. However, some of these economic or production drivers may be influenced by natural factors and climate change. For example, the authors of this chapter have done an excellent job noting the importance of land-use choices and their constraints due to climate change. Thus, it would improve the traceable accounts if there were a clear distinction between the literature and science that supports the human drivers and the literature and science that supports the climate and natural systems drivers.

Comments on Graphics and Boxes

The graphics should be reconsidered. There are specific mentions of graphics issue above, but generally they do not capture the reader's attention, and some are confusing. Graphics could be better used to support boxes and/or specific examples. A good approach to graphics can be found in Chapter 5 (Land Cover and Land-Use Change) of NCA4.

Figures 6.1 and 6.2 should include Alaska and Hawai'i. The zoom-in boxes in Figure 6.2 are useful to show additional detail which would not be apparent in the national-scale maps. Chapter authors should consider adding additional inset boxes, and add some simple overlays, such as the Yellowstone National Park boundary, to help audiences relate to the content.

Comments on Equity and Justice

There is little discussion of the equity and justice dimensions of LCLUC, which should be improved because equity and justice implications are very important in the context of LCLUC. It might be useful for chapter authors to lay out how Key Messages 6.2 and 6.3 relate to equity and justice, particularly the way choices could be constrained, and ways to think about inclusion in the process of decision making under climate change and LCLUC influences.

The equity and justice framework could be broadly used to consider the distribution of benefits and harms, recognition, and participation. The chapter could consider the equity and justice framework historically; what drives LCLUC decision making by whom? For whom? How? This approach could be used to consider these factors relative to climate change. The authors already note well how climate change will constrain land-use decisions generally, and chapter authors could also explore land-use decision making in the equity and justice context. Multiple histories of social and spatial marginalization with impacts on present-day LCLUC include zoning decisions, investment/disinvestment, redlining and connection to present-day spatial distribution of grey and green infrastructure, and ecological fragmentation.

There are also potential issues related to mitigation and adaptation because land systems are likely to be significant parts of many policies and measures. Chapter authors should consider the distribution of benefits and harms in this context, as well as decision-making structures or frameworks that may increase or reduce vulnerability to climate impacts and land-use impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in

equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

The analysis of data is fine, but there are few quantitative insights on how LCLUC and climate change could impact the economy. It would be useful to include a few examples. As noted above, it is important to make sure that the data on LCLUC are correct, consistent, and standardized, adhering to definitions and concisely stated in common units.

Comments on Literature Cited

The cited literature is good except in three areas: (1) concepts and findings from the land change science literature could be used more, especially as a way to frame the chapter in a broader LCLUC framework, which is a science area of its own; (2) the chapter could reference the current data on land cover and land-use areas and changes, some of which have been provided here; and (3) the drivers of LCLUC are perhaps distinct from drivers of ecosystem changes—they include economic and yield factors, for example. It would be an improvement to use this literature, especially for analyzing projections in Key Message 6.3. Some references could be updated with more recent literature.

Other Recommended Changes

There could be more emphasis on the connection between mitigation and adaptation and the importance of LCLUC. In addition, LCLUC is often referred to as the "other global change" and it will have its own impacts at the same time as climate change. This point is not well treated; the importance of LCLUC and its role as a mediator for climate change could be discussed more. Lastly, the chapter omits complex changes and impacts (e.g., degradation, fragmentation, regeneration in odd locations) in favor of simple changes and impacts (e.g., infrastructure).

CHAPTER 7: FORESTS

Summary

This is a generally strong chapter that reviews the important aspects of climate change impacts on forests in the United States, emphasizing its impact on creating new and complex changes to disturbance regimes, the potential for losing forests' capacity to continue to provide abundant and important goods and services, and the challenges and prospects ahead for adaptation management of forests. These three elements form the basis for three important, logically framed and presented key messages. The chapter meets the requirements of Section 106 of the GCRA but could be more explicit in the evaluation of projections.

Climate change impacts are presented well in the context of current and potential adaptation responses, but more examination of mitigation could be added. Generally, the chapter captures the most salient new developments in scientific understanding, the evidence base, and

research gaps. However, at times, the text is too nuanced for the intended audiences, defined in Chapter 2 of this report. For example, the discussion of how climate change exacerbates existing disturbances, interactions between disturbance agents, and disturbance regimes could be bolstered with different examples. The writing is at an appropriate technical level but could benefit from more citations emphasizing the domestic forest research basis of the key messages and fewer citations from global-scale forest analyses, as well as adding clarity and specificity on the emissions and removals estimates, since forests are a significant sink.

The key messages are objective and include statements where there is strong and weak evidence or certainty. Key messages also acknowledge complexities in attributing impacts, for example, referencing the compounding influence of management and land-use change. Although there is an explanation given in the traceable accounts, both confidence and likelihood levels should be assigned to statements in the key messages, consistent with definitions presented in the Front Matter and used in other chapters.

The Committee commends the chapter authors for their use of cross-chapter references to other key messages. The treatment of equity and justice, however, is light, giving most attention to Indigenous communities. This discussion could be enhanced with examples of notable successes, for instance, with tribal communities' mitigation and adaptation examples that are well known in the literature and public record and discussed in other chapters. Finally, the importance of natural variability cannot be overstated when trying to evaluate climate change impacts and demonstrating the difference between climate change and natural variability; it would be useful to acknowledge these differences to provide more confidence in the chapter's key messages.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is adequate but provides mostly background on the importance of forests. The addition of short text on how climate change impacts are affecting forests would provide essential context for the key messages and would balance the introduction with the rest of the chapter. The three key messages are logically ordered, so a few sentences in the introduction would provide readers with a chapter map (i.e., complex and changing disturbance regimes, resulting loss of value in goods and services, and adaptive and mitigative responses are under way but more will be needed) to provide relevant context. Whether here or later in the chapter, it may be useful to address the issue of the recent loss of forest stock and the associated risks of a declining carbon sink at a time when adaptation and mitigation measures need to enhance biological sinks, especially in forests. Additionally, introducing the importance of forests for overburdened communities would also be valuable in the introduction to help better integrate equity and justice principles throughout the chapter. Similarly, the introduction lists the goods and services that forests provide, including "spiritual renewal" but does not mention the Indigenous cultural values of forests. Although these cultural values are covered in Key Message 7.2, they are also important to integrate into the introduction.

Finally, more discussion of the role of natural variability in addition to climate change would benefit the chapter; to frame this discussion, the Committee suggests adding a sentence in

the introduction about how extreme events occur naturally and how climate change can change the frequency.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The three key messages presented in this chapter accurately reflect current understanding of impacts associated with climate change are logically connected and follow a good sequence. However, as presented, their titles are not effective. Each key message is well described by providing the reader with background on how forest ecosystems function and how changes could occur with climate change and the implications for forest structure and function, their provisions of ecosystem services, and management challenges. They are written well and presented objectively, considering areas of certainty and areas of uncertainty. The use of confidence rankings is adequately done, but the use of likelihood differs from the definition used in the report and by other chapters. This chapter is very similar to the chapter on Forests in NCA4—for example, the three key messages are the same and the emphasis on fire (severity and scale), extreme weather effects, carbon, and water are overlapping. This chapter should emphasize more the interaction of disturbance agents, which would be an important new element to present, but it would need additional detail and better examples in Key Message 7.1 (e.g., the example on bark beetles is good but that on ghost forests, which is more of a direct impact issue, is less useful). Continuing to update audiences on the impacts of the provision of goods and services is useful, but new evidence or examples would be more insightful than those presented. To this end, the declining carbon sink observation presented here is also perhaps new in Key Message 7.2, so that could be elaborated on.

The key messages, especially Key Message 7.1, focus on the interaction between agents of change. This focus is useful for demonstrating the complexity of system-wide impacts, but the Committee suggests that the chapter authors revise the text to be explicit about the interactions between agents. For example, to increase readability, it would be useful to better describe interactions of climate factors, such as temperature and drought, and interactions of ecosystem factors, such as pests and fire and include brief text that makes it clear how scientific evidence is distinguishing between the natural background variability and attribution to climate change.

Most of the text on risks and impacts is somewhat general. It would be useful to have a few specific quantitative forecasts of impacts or provide an update on the discussion of "future forests" from NCA4. The key messages focus on impacts from climate changes related to extreme events and impacts related to increased severity and frequency due to precipitation and temperature.

Lastly, the discussion of equity and justice should be bolstered. There is some discussion of Indigenous communities, but less on other aspects of diversity, including key issues such as access to forests benefits generally, and trees in urban areas. There are some good examples of mitigation and adaptation activities in tribal areas that could be discussed in detail, such as the Yurok tribal forest carbon credit projects in northern California, which are long-standing climate change mitigation and sustainable forest management examples that demonstrate the effectiveness of alternative models of natural resource management (Fleischman et al., 2021; Manning and Reed, 2019).

Comments on Specific Key Message Language

Key Message 7.1. Climate Change Affects Forest Change

Forest ecosystems support livelihoods, regulate climate, and maintain and protect biodiversity. Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*). Continued warming and regional changes in precipitation are expected to amplify interactions among disturbance agents (*likely*, *high confidence*) and further alter forest ecosystem structure and function (*likely*, *high confidence*).

Suggested title: "Climate Change Is Now a Dominant Form of Human-Induced Disturbance to Forests That Exacerbates Existing Disturbances."

This key message is well done, but there is some confusion in the title and the key message text with the use of "change" twice. The Committee suggests an alternative, formulated as a statement as shown above. This key message first introduces a few important disturbances affected by climate change, including increased fire severity, pests and insects, and disease. It then introduces factors that affect forest indirectly due to changes in climate factors such as drought, extreme weather, and others that exacerbate the disturbance impacts. For example, drought or warmer winters affect pests which causes increased disturbances. Thus, while this key message is very similar to the presentation in NCA4, it introduces or emphasizes new concerns about complexities introduced by disturbance interactions. As this point is important, the Committee suggests elevating it within the key message. Additionally, it could be strengthened by elaboration, more focused examples, and noting the importance of distinction from natural variability in the supporting text.

Including a point about direct and indirect influence of climate change means the text should clarify whether the supporting evidence points directly to climate change or to factors that are logically but perhaps not demonstrably linked to climate change. For instance, the sentence "Climate change is increasing the frequency, scale, and severity of some disturbances that drive forest change (*high confidence*)" is fine. However, it is unclear whether evidence exists, and confidence is high, that climate change has in fact, caused severity to increase and has resulted in some impact on forests. It is important to be concise and perhaps explain the evidence directly in the text supporting the key message or in the traceable accounts. Also, the use of the words "some disturbances" is vague, and the Committee suggests rephrasing or elaborating with examples.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests

Forests provide goods and services that enrich human lives and sustain life more broadly. Increasing temperatures, changing precipitation patterns, and altered disturbances are reducing the capacity of forest ecosystems to sequester and store carbon (*high confidence*), provide clean water and clean air (*high confidence*), produce timber and non-timber products (*high confidence*), and provide recreation (*medium confidence*), among other benefits. Future climate effects will interact with societal changes to determine the future capacity of forests to provide goods and services (*likely*, *high confidence*).

Suggested title: "Climate Change Alters and Diminishes the Goods and Services Provided by Forests."

Unlike Key Message 7.1, this title is already an informative statement, but a slightly modified example has been provided.

> **Key Message 7.3. Adaptation Solutions**
> Climate change creates challenges for natural resource managers charged with preserving the function, health, and productivity of forest ecosystems (*high confidence*). Forest landowners and managers are preparing for climate change through the development of vulnerability assessments and adaptation plans (*high confidence*). Proactive adaptation of management strategies that create, maintain, and restore resilient forest ecosystems are critical to ensure continued and equitable provisioning of goods and services (*high confidence*).

Suggested title: "Forests Provide Significant Adaptation and Mitigation Opportunities, But Some Forests Are at Risk."

Comments on Text Supporting the Key Messages

The supporting text for the key messages is strong but sometimes rather nuanced. Some of the ideas repeat NCA4, so emphasis should be placed on the new material and evidence, such as the interaction of disturbances and the shrinking carbon sink. However, when using estimates of emissions and removals, some standardization of data sources should be used, and where differences are necessary (e.g., in Key Message 7.2), they should be clearly described in the text supporting the key message or traceable accounts. The key messages would all benefit from more cogent examples. Similarly, the chapter is strong on presenting evidence of trends, but this should be followed by a brief statement about how a trend is directly attributed to climate change. Forecasts would be useful, as would some references to economic impacts in Key Message 7.2. The chapter overall is good at identifying cases where evidence is weak, but it should also clearly state what is known. Key Message 7.3 is good but heavily focused on adaptation and should also include a discussion of mitigation. To do that well, it would be important here and in other chapters to ensure that there is consistency in how emissions and removals are reported, and in the data source(s) used. In particular, the forest sink term is reported differently throughout the draft NCA5 report, not only in the magnitude but also in attribution (e.g., agricultural land abandonment is noted as a major sink in Chapter 11 (Agriculture, Food Systems, and Rural Communities) when it is not actually reported as such in EPA [2022]). In the draft NCA5 report, the emissions from harvested wood products (HWPs) are reported with no reference nor explanation of how or why it appears to differ from EPA (2022) and Domke et al. (2021).

Key Message 7.1. Climate Change Affects Forest Change. In addition to the points mentioned above, it is noted that climate change would amplify the interactions of agents of disturbance but assumes the reader will know this is a negative influence. Forests are dynamic; they experience disturbances, but climate change will increase the frequency and severity of these agents. There will be interactions among them (e.g., drought, insects or pathogens, tree die off, hurricanes, land-use change, fire). The chapter points out that fire suppression and land-use change reduce the adaptive capacity of forests to climate change. The text discusses tree

mortality as an impact, but there are also more complicated and serious impacts on overall demography, especially the balance between mortality and recruitment, which itself is complicated by fecundity and migration dynamics.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message extends logically from Key Message 7.1 and aims to identify the important ways climate change reduces the current and future provisioning capacity of forests. Emphasis is given to carbon sequestration, non-timber products, biodiversity, heritage and cultural values, recreation, and water. These are important and could be strengthened by emphasizing economic impacts or cross-referencing other chapters. Estimates for future economic impact, including from HWPs, would engage readers. The key message is very similar to what was presented in NCA4. A new emphasis could be a focus on reductions in the current forest sink, which is important. Although this is in part attributed to land-use change, it would be useful to explicitly emphasize the link to climate change and supporting evidence.

As in other chapters, current estimates of emissions and removals of carbon and other GHGs is provided as an important consideration. However, the text supporting this key message is confusing regarding the source of data and how they are used. As discussed in Chapter 2 of this report, the Committee suggests using a standard source for the US GHG inventory (i.e., EPA, 2022). In doing so, this chapter should explain how the US Department of Agriculture (USDA) estimates may differ (i.e., how harvested wood products are computed as emissions and removals). The citation to Domke et al. (2022) does not exist in the references, and it is not possible to locate the citation nor a publication that can be used for Figure 7.8. The net sink term from this chapter and in this figure appear to contradict other estimates in other chapters. These estimates also appear to contradict EPA (2022), and the estimation method in this chapter appears to differ from EPA (2022); here, the net sink is diminished compared to EPA (2022) due to high emissions from HWPs that are not clearly reported in national inventory reports. The reader should be aware that a HWP pool has emissions and is only effective over the long term if the harvested wood is part of a rotation with regrowth. The citation to Johnston and Radeloff (2019) is not the best citation or should be clarified because it is a global analysis and does not consider the rotation issue in the same way as in the US inventory.

This key message does a good job of distinguishing between chronic and abrupt changes. Additionally, this key message is an adequate discussion of environmental justice and cultural issues, but it is somewhat narrow. The discussion could include success stories from Indigenous actions and management such as carbon management on tribal land (e.g., Yurok). There are no citations for the first sentence of each of the first three paragraphs of the supporting text for this key message (page 7-10, lines 17-27, and page 7-11, lines 1-7), making these sentences appear as assertions. The text would be more compelling with citations, and the Committee suggests rewriting assertions to avoid stand-alone text without citations.

Key Message 7.3. Adaptation Solutions. This key message is well done and backed by evidence and examples. It could be improved using better examples from an equity and justice perspective. As mentioned above, there are good examples from tribal management of carbon projects for both mitigation and adaptation. The focus is on adaptation solutions, but mitigation is also very important for forests. One of the most important messages relates to the already strong role forests play as carbon sinks, and this is currently at risk due to a decline in forest stock and productivity caused by climate change (e.g., fire) and land-use change (e.g., urban encroachment). This point and the loss of buffer against severe impacts of fire at the wildland-urban interface could be stated more strongly.

Comments on Traceable Accounts

The trend and current emissions and removals of GHGs have not been considered coherently in this chapter; placing more emphasis on mitigation versus adaptation could help. However, the estimates of carbon and CO_2-equivalent in this chapter are difficult to interpret; they appear to have inconsistencies with other chapters and within this chapter. This chapter suggests that the national net sink for carbon is ~402 Mt CO_2-equivalent in 2020. This is based on Net Ecosystem Carbon Balance in 2020, taking into consideration transfers and emissions from HWPs. These estimates appear to differ from other chapters, from the incorrectly cited Domke et al. (2022) (which is perhaps Domke et al. [2021]) and EPA (2022). The traceable accounts section should either reconcile these apparent differences or clearly explain how the accounting is done.

Key Message 7.1. Climate Change Affects Forest Change. The evidence basis for forest disturbances attributed to climate change either directly or indirectly is lacking. These include changes in fire regimes (frequency, magnitude, severity), pests (e.g., bark beetles), forest health, and disease. The traceable accounts provide background evidence for climate change effects on fire regimes, and far less for other factors. Evidence directly showing the linkages from climate change to ecological factors to forest impacts is less clear and should be strengthened. The interpretation of the literature on page 7-8, lines 11-12 is incorrect: "western tree species are migrating poleward through seedling success (Sharma et al. 2021)." The analysis by Sharma et al. (2021) actually cautions that although a migration potential exists due to changing climate factors that influence seedling success, local terrain conditions actually constrain migration at the same time." Specifically, the paper says: "Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Figure 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain."

Additionally, natural variability is important, not only because natural ecosystems such as forests are dynamic and some of the adverse impacts of climate change are also naturally occurring, but also because in any observational sense the climate impact is buried in the "noise" of the natural dynamics and needs to be teased apart from it. This complexity makes it complicated to measure, assess, and attribute impacts to natural variability versus climate change. This complexity could be noted, with a rationale or examination of the evidence within an explanation of how the science can attribute climate change impacts. Clarifying these attributions is especially important for Key Message 7.1 since it focuses on the complexities added by multiple agents and stressors.

The discussion of gaps is very useful, but it may understate the current knowledge gaps. One reference worth citing and describing is the recent report by Novick et al. (2022), and overall, the discussion of gaps could be expanded with more citations. One area of concern not addressed in this section is the multiple, and perhaps confounding, influence on climate change from forest management and forest cover change. This is a consideration of the difference between radiative forcing due to GHGs and surface water and energy balance; in some cases, forest cover increases warming even while it sequesters carbon. The traceable account rightly acknowledges gaps in understanding related to hydrology.

Key Message 7.2. Climate Change Affects the Goods and Services Provided by Forests. This key message focuses on the importance of changes in US carbon sinks, forest products, ecological functions, cultural and heritage values, recreation, and water resources. As noted above, there should be a discussion on the data sources and use of data on emissions and removals. The new estimates on forests that appear in Figure 7.8 are neither referenced nor cited. Domke et al. (2022) is cited in the traceable accounts but not found as a reference; if this is a mistaken reference to Domke et al. (2021), then the citation in the traceable accounts is misplaced. Other than carbon sequestration and water, the main statements in the key message are associated with diminished goods and services, including changes in the range and abundance of species, heritage values, recreation, and health, but only supported by a few references to literature. This section of the traceable accounts could be bolstered.

Key Message 7.3. Adaptation Solutions. This key message focuses on adaptation. The review of evidence in the traceable account is not deep; it would be useful to know more about the review of evidence on the potential for success with assisted migration. The key message does not address mitigation, so there is no discussion of it in the traceable account.

Comments on Graphics and Boxes

There are many graphics and figures that were not available for the Committee to review, so evaluation here is limited. Key Message 7.1 would be improved if the figures and boxes directly expanded on the idea of interactions with and between agents of disturbance to highlight this aspect and advancements since NCA4. Table 1 from Key Message 7.3 has errors. Figure 7.7c attributes the decline in the US carbon sink to tree mortality but in other places and chapters, the reason is given as land-use change. The Committee has additional comments on individual graphics and boxes below.

Figure 7.1 is useful but needs an expanded caption and a citation. Additionally, it is not clear what the pink, white or grey colors are, and clarification would be useful.

Figure 7.3 is not shown but could be eliminated or replaced. It is indeed a good example of direct forest impact from climate change (SLR) but detracts attention from the point about the interaction of disturbances.

Figure 7.4 is not shown. It may be useful but possibly more relevant to NCA4 than here.

Figure 7.5 is somewhat general and might be replaced.

Figure 7.6 is not clear where it shows spruce beetle damage, and the box may serve the reader better.

Figure 7.8 should be better documented and explained. Abbreviations should be defined. It is unclear where these estimates are sourced, and how they are derived, compared to other sources such as EPA (2022).

Figure 7.10 is not useful on its own and does not show examples of adaptation practiced as referenced in the text.

Box 7.2 would be very useful if more details are included, and the numbers are verified.

There is an opportunity to create a box in Key Message 7.3 describing the Yurok tribal work in carbon management, sustainable forestry, and heritage values.

Table 7.1 is useful and would be improved with a box for Key Message 7.3.

Comments on Equity and Justice

Broadly, there should be more integration of equity and justice, including in the introduction. There are opportunities for positive stories of successful adaptation and mitigation, especially from tribal communities. There is adequate discussion of Indigenous communities, including traditions and governance issues, but this discussion could be bolstered with the inclusion of adaptation and mitigation examples of carbon management projects, such as the Yurok projects in California and the Great Lakes states. Additionally, different dimensions of equity (distribution of costs and benefits, recognitional, procedural, intergenerational equity) as they relate to forests should be integrated where possible. Discussion of governance and access as well as supporting literature should be included. Urban heat islands and reforestation efforts, particularly in formerly redlined areas, can be discussed.

There is an emerging literature on urban forestry and environmental justice (Grant et al., 2022; Watkins and Gerrish, 2018), which could be referenced to review ways to remedy past inequities and create future benefits derived from new approaches to the management of urban tree systems (Nyelele and Kroll, 2020; Zhou et al., 2021).

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible, to highlight the interconnectedness and complexity of these issues. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

Data analysis is generally well done, but there is little analysis for future projections, nor specific forecasts in terms of economic loss or cost of lost ecosystem services. The analysis of hardwood products and the US carbon sink should be clearly stated and described.

Comments on Literature Cited

Generally, the chapter cites appropriate literature, but the use of global literature can confuse the reader since the condition of US forests is vastly different than the global condition and trends (Auch et al., 2022; Kubiszewski et al., 2020). There are also more sources available on research gaps (e.g., Novick et al., 2022; Seddon et al., 2021) that would strengthen the chapter. In addition to citations provided to examples from Yurok, more references to Indigenous forest management and restoration could be explored, such as Reyes-García et al. (2019) and Long et al. (2020). The citation made in this chapter to Domke et al. (2022) is confusing—the Committee cannot find it referenced and does not readily appear in the literature when searched. If it is an update of Domke (2021), which is also cited in the chapter, it is an important reference given how it is used for evidence. Another issue with the literature cited is the lack of standard references for some important data, discussed above. For example, the chapter should use a standard GHG emissions reference or source, such as EPA (2022). This could be augmented with any critical USDA data on GHG emissions, when differences are explicitly stated and reconciled. Similarly, there should be a standard and common reference or source for land-use change data and statistics.

Other Recommended Changes

It may be worth explaining briefly in the introduction why forested ecosystems have their own chapter (in addition to Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity] that covers all types of ecosystems). Is it their extent, the economic value of goods (provisioning), their importance for regulating services, carbon sequestration? These are all implied in the introductory material but should be explicitly stated. No other terrestrial ecosystem (e.g., rangelands) is the sole focus of a single chapter.

CHAPTER 8: ECOSYSTEMS, ECOSYSTEM SERVICES, AND BIODIVERSITY

Summary

Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) analyzes the effects of climate change along with other stressors (i.e., other global change drivers) on the natural environment and biological diversity by integrating current evidence about ongoing trends and projected trends for the future. It also examines trends in the knock-on effects of ecosystem change on agriculture, water resources, and human health and well-being ("ecosystem services"). The key messages encompass the key impacts of global change on ecosystems and reflect the current understanding that climate change interacts with other global change drivers to affect ecosystems. Emerging issues identified included abrupt changes triggered by extreme (weather) events. Also novel, the chapter provided a framework for adaptive ecosystem management—Resist-Adapt-Direct. Examples of operational adaptation (e.g., restoration, habitat protection, assisted migration, intensive management) were included. This chapter examines natural ecosystems and does not go into detail on managed ecosystems such as agroecosystems or working forests. It would be useful to provide this perspective to the reader as well as references to other chapters that discuss these issues. The chapter could explicitly note that it does address land-use and other human impacts, which provides useful and important context.

Key findings are generally stated at an appropriate technical level (see specific suggestions for plainer language and avoiding jargon) and are supported by evidence that is documented in a credible way (see specific suggestions for providing concrete examples). The chapter includes many abstract or general mentions of adaptation, and more specific examples would enhance the narrative. While the chapter broadly meets the requirements of Section 106 of the GCRA, it would also be more compelling if the introduction began with a stronger message reminding the reader that ecosystems are central to everything humans (and all life forms) do, make, breathe, and eat—reliance that is invisible or abstract to many people in their day-to-day lives.

Chapter 1 (Overview) in the draft NCA5 report emphasizes many issues in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) (e.g., climate change harms ecosystems and reduces ecosystem services; coral reefs and rainforests are particularly vulnerable to extinctions; without emissions reduction ecosystem change may be irreversible; adaptation options are limited but restoration could be targeted). However, Chapter 1 (Overview) could emphasize more that climate change interacts with other stressors that affect ecosystems (e.g., human activities including land-use, pollution, overharvesting, and novel pests and pathogens), as is emphasized in this chapter. Chapter 1 (Overview) uses the term "compound" in several

instances; there could be more consistency between this chapter and Chapter 1 (Overview) on the concept and terminology for multiple stressors, and compound events or effects.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction explains that humans depend on ecosystems and biodiversity (ecosystem services), and outlines, with examples, how climate change damages and changes ecosystems and how those impacts degrade ecosystem services. The introduction also outlines risks to ecosystems and lists adaptation strategies. However, the chapter needs a stronger lead conveying with urgency that ecosystems are central to the fundamentals of living. The introduction should emphasize how human actions are threatening the Earth system including the biosphere; the extinction event we are causing will be visible in the fossil record for as long as Earth persists. Context should be provided to explain how species make up ecosystems that provide air, water, food, materials, and energy. Through kinship and reciprocity, ecosystems also are the foundation of human spiritual and mental health. These "fundamentals" about ecosystems as life support, are given in the first few paragraphs but could be strengthened through rewording.

This framing could include an even more basic reminder of important first principles—key concepts such as "ecosystems," "biodiversity," and "adaptation strategies" (as they apply to ecosystems) should be briefly defined without jargon in the introduction. For example, the reader should be reminded that ecosystems consist of plants and animals, and plants not only provide food at the base of food webs, but they also fix carbon and release oxygen (making life on Earth possible for air-breathing animals). The introduction should mention that the biosphere is important to the global carbon, nitrogen, and other biogeochemical cycles and how the biosphere is already buffering against climate change through sinks and feedbacks. This basic description of what ecosystems are and do is implied in the chapter where, for example, carbon sequestration in ecosystems is mentioned in several places. It would, however, improve the impact of the chapter to briefly introduce the chapter's "main character" (ecosystems) in this way. Some text could be moved up to the introduction from later in the chapter (e.g., page 8-7, lines 16-18) so that the word count would not increase with these additions. In addition to the key concepts already mentioned, "ecosystem services" should be defined in the introduction before it appears elsewhere in the chapter (e.g., in Figure 8.1).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages encompass the key impacts of climate change on ecosystems and reflect current understanding that climate change interacts with other global change drivers in affecting ecosystems. The key message titles should be written as short, informative statements, rather than few-word headings.

Comments on Specific Key Message Language

Key Message 8.1. Ecosystem Transformation

Climate change, together with other stressors, is driving transformational changes in ecosystems (*very likely*, *high confidenc*e), which presents increasingly serious challenges for natural resource management (*very likely*, *high confidenc*e). Many types of extreme events are expected to increase in frequency and severity and potentially trigger abrupt ecosystem changes (*medium confidence*). Adaptive management to prepare for, respond to, and lessen potential impacts can be advanced by decision frameworks that identify key risks and by monitoring for early warning indicators (*medium confidence*).

Suggested title: "Ecosystems Are Being Degraded and Irreversibly Altered by Climate Change."

This key message appropriately emphasizes the interaction of climate change and other stressors, as well as current understanding of abrupt and irreversible change. The key message manages to avoid jargon (e.g., the key message uses the term "tipping point" but also defines what it means). While the key message is somewhat abstract, examples are given in the subsequent text. However, "transformation" is not consistent with terminology in the current literature: degradation and collapse (Keith et al., 2015, 2022).

Additionally, the key message could have been written in even plainer language. Here is an example of paraphrasing (we have not included the certainty language in this example for simplicity):

> Climate change along with other human-caused stressors like habitat loss and pollution, is completely transforming (degrading) some ecosystems (transformations that may not be reversible—ecosystem collapse) and increasing extreme weather events like hurricanes and marine heat waves are likely to trigger abrupt change. Examples of ecosystems on or over the brink of collapse are coral reefs and Arctic tundra. Ecosystems should therefore be monitored to look for signs of change and managed adaptively with an eye toward the future.

Key Message 8.2. Species Changes and Biodiversity Loss

The interaction of climate change with other stressors is causing biodiversity loss, changes in species distribution and phenology, and increasing impacts from invasives and diseases, all of which have economic and social consequences (*very likely*, *high confidence*). Future responses of species and populations will depend on the magnitude and timing of changes, coupled with differential sensitivity of organisms, with heightened extinction risks for some (*very likely*, *high confidence*). Identification of risks and prioritization of species and locations for protection will improve options for management (*very likely*, *medium confidence*).

Suggested title: "Climate Change Displaces Species and Reduces Biodiversity."

The key message identifies the links between ecosystems (made up of species and their environment) and things people care about (security, livelihoods, and treasured aspects of nature). The key message could be paraphrased with plainer language (we have not included the certainty language in this example):

> Climate change together with other stressors such as land-use and pollution are affecting populations of organisms, sometimes with compounding effects, leading to changes in phenology (e.g., seasonal timing of flowering), changing distributions and species loss, and increasing impacts of pests and diseases; these changes have economic and social impacts. It is important to identify risks and prioritize species and areas that are at the greatest risk for protection, management, and restoration (coral reefs, and insect pollinators are examples).

Comments on Text Supporting the Key Messages

Key Message 8.1. Ecosystem Transformation. In the text supporting this key message there are opportunities to add some specifics to the examples given. For example, the text could explain how extensive some of these "abrupt and irreversible changes" are in the tundra, coral reefs, and sagebrush rangelands shown in Figure 8.6, and explain the implications (e.g., loss of critical habitat for endangered species along with rangeland livestock production, magnitude of carbon that could be released from permafrost, numbers of unique species lost from US tropical forests as a proportion of all US species). There are many good examples given on invasive species risk (page 8-22), but the example of woody encroachment in grasslands is also a widespread large-scale ecosystem transformation in drylands that should be noted somewhere. Furthermore, it could be noted if in some cases, species invasions are driven directly by increased atmospheric CO_2 concentration, rather than the climate changes caused by GHG emissions.

Key Message 8.2. Species Change and Biodiversity Loss. In the text supporting this key message, abundant evidence for current trends and future risks is given, emphasizing crop pollination, disease threats to humans and wildlife, and invasive species. Examples are also given of adaptive management. More emphasis could be placed on diseases and pests affecting plants—bark beetles are mentioned, but little else—although this could also be placed in Chapter 7 (Forests) or some regional chapters where forests are important, and those chapters could be cross-referenced in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity).

It is worth emphasizing even more pointedly that the greatest human driver of terrestrial biodiversity loss is, and has been, habitat loss due to land-use. Climate change and other stressors layer on top of land-use changes with the compounding effects mentioned in the chapter. Species cannot easily "shift their locations" as the climate shifts if intervening places are modified and, therefore, inhospitable to movement, and this should be noted in the text.

Key Message 8.3. Ecosystem Services Risks and Opportunities. In the text supporting this key message, it would be useful to clarify, when nature-based solutions (NBSs) are discussed (page 8-27), that those "solutions" mainly consist of ecological restoration or habitat and species conservation (as is clear in Figure 8.19), which is why there are virtually always "biodiversity" co-benefits. This would better tie the new, but now widely used, concepts of NBSs (focusing on biodiversity) and natural climate solutions (NCSs, focused on climate impacts) to more traditional concepts in ecosystem management.

Moreover, this key message focuses on NBSs, but leaves agriculture out of NBSs for climate mitigation (Figure 8.19), whereas IPCC would include agroecosystems in NBSs for carbon sequestration. The concept NBSs comes from the biological conservation literature and is related more broadly to sustainability, while the NCS concept comes out of the climate community. In fact, Figure 8.19 is adapted from a paper that has "natural climate solutions" in

the title. It is acceptable if the authors want to delimit this chapter to natural ecosystems and not agroecosystems, but on the other hand, "cover cropping" is mentioned as a NBS in Figure 8.18. The chapter should in any case cite other chapters (e.g., Chapter 11 [Agriculture, Food Systems, and Rural Communities], Chapter 6 [Land Cover and Land-Use Change]) that discuss agroecosystem management for climate change (and more broadly global change) mitigation.

Comments on Traceable Accounts

The chapter authors describe the process of developing this chapter with its emphasis on new literature since NCA4. In addition to a diverse group of authors, there were ten technical contributors to this chapter. The traceable accounts section effectively describes the evidence base and uncertainties for each key message.

The traceable account for Key Message 8.1 should include the need for adaptive ecological management to consider power and social equity issues specifically to lead to equitable solutions (page 8-31, line 34).

In the traceable account for Key Message 8.2, the ability of climate refugia to reduce extinction risk should be mentioned as an uncertainty given that those areas, too, are at risk under some scenarios (page 8-33, line 2). The traceable accounts section for Key Message 8.2 also includes the potential for human assistance to species migration as an area for future research. In fact, there has been research published on the potential of assisted migration to protect biodiversity under climate change scenarios (e.g., Bonebrake et al., 2014; Etterson et al., 2020). Perhaps the statement on the research gap should be revised to narrowly focused on the unanswered research question.

Comments on Graphics

In general, attention is needed to the figures and tables in this chapter to effectively communicate their messages.

The map in Figure 8.2 is nice way to include all geographic domains included in the draft NCA5 report, but there should be lines around the different geographic parts to show that they are all different maps/scales. The symbols are a good way to communicate change in each region, but they are too small and there is also no key for the icons. The Committee appreciates the inclusion of the USAPI in the map. In the table part of this figure, it would be useful to include a reference for each example and the caption should describe how the examples for each region were selected. In the fourth column for the Midwest, it is not clear that the ecosystem service change is for "loss of lake ice." Similarly, for "pollen," the ecosystem service change should be stated explicitly.

In Figure 8.3, some entries in the table portion of this figure are confusing. For example, "plants" in row 2 should be "crops." Moreover, not all the ecosystem services in column 3 are clear—specifically, it is not clear how the phenomenon listed relates to an ecosystem (dis)service (e.g., "pollen," "loss of lake ice"). Furthermore, this figure shows global, rather than United States risks (the source is from the IPCC). The caption should explain that it is based on global data.

Figure 8.4 is a useful figure on climate change effects on watersheds, but it is referenced in the chapter to illustrate the idea of occasional extreme events amplifying the negative effects of gradual change, with no mention of watersheds. The figure title and caption should be

modified to make this link clear. The figure also needs to be modified with some horizontal arrows if it is meant to illustrate amplifying negative effects.

Figure 8.6 is a better illustration than Figure 8.4 of occasional extreme events amplifying negative effects of gradual change (i.e., hotter, longer growing seasons, invasive grasses) combined with extreme events (i.e., novel wildfire promoted by invasive grasses in an ecosystem that is not fire adapted) leading to large-scale ecosystem degradation or collapse and loss of ecosystem services. Perhaps Figure 8.4 is unnecessary.

Figure 8.8 is a nice way to show all geographic domains in the NCA5, and it would be helpful if a similar map format was used throughout the report. Lines for Canada and Mexico are attached to the lower-48 states, but not Alaska.

Figure 8.11 should add lines around Alaska and Hawai‘i to show they are different maps, scales, and locations.

Figure 8.13 is a nice summary of a lot of information, although the caption could state more directly what is shown in the figure: it is not just a (random) “varied” response across species, but that in this case managed, wide-ranging non-native species are expanding while native species with narrowed ranges are declining.

In Figure 8.18, instead of “cover cropping,” the phrase “cover cropping and other soil conservation measures” should be used to encompass practices beyond cover cropping.

It is useful to have an illustration in Figure 8.19 showing the climate mitigation potential of NBSs. It is unfortunate that the co-benefits appear as lines and therefore relatively “small” compared to the quantitative carbon estimates shown as bars on the right, but there may be no better way to convey this information.

Table 8.2 is somewhat unsatisfying because while it does give examples of ecosystem services and their indicators, more details in the column on trends would be informative (i.e., time frame and region[s] where a trend had been observed or projected).

Comments on Equity and Justice

The chapter addressed equity and justice issues in the context of unequal access to nature and ecosystem services and is a focus of Key Message 8.3. Pages 8-25 and 8-26 are explicit about communities of color having less access to ecosystem services, and that housing segregation has created inequitable distributions of ecosystem services, specifically, access to urban green spaces that meliorate air quality and heat. These specific and explicit examples of who is harmed, why, and what ecosystem services they lose are very useful.

In contrast, on page 8-27, lines 10-12, the reference to environmental justice “problems” is vague and could be improved by being more specific.

Examples could be added of traditional (Indigenous) ecosystem management and restoration practices that support both cultural and spiritual relationships with nature and an equitable climate transition, for example, by cross-referencing other chapters and citing additional literature (e.g., Chapter 7 [Forests], Chapter 16 [Tribes and Indigenous Peoples]; Long et al., 2020; Reyes-García et al., 2019).

Additionally, equity and justice concerns in natural resource management and conservation are increasingly recognized in mainstream natural resource management policy and practice. Concerns and issues should be identified, especially around equitable benefit sharing. This chapter should also mention the Reducing Emissions from Deforestation and Forest Degradation framework and protected areas for biodiversity conservation.

Comments on Literature Cited

The references are generally appropriate and represent the best recent literature on global change and ecosystems. The authors might consider citing Law et al. (2021) and/or Law et al. (2022) for Key Message 8.3.

Other Recommended Changes

It is noted (page 8-34, lines 29-30, under Key Message 8.3) that CO_2 fertilization affects ecosystem productivity and carbon cycling (and ecosystem services that result from those processes), but generally the chapter focuses on climate change effects on temperature, water balance, etc. The direct effects of increased CO_2 concentrations could be called out specifically and distinguished from increasing temperature effects given their important role as a driver of ocean acidification and resulting profound changes in marine ecosystems. This could be spelled out briefly in the introduction, perhaps with citation to other chapters that may talk more about CO_2 fertilization (e.g., Chapters 3 [Earth System Processes], 10 [Oceans and Marine Resources]).

In the section "Disease Risks" under Key Message 8.2 (page 8-20), in the context of increasing risk of human and wildlife disease, it may be relevant to mention the One Health framework, mentioned in other chapters (e.g., Chapter 23 [US Caribbean]). It may be more familiar to human health experts than ecosystem scientists which may be why it is not mentioned here. This is a question for the chapter authors to consider, not necessarily a recommendation.

In the "Implications for Management" subsection (page 8-23), given the importance of this section, it would be nice to have a table or map showing more examples (by region) of climate change adaptation actions on behalf of species beyond the two mentioned in the text. This is not essential but would be informative, and perhaps there would be room for it if Table 8.1 were condensed or reformatted to be smaller.

CHAPTER 9: COASTAL EFFECTS

Summary

Chapter 9 (Coastal Effects) is written at an appropriate technical level, provides a useful summary of coastal adaptation strategies, and effectively highlights issues of equity and justice—including the disproportionate impact of coastal change on under-resourced communities. However, the chapter fails to meet the third requirement of Section 106 of the GCRA, which states that the assessment should analyze and project major trends. Specifically, this chapter does not address regional sea-level trends and associated impacts across the United States, nor does it provide relevant attribution information and citations highlighting the relative roles of natural variability versus climate change in observed and projected trends. The lack of regional information is problematic because the target audiences of NCA5 is broadly defined as "decision makers," and it should be made clear that decision makers should not base decisions on continental US averages. There is also a lack of emphasis on low-likelihood, high-impact outcomes related to deep uncertainty and the evolving scientific understanding of instabilities and tipping points in ice-mass loss from West Antarctica, which should be considered by

decision makers with proper context. Finally, the chapter bases many of its conclusions (especially for Key Message 9.1) on the Interagency Task Force (ITF) SLR scenarios, which is not problematic in itself, but issues arise due to differences between the ITF framework used for sea-level and the IPCC framework used for all other climate indicators across the draft NCA5 report. As a result, the application of the draft NCA5 report likelihood language regarding is inconsistently applied, and more effort is needed to make the discussion of sea-level projections in this chapter consistent with the treatment of other climate indicators discussed elsewhere.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The chapter introduction offers reasonable context, but the first paragraph should end with a statement communicating that coastal trends and impacts are highly localized and that interpretation of observed and projected trends should include consideration of regional and local differences.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages reflect basic understanding of nationwide trends and impacts but lack relevant regional and local information, as well as nuanced discussion of the relative roles of natural variability and climate change in observations and projections. The key messages also lack sufficient support for likelihood statements in some cases. The discussion below expands on gaps that span multiple key messages, followed by comments specific to existing content in individual key messages. Additionally, the titles of the key messages should be rephrased to be short, informative statements, consistent with guidance in Chapter 2 of this report.

Regional Differences and Natural Variability

The lack of information regarding regional variations in coastal trends and impacts, and the lack of context in attribution of regional differences to natural variability and climate change is a critical gap in Chapter 9 (Coastal Effects) that should be communicated to decision makers (i.e., the target audiences as defined in Chapter 2 of this report). Presently, the chapter mentions regional differences in trends only once in a general statement on page 9-4, line 3, which is not sufficient, because acknowledging and utilizing regional and local information is essential for accurate science-based decision making and cost-effective adaptation measures. A key directive given to NCA5 authors is that the assessment should be relevant for decision makers, but, as this chapter is currently written, the lack of regional and local information (or even acknowledgment of its importance and where to find it) severely limits the utility of the chapter in the applied realm.

An example of this gap is the lack of any mention that the rate of SLR along the US west coast has been suppressed over the past 30 years by natural fluctuations in the Pacific climate, which is clearly demonstrated by Figure 2.5 in Chapter 2 (Climate Trends) yet not referenced at all by Chapter 9 (Coastal Effects). The spatial variability in sea-level trends is a critical context for practitioners in west coast coastal communities, who may wonder (or need to communicate)

why their coastlines have not experienced the sorts of regular impacts discussed as nationwide trends in Chapter 9 (Coastal Effects). It is equally essential to communicate that the suppression of SLR along the US west coast is associated with the natural climate variability that is expected to produce the opposite effect during future periods leading to enhanced rates of SLR and associated impacts relative to the global and US averages. There is a significant body of literature that discusses the suppression of SLR along the US west coast due to Pacific climate and its potential to produce enhanced trends during future decades (see any number of papers from Miller, Hamlington, Merrifield, Thompson, and others).

At a minimum, this chapter should point to the map of sea-level trends from satellite altimetry over the past 30 years in Chapter 2 (Climate Trends) and note the regional differences as context for the nationwide results presented here. In addition, the Committee strongly suggests that a map of future SLR across the United States and its territories be added to demonstrate how SLR is expected to vary spatially in the future. There is additional helpful discussion in the text of Chapter 2 (Climate Trends) that could be referenced as well (see page 2-13, lines 16-17). Chapter 3 (Earth System Processes) also includes relevant information on the relationship between sea-level and natural variability (see page 3-27) that could be leveraged to support discussion of the idea and its implications for decision making and adaptation without a significant impact on the word count. In general, this chapter provides few cross-references to other physical science chapters with relevant information that could be leveraged in the coastal context to provide nuance and utility at local to regional scales.

High-Consequence, Low-Likelihood Outcomes

Chapter 9 (Coastal Effects) lacks discussion of high-consequence, low-likelihood outcomes. The possibility of such outcomes is mentioned once on page 9-4, lines 17-18, where the authors state that more than 2 meters of SLR by 2100 is possible if emissions go undeterred. This statement needs to be explicitly connected to the ITF SLR scenarios that correspond to physically plausible, high-impact outcomes (Intermediate High and High) to provide context for the high-end scenarios and connect them to use cases in supporting text for Key Message 9.3 (e.g., critical infrastructure with long design lifetimes). As a corollary, it should also be mentioned that these high-end scenarios—while physically plausible—are either low probability (*very unlikely*) or of unknown likelihood. The fact that they are low or unknown probability does not make them unimportant, as our understanding of the processes that could lead to rapid ice loss (in the West Antarctic in particular) is still evolving. The authors should incorporate the growing literature surrounding rapid ice sheet collapse in the West Antarctic (there are many papers since NCA4 to draw upon) and inform the reader about these low-likelihood, high-impact possibilities, which directly addresses the risk-based approach adopted by the draft NCA5 report.

Overlap Between Key Message 9.1 and Key Message 9.2

There is substantial overlap between Key Message 9.1 and Key Message 9.2, and the ideas covered by each key message should be more carefully organized to make Key Message 9.1 and Key Message 9.2 distinct and independently useful. Otherwise, there is no need for two separate key messages. Key Message 9.1 focuses on coastal hazards and states that ongoing SLR "will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely*,

high confidence)." Key Message 9.2 focuses on people and ecosystems and states "the combination of reduced ecosystem services and damage to the built environment from exacerbated coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely*, *high confidence*)." These two statements are largely synonymous.

Examining the supporting text for Key Message 9.1, the focus is primarily on (1) the physical impact of SLR on coastal groundwater and the height, extent, and duration of flooding; and (2) the physical impact of rising sea levels coupled with extreme wave and storm events. Thus, the Committee suggests that Key Message 9.1 focus more narrowly on changes to the physical environment, with content related to human systems and ecosystems (i.e., page 9-4, lines 30-34; page 9-5, lines 10-12) moved to supporting content for Key Message 9.2. Such a reorganization would then allow the overlapping statement in Key Message 9.1 (page 9-3, lines 33-35) to be removed. The Committee also suggests that the word "hazards" be removed from Key Message 9.1, because it implies impacts to people and ecosystems, which is the focus of Key Message 9.2. A more appropriate title given the focus on SLR and the physical environment would be "Sea-Level Rise Is Altering the Coastal Zone," which is more independent from the title of Key Message 9.2.

Comments Specific to Individual Key Messages

> **Key Message 9.1. Coastal Hazards Are Increasing Rapidly**
> The severity and risks of coastal hazards across the Nation are increasing rapidly (*very likely*, *high confidence*), driven by accelerating sea-level rise and changing storm patterns, resulting in increased flooding, erosion, and rising groundwater tables. Over the next years, sea-level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years (*likely*, *high confidence*) and will cause significant disruption to coastal residents, including damage to livelihoods, economies, infrastructure (e.g., roads, utilities, wastewater facilities), and ecosystems (*likely*, *high confidence*). Accounting for mounting coastal and compound hazards could inform meaningful actions to address the cascading impacts of climate change.

The chapter authors should make clear what is meant by "rapidly" in the key message title or remove this subjective word. A similar statement is made in the title for Key Message 9.2 but without the word "rapidly." Does this mean coastal hazards are increasing more rapidly than impacts to people and ecosystems? If not, remove the word "rapidly." If so, justification should be added to the traceable accounts to define the difference between rapid change and slow change.

> **Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing**
> Climate change is already affecting the resilience of coastal ecosystems and communities (*very likely*, *high confidence*). Climate change and human modifications to coastal landscapes, such as seawalls, levees, and urban development, are limiting the capacity of coastal ecosystems to adapt naturally and are compounding the loss of coastal ecosystem services (*very likely*, *high confidence*). Without proactive strategies, the combination of reduced ecosystem services and damage to the built environment from exacerbated

coastal hazards will increasingly burden communities, industries, and cultures, degrading the quality of life in the coastal zone (*very likely*, *high confidence*).

Key Message 9.2 is well stated, but the overlap with Key Message 9.1 needs to be addressed as discussed above.

Key Message 9.3. Transformative Adaptation for Coastal Communities
Marginalized coastal communities are disproportionately vulnerable to the impacts of climate change and have limited resources for adaptation (*high confidence*). Maintaining cultural and economic connections within coastal communities will require transformative adaptation that addresses the interconnection between ecosystems, communities, and governance (*high confidence*). Transformative adaptation, including incremental adaptations, community co-development of adaptation strategies, nature-based solutions, and managed retreat, can equitably respond to coastal climate change impacts (*high confidence*).

Suggested title: "Transformative Adaptation Can Help Coastal Communities to Respond to Climate Change Impacts."

The key message title should be rewritten to be a short, informative statement, consistent with the recommendation in Chapter 2 of this report. Otherwise, Key Message 9.3 is well-stated, but authors may consider replacing the term "managed retreat" in the third sentence with "community-led relocation."

Comments on Text Supporting Key Messages

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. More detail is needed within the body of text supporting Key Message 9.1 regarding how likelihood statements are connected to amounts of SLR along the CONUS coast (page 9-4, lines 13-22). For example, how is the likelihood evaluated in the statement on page 9-4, lines 13-15? If this is based on the ITF SLR scenarios (Sweet et al., 2022), then it seems this statement assumes CONUS SLR will be greater than or equal to the ITF Intermediate Low Scenario. If so, this should be stated. It should also be stated in the traceable accounts how probability of SLR being greater than or equal to the ITF Intermediate Low Scenario is calculated. Why is this statement *very likely* rather than *likely* or *virtually certain*? Presumably, this is done by comparing to the ensemble-based projections from the IPCC, but this process needs to be outlined in the traceable accounts. Do the authors base this likelihood on specific SSPs? Or degrees of warming by 2100? More explanation and detail are needed. In general, it would be preferable to base likelihood statements regarding amounts of SLR on ensemble-based IPCC projections, which can be more readily discussed using the draft NCA5 report language for both likelihood and emissions scenarios. The discrete ITF scenarios provide useful decision-relevant timelines but are not well suited for making likelihood statements.

The handling of SLR projections is inconsistent across the draft NCA5 report (see Chapter 2 of this report). The regional chapters, for example, handle SLR projections differently, with some using ITF only (e.g., Chapter 22 [Southeast]), others using IPCC only (e.g., Chapter 23 [US Caribbean]), and still others attempting to relate the two but doing so incorrectly (e.g., Chapter 28 [Southwest], Chapter 30 [Hawai‘i and US-Affiliated Pacific Islands]). Chapter 9

(Coastal Effects) is the logical place for the connection between the IPCC and ITF SLR projections to be made clear. In this vein, the Committee suggests that the ITF scenarios be explicitly discussed in the context of the IPCC scenarios and that IPCC scenarios be added to Figure 9.1 to demonstrate (a) that the IPCC and ITF SLR projections are distinct, and (b) how the two sources of information compare to each other. Figure 12.4 in NCA4 provides an example for how to present this information on a single graph.

Describing the differences and connections between the ITF and IPCC projection frameworks is important because the framings for the IPCC projections and the ITF scenarios are designed for distinct purposes. One provides a range of possible SLR amounts; the other provides distinct decision-relevant timelines. In addition, it is intended that decision makers will use NCA5 to evaluate trends and risk across climate sectors and indicators. The draft NCA5 report prescribes language for likelihood and emissions (see Front Matter) to provide consistency, which is broken by the emphasis on a set of discrete scenarios that are not only not well suited for likelihood assessment but that also have names that overlap with draft NCA5 report confidence/likelihood language for emissions scenarios (Front Matter, Table 3). For example, if a decision maker wishes to evaluate how both precipitation and sea-level will change in their location under an Intermediate scenario, then for precipitation, they would be pointed to SSP2-4.5 (per Front Matter, Table 3). For SLR, however, the same decision maker would likely focus on the ITF Intermediate SLR Scenario due to the overlapping naming conventions, which according to the ITF report (Sweet et al., 2022) is roughly the 50th percentile of the Very High (SSP5-8.5) Emissions Scenario including Low Confidence Processes. Despite both being named "Intermediate," these represent two very different emissions pathways with very different outcomes and levels of likelihood if evaluated on a consistent basis. The unfortunate overlap in the names of SLR and emissions scenarios could lead to decision makers incorrectly weighting the risk of impacts due to SLR relative to other climate variables (such as precipitation in the example above).

The Committee recognizes that renaming the ITF SLR scenarios is not a viable solution given their wide adoption in practice, but the authors can use Chapter 9 (Coastal Effects) to clearly explain the relationships and differences between the ITF and IPCC emissions scenarios to prevent misunderstanding and misuse of the scenarios. The Committee also recognizes that there is a description of the ITF SLR Scenarios in Appendix 3 (Scenarios and Datasets), but not only is the description of the scenarios in the appendix inadequate, but it is also unlikely to be viewed by many readers. Given the apparent confusion that exists between authors across the draft NCA5 report in navigating the relationship between IPCC scenarios and ITF SLR scenarios, the Committee suggests that this information not be completely relegated to an appendix. As noted above, multiple regional chapters attempt to link ITF SLR scenarios to IPCC emissions scenarios but do so incorrectly. Thus, direct and accessible clarification is needed to assist decision makers in making accurate, well-founded assessments.

Finally, the low-likelihood, high-impact ITF SLR scenarios should be explicitly connected to the IPCC Very-High Emissions scenario (SSP5-8.5) with the low-confidence processes (e.g., marine ice-cliff instability) included. This allows the low-likelihood, high-impact scenarios to be mapped onto the NCA5 confidence/likelihood language for likelihood and allows readers to evaluate the SLR scenarios in conjunction with low-likelihood, high-impact outcomes for other climate indicators.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing. Supporting content for Key Message 9.2 is well written and includes a balanced approach that

includes broad themes and local examples. The Committee suggests the authors consider two additional items that were not covered in NCA4.

First, one of the greatest potential impacts of SLR on human systems in the United States is the disruption of the Sacramento-San Joaquin Delta. This delta sits about 50 miles inland, but the entire system is at or below sea-level and protected by 100-year-old levees that come within inches (literally) of overtopping during present-day (e.g., 2017) riverine flood events. With another foot or more of SLR, this critical delta will be flooded with seawater (some estimates are a 60% chance this century), and water supply conveyances from northern to southern California could be interrupted for as much as 18 months, devastating trillions of dollars of the economy and more than 20 million people. This is a local example, but it is one of high impact that has not been mentioned in previous reports and highlights acute risks from SLR interacting with aging critical infrastructures.

Second, the Committee suggests the chapter authors mention the interconnectedness of adaptation efforts that may deflect impacts from one community onto another. A recent study (Wang et al., 2018) used hydraulic modeling to investigate what happens when different counties around San Francisco Bay build or enhance seawalls and levees without coordinating with each other. If communities forge ahead independently with adaptation efforts, SLR impacts get shunted from one area to another (much like floods on the Mississippi get shunted to communities downstream when an upstream community builds up its levees without coordinating with the others downstream). This is an important idea to communicate to decision makers, and it intersects with environmental justice, because this mechanism could lead to communities with fewer resources being confronted with additional impacts diverted from communities with greater resources.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The Committee suggests that the assessment of mitigation and adaptation approaches provide discussion of sensitivity to low-likelihood, high-impact outcomes. The approaches necessarily change under extremes SLR scenarios, and this important consideration is not addressed in the chapter. Within this context, the authors may wish to consider the assessment of flexible adaptation approaches designed to account for the deep uncertainty that characterizes SLR projections, especially those associated with processes of unknown likelihood that correspond to the highest impact outcomes. For example, the authors might discuss Dynamic Adaptive Policy Pathways (see CCB DEEP in IPCC AR6 WG2), and if these ideas are not addressed here, they should be addressed in the adaptation chapter.

Comments on Traceable Accounts

Key Message 9.1. Coastal Hazards Are Increasing Rapidly. The description of confidence and likelihood for Key Message 9.1 does not match statements of confidence and likelihood in the key message itself. For example, the key message states that it is *likely* that "sea level rise along the majority of US coasts is expected to be as much or greater than the observed rise in sea-level over the last 100 years," but the traceable accounts states that it is *very likely* that "sea levels will rise about 10-12 inches between 2020 and 2050." These are not analogous statements, and the same can be said for other statements in the key message compared to what is stated in the traceable accounts. The traceable accounts section is meant to directly support the key messages, and that is not done here. Therefore, either the key message or the traceable

accounts should be rewritten such that the content in the traceable accounts directly supports the statements in Key Message 9.1.

Furthermore, there needs to be more detail in the confidence and likelihood section stating which SLR scenarios are used in estimating likelihoods and how these scenarios are used to establish likelihood. One example is lines 1-2 on Page 9-19, which states, "projections show that [SLR] is expected to continue to accelerate in coming decades." The authors should clarify under which emissions scenarios this is the case and should use the draft NCA5 report confidence/likelihood language instead of the word "expected," which is not precisely defined by the draft NCA5 report. Another example is where the traceable accounts section states that "It is *very likely* that sea levels will rise about 10-12 inches between 2020 and 2050 based on both trajectories assessed by extrapolating rates and accelerations estimated from historical tide gauge observations and model projections." This statement is problematic because the phrase *very likely* corresponds to a specific likelihood range of 90-100 percent (Front Matter, Table 2), but the provided range of 10-12 inches is extremely narrow for such a high likelihood. If one downloads the ITF SLR Scenarios for the United States coast,[4] the 2020-2050 increase for the 50th percentile of each scenario can be calculated to be as follows:

- Low: 7.8 inches
- Intermediate Low: 9.1 inches
- Intermediate: 10.5 inches
- Intermediate High: 13.1 inches
- High: 15.4 inches
- Observation-based extrapolation: 10.7 inches

Assuming the chapter authors seek to base their likelihood assessments on the ITF SLR scenarios, it is unclear how one arrives at a 90-100 percent likelihood range of 10-12 inches from this set of scenarios given that the only model-based scenario that falls within the 10-12 inches range is the Intermediate scenario. Even more problematic is that according to Table 2.4 in the ITF SLR Report, there is only a 10 percent chance that CONUS SLR exceeds the Intermediate scenario for high-emission scenarios resulting in 4ºC of global warming by 2100 and only a 23 percent chance for 5ºC of warming. Thus, the ITF Intermediate Scenario is not a good central estimate of SLR between 2020 and 2050, and 10-12 inches is not a good estimate of the *very likely* range. The median of the observation-based extrapolation is also within that range, but it has a *likely* (not *very likely*) range of 8.8-12.6 inches, which again suggests 10-12 inches is much too narrow. More work is needed in this chapter to ensure that *all* likelihood statements in Key Message 9.1 (not just the one described above) and its associated traceable accounts are precise and map directly onto NCA5 language regarding likelihood. In cases such as these, it would be preferable to simply use the IPCC SLR projections for which likelihood statements for specific emissions scenarios can readily be made. If the NCA5 authors wish to make likelihood statements based on the ITF scenarios, then more work is needed to develop how to map the discrete ITF SLR scenarios—which are developed based on predetermined amounts of SLR in 2100, not model ensembles—onto NCA5 confidence/likelihood language.

Key Message 9.2. Coastal Impacts on People and Ecosystems Are Increasing. The confidence statements in Key Message 9.2 are reasonable, but the likelihood statements provided

[4] See https://sealevel.nasa.gov/task-force-scenario-tool?type=regional&subview=USA.

in Key Message 9.2 require specific citations in traceable accounts. According to the Front Matter, the "*likelihood* of a finding is based on measures of certainty expressed probabilistically; in other words, based on statistical analysis of observed or projected results or on the authors' expert judgment based on their assessment across scientific information sources." Thus, in the absence of quantifiable probabilities (as is the case for statements made in Key Message 9.2), the likelihood should be based on assessment across sources. However, no sources are given in the traceable accounts to support the likelihood statements.

Key Message 9.3. Transformative Adaptation for Coastal Communities. The description of confidence and likelihood restates the statements in Key Message 9.3 and does not provide the *rationale* for the confidence statements as described in the Front Matter (page 0-10, lines 9-12). *High confidence* is attributed to all statements, but it is not stated how the confidence is derived. If the confidence is derived from the literature, sources should be provided.

Comments on Graphics and Boxes

The efficacy of graphics in this chapter is mixed. The graphics target the appropriate audiences in terms of complexity, and the general content of the figures is consistent with the content of the chapter, but the graphics fall short of communicating effectively in multiple cases.

Figure 9.1 shows projections to 2150, but there is only one mention of SLR beyond 2100 in the text, and the statement focuses on the continuation of SLR for millennia (not 2150 as depicted). The Committee suggests that the authors do one of two things. The first (and preferred) option is to add discussion of the 100-year time frame (i.e., 2125) currently depicted in the figure, which can be relevant for infrastructure investment. If this option is chosen, then the deceleration in the higher scenarios beginning at 2100 needs to be explained, as this could be confusing to some. The authors should explain whether these inflections in the rate at 2100 are due to a physical process (in which case the process should be named and described) or whether these inflections are due to the nature of the ensemble used to create the scenarios, which may or may not be homogeneous before and after 2100, as some models do not simulate the post-2100 period. The second option would be to add none of the discussion mentioned above, but in which case the post-2100 period should be excluded from the figure given the lack of discussion and context. Regardless, depicting the post-2100 period without any discussion is not recommended.

Parallel to the issue above, the caption states that "Acceleration of sea level rise in the observed record is expected to continue in all five scenarios (colored lines) through 2150." This does not appear to be the case based on the depicted curves. The rate decreases around 2050 in the Low scenario. The rate appears approximately constant after 2100 in the Intermediate Low and Intermediate scenarios. The rate decreases around 2100 in the Intermediate High and High scenarios.

As discussed above regarding Key Message 9.1, the Committee strongly suggests that the content of Figure 9.1 be expanded to show the *likely* or *very likely* ranges of the IPCC scenarios in addition to the ITF scenarios. A good example of how to do this is Figure 12.4 in NCA4, where the *very likely* ranges spanned by the various IPCC scenarios in 2100 are provided as bars to the right of the graph. This graphical comparison is needed in NCA5 since the IPCC projection framework is used for every other climate indicator. Thus, the target audiences of NCA5 (i.e., decision makers) should be able to clearly relate the ITF sea-level projections to the SSPs used across the rest of the report. This also provides an opportunity to provide needed context for the higher-end ITF scenarios that represent low-likelihood, high-impact outcomes

associated with low-confidence, physically plausible instabilities in marine ice cliffs. The use-case for these high-end scenarios is the design of expensive and critical infrastructure with long design lifetimes, which can be referenced within the supporting text for Key Message 9.3.

Finally, the authors should be specific about which observations are used for the extrapolations mentioned in the figure caption. There are multiple sources of sea-level data, and general audiences will not know to assume that the CONUS extrapolation is produced via a technique—unspecified in the chapter or traceable accounts—that averages local sea-level observations from an unequally distributed set of tide gauges.

Figure 9.2 mixes "flooding" and "inundation" terminology. These terms have specific meanings that should be defined in the text and should not be used interchangeably unless explicitly stated.

Figure 9.2 also demonstrates a theme of this chapter review, which is that statistics aggregated over the entire United States coastline are not only inadequate indicators of current and future impacts, but they may also be detrimental to the decision-making process by overstating impacts in communities that have not yet experienced frequent flooding events and minimizing impacts in communities currently experiencing frequent events. The observed frequency of minor, moderate, and major flooding varies widely across the United States, and the same goes for projected frequencies in 2050. A key goal of this report is to be relevant for decision makers, and not addressing the regional and local differences in high-tide flooding means that this chapter falls short of that goal. At a minimum, the Committee suggests that an indicator of the range of possible event frequencies across the United States be added to each bar in the figure. Perhaps a thin vertical line could be added to the center of each bar that extends between the minimum and maximum frequency (or some percentile range) across the United States. Further improvement could be made by including three bars (plus vertical lines as described above) for each year and category—one each for east coast, west coast, and islands (Pacific and Caribbean). This would still fall short of being relevant for local decision making, but it would at least give the target audiences some indication of the importance of regional and local variation in the frequency of these events and the need to include such variability in the decision-making process.

The Committee also suggests that the authors provide at least one qualifying sentence noting why coastal communities should be concerned about "minor" flooding. Those not familiar with the terminology may not be aware of the compounding effects over time of many repeated seemingly minor events.

Figures 9.3, 9.4, and 9.5 are potentially useful summaries of concepts in the text, but the lack of effective labeling and captions limits their utility and makes them cumbersome to digest. Readers may not be able to readily connect the limited descriptions in the caption (which in the case of Figure 9.5 does not list the specific adaptation strategies depicted) to the intended components in each graphic. The Committee suggests that these figures be improved by adding relevant labels to the graphics. See Figures 28.1 and 28.6 in Chapter 28 (Southwest) for similar graphics that also include effective labeling.

Comments on Equity and Justice

Chapter 9 (Coastal Effects) provides useful discussion and review of the human dimensions of coastal change, including equity and justice issues regarding disproportionate impacts on under-resourced communities. However, discussion of these issues is weighted

toward economic disparity with less focus on the intersectionality of economics with race and other factors. The chapter could be improved by seeking out and adding references that point out the correlation between race (or other factors) and economics in at-risk coastal communities. Alternatively, the authors could cross-reference other NCA5 chapters if these ideas are discussed elsewhere.

NCA5 will be a widely viewed and referenced document, and it represents an opportunity to inject new—and less controversial or offensive—terminology into climate-related discussions and planning. The Committee suggests the chapter authors refrain from describing communities or groups of people as "marginalized," because it perpetuates perceptions of inadequacy and lack of autonomy. The Committee suggests using terms that focus on the systemic reasons that a given community may be disproportionately impacted by climate change, such as "overburdened" or "under-resourced." Similarly, the phrase "managed retreat" may be offensive to the people affected due to the association of the word "retreat" with giving up, while the word "managed" implies that those affected are not in control of the process. A term such as "community-led relocation" may be preferable.[5]

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Chapter 9 (Coastal Effects) is not well integrated with the wider draft NCA5 report. There are few links to the physical-science basis chapters (Chapters 2 [Climate Trends] and 3 [Earth System Processes]), which also provide sea-level and coastal information that could be leveraged and discussed here. An overarching theme of this chapter review is the lack of regional and local information, which could be partially remedied by cross-referencing the regional chapters and focusing on providing the needed scientific and adaptation context for the regional chapters. A connection to discussions of economic impacts in the coastal zone elsewhere in the draft NCA5 report would also be welcome.

There are a couple of repeated wording issues that warrant a general statement. First, it is not clear if the terms "flooding" (typically meaning dry becoming temporarily wet) and "inundation" (typically meaning dry becoming permanently wet) are used intentionally or interchangeably. It would be preferable to define these terms to be as clear as possible and then use them consistently. Even if the chapter authors wish to use these terms interchangeably—which is not recommended—this should be explicitly stated because some in the coastal science and adaptation communities do attach specific meaning to these terms. Second, the word "already" is used often, which is (a) an ambiguous term and (b) implies that the described observation or impact is occurring prior to expectations without providing the concomitant expectations. It would be preferable to use words such as "currently" that do not link the observation or impact to unstated expectations.

[5] See https://eos.org/opinions/reframing-the-language-of-retreat.

CHAPTER 10: OCEANS AND MARINE RESOURCES

Summary

This chapter summarizes the ocean changes surrounding the United States and their impacts. In general, the chapter is well written in a consistent, transparent, and credible way and at an appropriate technical level for the intended audiences. It covers a wide range of topics from economic resources to marine ecosystems. However, less discussion is included on the physical and chemical aspects of ocean changes. It may be too late in the process to make a substantial change to the content, and the content is appropriate for this report; thus, the Committee suggests a chapter title change to "Ocean Resources and Ecosystems," which would more appropriately reflect the content of the chapter. This chapter is not about the ocean system as a whole (i.e., the connected physical, chemical, and biological system) as the title might suggest, but rather impacts on economic resources and marine ecosystems. The key findings presented are well stated and supported by the details provided. The chapter meets the requirements of Section 106 of the GCRA.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction of this chapter is generally well written but reads as an executive summary rather than an introduction. It will be helpful to provide motivation for why readers should care about issues discussed in the chapter—this includes putting the key messages into context, highlighting what is new information since NCA4, and what is not included in the chapter. The definition of ocean economy should be clearly given. For example, does ocean economy include the freshwater component (e.g., the Great Lakes)? It is also not stated what area of the ocean this chapter covers. Is it just the US exclusive economic zone? If so, this should be clarified in the introduction. The introduction should also state that changes across global oceans and their ecosystems affect the United States. References to Chapter 3 (Earth System Processes) and Chapter 17 (Climate Effects on US International Interests) would be useful.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Key Messages

The key messages are generally well written, consistent, and appropriate. They reflect current understanding about observed and projected impacts to the United States; the challenges, opportunities, and success stories for addressing risk; and identification of emerging issues related to climate change. Key Message 10.1 is an excellent example of a key message that says a lot but uses mostly plain language throughout. However, the first sentence of Key Message 10.1 is confusing because coral reefs also exist in the Arctic; the chapter authors should rephrase this sentence to not compare "warm" areas of the globe (i.e., coral reefs) to "cold" parts of the globe (i.e., Arctic). There are no likelihood statements provided in the key messages. Many of the key message statements seem to be supported by quantitative evidence, and therefore

likelihood statements should also be provided in all three key messages. If there is no quantitative evidence to support the statements, this should be stated in the traceable accounts.

The text supporting the key messages is generally well written and contains sufficient details that provide further evidence. Detailed comments are provided in Appendix A.

Comments on Traceable Accounts

The traceable accounts section is well done and appropriately builds a case describing the authors' process in determining the confidence statements without introducing new concepts or conclusions. The traceable accounts would be more compelling and consistent with the framework for traceable accounts recommended in Chapter 2 of this report if the section on confidence, likelihood, and gaps included more citations.

Comments on Graphics and Boxes

The graphics are well done and are useful summations of the information in the text. They are generally effective, appropriate, and easy to interpret for the intended audiences.

Figures 10.1 and 10.2 are nice figures, but the figure captions should include source(s) and more information about how they were produced. Figure 10.1 should use lines to show that the contiguous United States, Alaska, and Hawai‘i and US-Affiliated Pacific Islands are on different maps/scales. Most icons are too small to be very informative in both Figures 10.1 and 10.2.

Figure 10.5 is from the Center for American Progress. Chapter authors may consider choosing a different figure that is not from a left-leaning advocacy organization. Also, schematic figures like Figure 10.5 should have captions with some explanation of how and from where the findings in the figure were generated.

Comments on Equity and Justice

The committee suggests stronger framing of equity and justice-related issues in the introduction, as well as related dimensions of equity as relevant to oceans and marine resources. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

The importance of access to knowledge and information is well addressed, as is the discussion of governance. There is mention of equity in the introduction and in the "Adaptation and Mitigation" section, but the connections in subsequent sections are not sufficiently explained. In general, issues of equity and justice are not well-developed outside of the somewhat narrow focus on disproportionate impacts to coastal Indigenous communities. It is not clear whether this is due to a lack of literature on disparate impacts of ocean change across racial and/or socioeconomic boundaries. If that is the case, it could be added as an area of uncertainty and research gap in the traceable accounts.

In Key Message 10.1, "human well-being" should be defined. In Key Message 10.2, equity and justice framing could be incorporated into benefits and burdens of impacts and adaptation measures described—who is likely to benefit and who will be left out unless intentional measures are taken?

There are opportunities to discuss where conservation efforts are most concentrated and who is benefiting the most (e.g., SLR protection measures). The text (i.e., page 10-12, lines 21-

23) should explain which communities are being more harmed by flooding and pollution. For example, more context should be given on the impact of black carbon on communities, which communities are most affected, and the structures of decision making that enable and perpetuate such harms. There are also opportunities to discuss issues related to the "not in my back yard" sentiment often associated with renewable offshore energy.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted in the text or traceable accounts.

Comments on Data and Analyses

All the results adopted from other sources and presented in this chapter seem appropriate. There is a section discussing the needs of data and the importance of data accessibility, which is helpful.

Comments on Literature Cited

Overall, appropriate literature is cited, though the use of a broader knowledge base should be explored. The literature review appears robust and mostly focused on publications since NCA4.

Other Recommended Changes

In the section on commercial fisheries (page 10-10, lines 1-24), the text implicitly blames all changes in fishery productivity on climate change, when other issues (e.g., overfishing) could also be responsible or at least have compounding effects. The text should more clearly separate these issues. Not until the third paragraph of the section is it hinted at that many of the fisheries could be overfished currently. There are already many stressors on fishery productivity (especially overfishing), which are then exacerbated by climate change.

The discussion on the importance of the ocean observing system ("Data and Research" on page 10-16) is helpful. However, the authors could expand from the narrow biological focus and highlight that observing the entire ocean system (physical, chemical, and biological aspects) using both in situ and remote sensing techniques is critical. Research cruises to assess fish stocks, and satellite missions to detect marine heat waves or phytoplankton distributions, for example, are significant and critical national investments in our collective ability to quantify and predict the impacts of climate change, which in turn determines the evolving human and policy response. NCA5 should emphasize that the nationwide environmental observing system requires continued investment. It is an essential component of the ongoing ability of the United States to track and respond to climate change.

Lastly, the text should also specify which scenarios are being referenced if they are different from the scenarios introduced in the Front Matter. Appendix A includes detailed comments on this point.

CHAPTER 11: AGRICULTURE, FOOD SYSTEMS, AND RURAL COMMUNITIES

Summary

Agriculture is a crucial component of the US economy. Agriculture is unique in that it is both a source and a sink for GHGs. At the same time, agriculture provides nutrition for a diverse population. This chapter meets the requirements of Section 106 of the GCRA, with the exception of adequate projections 25 to 100 years into the future and is written at the appropriate technical level. Given the importance of agriculture, this chapter needs to better explain the positive and negative impacts of climate change on production as it cascades up through the supply chain. The chapter focuses on growing season length, but this is not a critical challenge for agriculture. The key aspect of climate change for agriculture production is extreme events and uncertainties that impact production. The other key aspects are mitigation and adaptation strategies for both crops and livestock. The US government and the private sector are making significant investments in climate-smart practices, but the chapter does not acknowledge these investments. The chapter also discusses climate change impacts beyond the farm gate. This is important and could benefit from further discussion on impacts, mitigation, and adaptation measures. The chapter recognizes the impact of climate change on rural communities and Indigenous populations, but some additional discussion could be added.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction could provide a better road map for the rest of the chapter. The introduction cites unpredictable weather as one challenge but refers to the regional chapters as examples. Unpredictable weather is probably the most severe challenge facing agriculture production. This chapter should provide an overview of the issues, and more specific examples can be provided in the regional chapters. Shifting plant hardiness zones and growing season lengths are not the only challenges. Changes in plant hardiness zones could be seen as positives or negatives. The change in the intensity and seasonality of precipitation and temperature are a cause for concern, which should be explained. The temperature effects on plant growth stages are more severe than the annual changes in temperature. For example, early bud break on fruit trees followed by a cold snap is more damaging than longer growing seasons. The chapter rightly highlights the effect of extreme events as becoming more intense and frequent, but this is not well documented. The introduction should also state the potential synergies between mitigation and adaptation to climate change. The chapter could be more explicit about mitigation and adaptation options. Agriculture is a complex system and meets societal needs for food, fuel, and fiber. It is also a source and a sink for GHG emissions. A systems approach is needed that includes best practices and technology (e.g., breeding, precision agriculture, precision conservation, new crops). In some cases, mitigation options improve productivity and resilience.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages in this chapter are done well, and the key message titles that communicate a message can be used as examples in other chapters. However, there are a number of key issues that do not receive sufficient attention, and suggestions are made below of areas to emphasize. Key Message 11.1 seems like two distinct key messages and should be considered in light of feedback below.

Comments on Key Message Language and Supporting Text

> **Key Message 11.1. Agricultural Adaptation in an Evolving Landscape**
> Climate change has increased agricultural production risks by disrupting growing zones and growing days, which are dependent on precipitation, air temperature, and soil moisture (*very likely*, *very high confidence*). Growing evidence for positive environmental and economic outcomes of conservation management has led to greater farmer and rancher adoption of agroecological practices (*very high confidence*) which increases the potential for agricultural producers to limit greenhouse gas emissions (*likely*, *medium confidence*) and improve agricultural resilience to climate change (*high confidence*).

Suggested title: "Agricultural Adaptation and Mitigation in an Evolving Landscape."

The first part of Key Message 11.1 does not agree with the literature. Growing zones and growing degree days can be seen as positive, except crops might require additional inputs (i.e., herbicides, pesticides, and nutrients) to accommodate the additional growing period. One problem is the increased weather variability and extremes in temperature and precipitation. For example, early heat stress in April can devastate wheat crops. The Committee suggests removing Figure 11.4 on plant hardiness zones. Migration of plant hardiness zones could be a benefit, especially in the higher latitudes.

The Committee is surprised that the chapter authors chose agroecology principles to provide resilience to climate change. Some define agroecology as not utilizing technology or any synthetic inputs. The chapter needs to clearly define terms and intent. The USDA has been using the terms "climate-smart practices" or "conservation practices." These terms are more commonly accepted within the agricultural community. US agriculture has promoted no-tillage agriculture with cover crops and crop diversity (rotations). Agroecology sometimes promotes polyculture and no chemicals. Agroecology is not the prevailing terminology in US agriculture.

This key message does not mention technologies to improve resilience and reduce inputs. Precision conservation should be discussed. For example, sensors could reduce inputs, especially nitrogen and water. Biotechnology options included deep rooted crops and changes in root architecture. The National Academies have reported on soil carbon sequestration technologies and ways to reduce emissions in agriculture (e.g., NASEM, 2019). Robotics and drones could reduce nutrients, water, pesticides, and energy inputs. The chapter would benefit from a table on technologies to reduce greenhouse emissions (i.e., N_2O and methane) and enhance soil carbon. The chapter could also relatively rank the scale of mitigation impacts. Reducing food waste and consumption also are mitigation options. The role of biofuels is not discussed especially since this is a major US policy. The evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive. This could be briefly explored in this chapter, in the general text or in traceable accounts discussion.

Water use in agriculture is an evolving issue and is complicated by climate change. For example, precipitation in the Ogallala aquifer region is expected to decrease and evapotranspiration increase. This scenario exacerbates the declining water availability in the Ogallala aquifer. Energy reduction could be realized with irrigation technologies. This issue is not confined to the Ogallala region but is also relevant to California, Florida, and other areas of US agriculture and should be mentioned.

The discussion of mitigation options for methane production in US agriculture could be expanded. The text does not give the reader a sense of the mitigation options. The text says there is much variability in production systems, but the reader is not provided with any solutions. The text should provide some citations for cell-cultured meat instead of just mentioning it. The data source presented in Figure 11.10 is for global production, not US production, which should be lower.

It is surprising that the chapter does not mention any USDA programs except for the Conservation Reserve Program and Environmental Quality Incentives Program. The current administration has spent more than $2 billion on climate-smart commodities, released last April 2021. The chapter should mention this investment in potential climate reductions for US agriculture. Both government programs and private sector investments are being made in US agriculture for climate-smart practices and ecosystem services, including carbon sequestration, which should be mentioned.

There has been an increase in wildfires in the Great Plains, which is mentioned in several regional chapters. There is no mention of wildfires and their effect on grazing land systems. As an example, a wildfire outbreak in Kansas in December 2021 burned more than 163,000 acres (66,000 ha) in portions of western and central Kansas, resulting in two deaths and more than 42 structures destroyed. The windstorm and wildfires caused more than $2.3 million in damages, and many cattle were lost from the fires.

Drought and heat also affect livestock. The chapter could mention the effect of extended drought and its impact on animal agriculture. In the past decade, several droughts have occurred, and cattle had to be moved from the Southern Great Plains to the Northern Great Plains. This affected production and transportation costs. There was a connection to the reduction in the cattle herd, and meat prices could be used as a case study or an example. This is an example where one part of the United States impacted by climate change affects the production of the entire United States. There was an instance in the spring of 2022 where several thousand head of cattle died because of an early heat wave.

Lastly, there are cases where climate change is positive. In the Northern Great Plains, warmer temperatures have allowed for planting higher-value grain crops such as corn.

Key Message 11.2. Climate Change Disrupts Our Food Systems in Uneven Ways

Climate change is projected to reduce the availability and affordability of nutritious food (*likely*, *medium confidence*). These risks to food security create social and economic challenges, some of which are distributed unevenly, including worsening heat stress among farmworkers (*high confidence*) and increasing food prices (*medium confidence*). Climate change has disrupted the ability of subsistence-based people to obtain food through hunting, fishing, and foraging (*high confidence*).

This key message is reasonable. However, with current technology and agricultural adaptation, the United States has not seen a change in availability and affordability of food. This is also mentioned in the traceable accounts. The question is how adaptable US agriculture is across the different states.

> **Key Message 11.3. Rural Communities Face Challenges and Opportunities**
> Rural communities steward much of the Nation's land and natural resources, which provide food, bioproducts, and ecosystem services (*high confidence*). These crucial roles are at risk as climate change compounds existing stressors such as poverty, unemployment, and depopulation (*medium confidence*). Opportunities exist for rural communities to increase their resilience to climate change and protect rural livelihoods (*high confidence*).

The discussion on rural community resilience is useful for this chapter. However, the space devoted to explaining the Baseline Resilience Indicators for Communities (BRIC) Index is not helpful and could be included in Chapter 20 (Social Systems and Justice) because many of the BRIC principles do not apply to this particular chapter. The Committee suggests reducing the explanation of BRIC, which would allow more space to be devoted to climate variability and the impact on agricultural production and food systems.

Comments on Traceable Accounts

In general, the traceable accounts for Key Messages 11.2 and 11.3 are well supported and described.

Production constraints induced by climate affect distribution across the United States. In the traceable accounts section, the authors describe the process by which they decided to minimize the discussion on production and focus on food systems. The authors could provide examples where climate disasters have shifted production from one area of the country to another if they want to discuss the supply chain.

In the traceable account for Key Message 11.1, the authors cite literature that supports the evidence for increased variability and vulnerability. They also provide citations for technological solutions. However, in the main text, technology such as digital agriculture, information technology, and other options is not discussed as an adaptation or a mitigation tool. New citations should not be introduced in the traceable account; instead, the literature in the main body should be used as supporting evidence. The citations provided for adopting practices are focused on conservation, not agroecological practices discussed in the text. There is a disconnect between the terminology that uses agroecology and the more commonly used language within conservation agriculture, climate-smart agriculture, or other terms in current US agriculture. The Committee does not believe the authors use agroecology incorrectly but suggests that the authors improve and focus its discussion by using the terminology and conceptual framework of climate smart agriculture. This terminology is more current and specifically focused on climate mitigation and adaptation, while agroecology is a general technical framework concerning broad environmental management of agricultural production systems incorporating ecological concepts.

Comments on Graphics and Boxes

Figure 11.3 is not the first figure of ecosystem services in the draft NCA5 report. Consider cross referencing with other chapters to use one model consistently throughout NCA5 or present the concept of ecosystem services in Chapter 1 (Overview) and reference back to it.

In Figure 11.4, the plant hardiness zone does not represent the impact of climate change. Graphs illustrating weather extremes would be more appropriate, such as a change in precipitation intensity and increased rangeland wildfires (e.g., figures from the National Oceanic and Atmospheric Administration [NOAA] showing the change in the intensity and aerial extent of droughts). This figure should either include Alaska, Hawai‘i, and the US Caribbean or explain why they are missing in the caption. In addition, please include in the caption which scenario is being used for this projection.

In general, the figure captions should be longer throughout this chapter to ensure that figures are self-contained. Also, schematic figures like Figure 11.5 should have captions with some indication of how/where the findings in the figure were generated.

Regarding Figure 11.6, agroecology is not the most commonly used terminology, as described above. Agroecology principles are more associated with small-holding farming and eliminating technological inputs. A similar illustration could be used for climate-smart agriculture or regenerative agriculture. In the current figure, the text on top of the photo is difficult to reach; consider adding shading behind the text so it stands out more.

Figure 11.7 is not available for the Committee to comment on, although it might be better to use a figure from a scientific publication rather than from the American Farm Bureau.

The caption of Figure 11.8 does not incorporate all the elements in the figure. Rather than only showing incorporating perennial production into the landscape, a full menu of climate-smart practices or regenerative agriculture would make a better illustration.

Figure 11.9 is relatively basic and does not capture the variety of livestock production. There should be a separation between types of livestock. For example, beef and dairy produce more methane than hogs or chickens. This figure lumps livestock as one single unit. This figure also does not illustrate the avenues for adaptation or mitigation.

The source for Figure 11.10 is global agriculture and not the United States. The US livestock emissions should be much lower than the global emissions. This graph could be very useful if it were put in the US context.

Figure 11.14 is important because it shows the GHG emissions along the food supply chain. This figure could be used to discuss mitigation options through the food supply chain in the text.

The discussion of considerable spatial variability in resilience to natural hazards in Figures 11.15 and 11.16 is essential to policy and planning decisions. However, it may be worth discussing the placement of these figures with the authors of Chapter 20 (Social Systems and Justice).

Comments on Equity and Justice

The committee suggests stronger framing of equity- and justice-related issues in the introduction, as well as related dimensions of equity (distribution of benefits and burdens, procedural, recognitional, intergenerational equity) as relevant to agriculture, food systems, and

rural communities throughout the chapter. Context on historical and systemic drivers of vulnerability or disparity should be offered where appropriate.

Specifically, this chapter should note connections to structural factors that drive inequitable nutritional outcomes. For instance, food deserts occur in both urban and rural areas causing the lack of availability of nutritious food. In addition, historical connections to current structures maintain inequitable agricultural support that determines who benefits and who bears the burdens, who participates, and recognizes sources of knowledge, and this should be acknowledged. The current administration has tried to compensate Black farmers with additional funding support, and this initiative should be mentioned. Climate smart agriculture could also be discussed in the context of equity, identifying benefits and burdens and their distribution, and power structures that may perpetuate inequities.

Specifically, page 11-12, line 17, should comment on the issues of data accessibility. Page 11-13, lines 26-28, should expand on concerns raised by Indigenous communities. Page 11-18, lines 6-20, should discuss children experiencing food insecurity and intergenerational impacts.

The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

The chapter does not include some technological tools for climate adaptation and mitigation. Additional references would add to the discussion in this chapter (Basso, 2021; Cheng et al., 2022; Field et al., 2020; Gaffney et al., 2019; Hatfield et al., 2018; Khanna et al., 2021; Lark et al., 2022; Liu and Basso, 2020; Martinez-Feria and Basso, 2020; Martinez-Feria et al., 2022; Northrup et al., 2021; Ortiz-Bobea et al., 2019; Schulte et al., 2022; Yang et al., 2022).

Other Recommended Changes

There is no discussion of biofuels in this chapter. Many states and federal programs support biofuels, including biodiesel and ethanol production. Furthermore, the evidence basis for the magnitude of mitigation provided by biofuels may be inconclusive, and this could be briefly explored in this chapter, in the general text or in traceable accounts discussion. In addition to ethanol production from corn, the byproduct is distillers' grain, which can then be used for livestock feed. This is a major contribution of agriculture to substituting fossil fuels for renewable energy and should be mentioned.

Another consideration is the dual purpose of agriculture production with wind or solar production. Much of the central United States has wind production on agricultural landscapes. There was one statement on agrivoltaics, but no citations were provided.

Finally, there is no discussion on reducing food waste and loss. If the chapter will focus on the food system as noted in the traceable accounts, then reducing food waste should be discussed because it would reduce GHG emissions and production inputs.

CHAPTER 12: BUILT ENVIRONMENT, URBAN SYSTEMS, AND CITIES

Summary

Chapter 12 (Built Environment, Urban Systems, and Cities) adequately addresses the requirements of Section 106 of the GCRA, with the exception of providing projections 100 years into the future. The introduction is clear and compelling, but overall, the chapter is very technical, and, in many instances, specific themes should be rephrased for accessibility so that all sections are digestible and of interest to the broadest possible audiences.

The key messages and supporting text are well written, and sufficiently supported by the subsequent text, but the Committee suggests that text of the key messages be reordered and, in some instances, rephrased in a succinct way for readability. It is likely that language lacking in other chapters is consistently used in this chapter. The findings in this chapter are mostly clear, concise, consistent, and supported by credible, timely research. A broad number of resources are used and referenced, with some exceptions, including Table 12.1 where the Committee encourages additional citations be included.

Overall, this chapter is balanced, informative, and well referenced. However, and most critically, there should be a clearer definition of the built environment explicitly stated in the introduction that aligns with the focus of the chapter. As written, this chapter focuses on urban areas and cities, and cities and built environment are used interchangeably throughout this chapter. The chapter authors should consider either focusing on urban/cities more explicitly or having a more balanced approach to describing built environments that are not urban/cities. There is also an opportunity in this chapter to highlight built environments like the wildland-urban interface, which could reference Chapter 7 (Forests), or emphasize additional built environment systems like, stormwater. These additions may help frame topics that are or are not being covered within the chapter. Either way, the Committee suggests expanding the discussion on non-urban areas as well as referencing the intersectionality between rural and urban areas. The Committee also suggests, where appropriate, cross-referencing other chapters to both highlight the interconnected nature of topics across the report, as well as to help the chapter expand on themes without increasing the word count significantly.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is an opportunity to focus on readability for broad audiences. As currently written, the introduction is not as compelling as it could be, nor does it provide the relevant context or background to support the key messages. Using language like “recent science highlights” is passive and lacks urgency. The chapter authors should consider revising the introduction to clearly define the built environment so that it aligns with the focus of the chapter and introduce the key messages that are the focus of subsequent sections. Specifically, Key Message 12.2 says, “Climate impacts create negative and cascading effects on the built environment, with many systems either projected or observed to be at risk of failing.” The Committee suggests using this key message as an example for clear and accessible language that should be used throughout the chapter. Additionally, the second paragraph of the introduction

presents one of many opportunities to link to other chapters including Chapters 5 (Energy Supply, Delivery, and Demand), 6 (Land Cover and Land-Use Change), 7 (Forests) 18 (Sector Interactions, Multiple Stressors, and Complex Systems), 31 (Adaptation), and 32 (Mitigation). Furthermore, the wildland-urban interface is an important facet of urban changes with climate related aspects such as increase wildfire, so the Committee suggests better integration with Chapters 7 (Forests) and 8 (Ecosystems, Ecosystem Services, and Biodiversity).

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, key message titles are written as general labels. Aligned with the recommendation in Chapter 2 in this report, the Committee suggests chapter authors consider providing titles that are more declarative, written as short, informative statements. Rewriting titles as such will make the key messages more effective and impactful. Some of the key messages could also use additional clarification as to their relationship to the definition of built environment, urban systems, and cities, as these topics are not as interchangeable as this chapter suggests. The assessments of confidence and likelihood are communicated effectively and correspond with a strong traceable accounts section. The text supporting the key messages is communicated effectively, except for some line edit suggestions in Appendix A.

Comments on Specific Key Message Language

> **Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change**
> Consumption of food, energy, and materials in urban areas is a driver of global climate change (*likely*, *high confidence*). Changes in land use, development, and human settlement patterns have driven and will continue to drive local and regional climate change in and near urban areas (*virtually certain*, *high confidence*).
>
> *Suggested title:* "Urban Areas Are Drivers of and Centers for Climate Change Impacts."
>
> **Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment**
> Climate change is already amplifying existing loads on the built environment and is burdening urban communities, and these impacts will intensify over the next decades (*virtually certain*, *high confidence*). Cities concentrate risks given current levels of infrastructure deficits, unequal exposure of people and assets, and high levels of socioeconomic inequalities (*virtually certain*, *high confidence*).
>
> *Suggested title:* "Attributes of the Built Environment Create Climate Impacts, Risks, and Vulnerabilities."
>
> **Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities**
> Cities across the United States are mitigating greenhouse gas emissions and adapting to adverse climate impacts (*likely*, *high confidence*). Although some states and cities are integrating climate considerations into relevant codes, standards, and policies, the pace, scale, and scope of action are not yet sufficient given the magnitude of observed and projected climate changes (*virtually certain*, *high confidence*).

Suggested title: "Urban Environments Create Opportunities for Climate Mitigation and Adaptation Measures."

Key Message 12.4. Fairness in Urban Climate Governance
Urban plans show varying progress in considering who benefits or bears the burden of climate investment and efforts (*very likely*, *high confidence*). The emergence of local and community-led approaches—coupled with increasing collaboration among city, tribal, state, and federal governments—delineates a shift toward inclusive planning and implementation (*likely*, *high confidence*).

Suggested title: "Equitable Climate Investments and Planning by Communities Are Important."

Comments on Text Supporting the Key Messages

Key Message 12.1. Urban Areas as Drivers and Centers of Climate Change. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples that would be more compelling. Specifically, resource consumption and land use impacts will drive local and regional climate change. The Committee suggests including specific information on the impacts of pavements or traditional roofs versus interventions like cool streets, cool roofs, or green stormwater infrastructure, or including urban areas examples. This key message is very important, and the lack of examples is a missed opportunity.

Key Message 12.2. Key Climate Impacts, Risks, and Vulnerabilities in the Built Environment. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. Cities concentrate risks that are amplified by infrastructure deficits, unequal exposure, and inequality. The Committee appreciates the discussion of the perilous state of US infrastructure, which will require unprecedented investment. The Committee suggests elaborating on the opportunity for infrastructure investment and climate change response as mitigation and adaptation responses.

Key Message 12.3. Urban Climate Mitigation and Adaptation Opportunities. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling.

Key Message 12.4. Fairness in Urban Climate Governance. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, though the Committee suggests also including more specific examples as they would be more compelling. However, the Committee suggests revising the first full paragraph on page 12-19, lines 3-12. While overall this section is well done, there are some outstanding questions that are not addressed in relation to "Fairness in Urban Climate Governance." For example, who pays and who benefits? Additionally, this section could use graphics and perhaps a memorable concrete example.

Comments on Traceable Accounts

The traceable accounts are clear and provide sufficient context for the embedded text that reflects the current understanding of the state of the science. Specifically, the traceable accounts adequately explain the basis for confidence/likelihood assignments. However, at the beginning of the traceable accounts, the authors identify eight topical areas for the literature search. These areas may have been prescribed, but if they were not, the Committee suggests not listing urban social equity and justice as last, so as not to have it appear as an afterthought.

Comments on Graphics and Boxes

Some of the images and graphics for this section were not available to the Committee to review. Many of the maps and graphics provided are sufficient, and the Committee commends the authors for these self-contained figures that have good captions that describe both the data sources used as well as what is missing. However, many of the graphics chosen for this chapter do not add to the narrative. The Committee suggests focusing on updating Table 12.1 as detailed below and to consider removing or replacing Figures 12.6 and 12.7.

Figure 12.1 documents emissions across the United States and how this largely reflects patterns of human habitation, but the data included are from 2015. If available, the Committee suggests using updated data to create this figure. Additionally, authors should consider adding boxes around the parts of the map that show that it is at different scales/locations, and boxes that "zoom in" on a particular region(s) of interest. Also, the caption should cite more precisely the data sources, and clear labels would also be helpful.

Figure 12.2 is a useful idea, but at a nationwide scale, lacks the details to be useful. The Committee suggests focusing on an area that is predicted to have rapid change.

Figure 12.3 categorizes many land-uses into five typologies. However, the graphics could be improved, and it may be helpful to reevaluate which cities are highlighted in the heavy industry section. Additionally, the Committee suggests explaining what different impacts these building types might have on urban climate and temperatures in the caption.

Figure 12.5 has not yet cleared copyright, but it should reflect the day and night heat differences and why these are important. Additionally, the figure caption should clarify the links between the urban heat island effect (which itself is not directly caused by climate change per se) and climate change.

Figure 12.6 highlights the important correlation between local heat increases and median household income declines. However, the complexity of the graphic might be lost on broad audiences. The Committee suggests simplifying the caption to make the figure more accessible. Also, if there is no particular order for the maps, the Committee suggests alphabetical order.

Figure 12.7 is ineffective and is unlikely to inform the public or policy makers. The Committee suggests removing this figure or replacing it with a specific example. If kept, the figure should include additional examples to make it more relevant.

Figure 12.8 captures Table 12.2 well; however, it is difficult to read. The Committee suggests enlarging the graphic and moving the legend on the bottom of the figure so that the icons can also be enlarged.

Table 12.1 provides examples of climate risks to the built environment and projected losses to 2090. This is very ambitious in scope for economic losses in 2090. The Committee is unsure whether the precise numbers for 68 years from now are useful or realistic because dollar

value numbers associated with such projections are hard to interpret without a measure of the assumed size of the economy in 68 years. Also, the table would be enhanced by citing multiple sources for the data included or providing an explanation for the heavy reliance on one source. It is also unclear if staggering estimated cost of more than $150 trillion from one year of SRL is a US cost or a global one and should be clarified. As these findings are so alarming, they should be referenced more effectively and consistently with multiple sources. In addition to the RCP names, chapter authors should consider using the scenario labels as described in the Front Matter to make the table more accessible. Finally, the Committee suggests either focusing on this table and ensuring that the information is complete and more robust by including additional sectors (e.g., sewers, schools, medical facilities, telecommunications) with additional information and sources, or re-envisioning the table in another way.

Table 12.2 highlights perhaps the most important information in the chapter and should be carefully crafted to be a self-contained and accessible table to broad audiences, and chapter authors should consider moving it to the introduction. Additionally, NCA5 authors may consider expanding each category to include more detail. For example, disaster and management should require changes in building permits, construction, flood insurance; the authors should ensure that both public and private insurance for flood or for violent weather have costs and premiums that reflect reasonably anticipated damage. One significant omission from this table is walking, yet it is the primary exercise of Americans, more than biking and running. NCA5 authors should also consider adding ferries/boats (including electric) in urban transport. Additionally, terminology should be used more carefully. Managed retreat language should be rephrased to be inclusive and consistent with other chapters, and the phrase “tree canopy” should replace “street trees.” Finally, the Committee suggests referencing minimizing parking under building options.

Table 12.3 has good examples but is too general. The Committee suggests using specifics which could potentially be done by linking to appropriate examples already in the regional chapters.

Box 12.1 does not have a clear focus and therefore as written is not effective. The Committee suggests clarifying if this box is focused on cities/urban environments or any local government, suburban, or rural areas. Additionally, the title should be updated to reflect the intent. Often boxes are best for examples and are more impactful that way. However, there is no discussion about public-private partnerships as an investment strategy.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated throughout the chapter, though more specific examples could be used to better illustrate the disproportionate impacts of climate change on historically overburdened populations. For example, the chapter could reference that Houston’s urban heat island mapping showed a 17-degree difference between two neighborhoods at the same time and on the same day. Historically disadvantaged communities language may be updated to be consistent with the recommended equity and justice glossary and/or other chapters for greater consistency. Additionally, a missing area that ties together climate change, extreme precipitation, storm water, urban areas, and equity and justice principles, is the increasing inability of urban areas, particularly in communities least able to respond, to adequately manage storm water from intense storms. This could and should be a strong integrating theme of this chapter, but it is understated. This is critical due to recent trends which are likely to be sustained.

Additionally, the Committee suggests using "resident" rather than "citizen" when describing community members, for greater inclusivity. Managed retreat language should also be sensitive to communities being displaced. There is an opportunity to broaden this language, consistent with other chapters. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

As detailed above, there is an opportunity to use more recent data, ideally available since NCA4, to ensure the most current information is being presented. If recent data are not available, this should be noted as a research gap. Additionally, data analysis is not always presented clearly with sufficient supporting information, which makes it challenging to confirm its credibility and if it is applied appropriately.

Comments on Literature Cited

This chapter accurately reflects the knowledge base and incorporates ample recent literature appropriate for NCA5. However, authors should include citation when discussing uncertainties in the traceable accounts.

CHAPTER 13: TRANSPORTATION

Summary

The chapter provides a thorough discussion of the US transportation network; however, it does not yet meet the requirements of Section 106 of the GCRA due to its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. Overall, the chapter is written at an appropriate technical level for the intended audiences, and the key messages are well stated and supported by details in the chapter. The traceable accounts could be improved to better support the key messages by providing likelihood statements, where appropriate; including citations; and including major knowledge gaps. The chapter should also add cross-references to other relevant chapters (e.g., Chapters 6 [Land Cover and Land-Use Change], 12 [Build Environment, Urban Systems, and Cities], 14 [Air Quality]).

Additionally, the chapter does not address mobility, so there is an imbalance in which types of transport modes are covered. Since this chapter is short overall, there is an opportunity to add more text. The chapter introduction could be expanded to include a discussion on mobility, movement of people, and transport futures for people. The chapter should also add text in Key Message 13.2 on alternative transport modes, particularly public transportation, shared mobility, and micromobility. Additionally, a central challenge for transportation and climate change is the automobile-dominated transport system. This chapter should address how the United States is transitioning from an auto-dependent system to alternative, low-carbon transport modes.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

This is a very well written introduction with a good use of plain language. The inclusion of what previous assessments discussed is a strength. However, the introduction should explicitly discuss mobility, how people move, and who is impacted by transportation vulnerabilities. The introduction is also a chance to make more connections to urban and rural transportation. The introduction notes that previous assessments highlighted risks arising from not considering climate change when investing in transportation but could more clearly discuss how the state of knowledge has advanced since NCA4.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

The key message titles should be short, informative statements rather than descriptions. For example, Key Message 13.2 could be titled "Climate Change Is Requiring the Transportation Sector to Change" instead of "A Changing Transportation Sector." Additionally, the key messages are all missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

> **Key Message 13.1. Limiting Emissions and Managing Risk**
> The transportation sector remains the largest source of greenhouse gas emissions, although transportation emissions sources are changing (*very high confidence*). The industry also faces increasing risk from climate-related extreme weather (*very high confidence*). Strategies incorporating climate data into transportation planning, design, operations, and maintenance can reduce such risks to the sector (*very high confidence*).

The last sentence of Key Message 13.1 is confusing wording. The Committee suggests removing the word "strategies" for clarity.

Comments on Text Supporting the Key Messages

Key Message 13.1. Limiting Emissions and Managing Risk. This section discusses transportation as the largest source of greenhouse gas emissions and notes that climate change poses a significant risk to transportation infrastructure. While the section mentions the marine sector, chapter authors should include interstate water systems, particularly the Mississippi system. These systems have a different set of issues and particular sensitivities. In Table 13.1, the inclusion of pipelines as a transport mode is a great addition.

Key Message 13.2. A Changing Transportation Sector. This section explores changes in terms of technology in transportation and workforce development needs, with a particular focus on an aging workforce. The Committee appreciates the discussion of workforce development. However, on page 13-12, there should also be a discussion of the supply chain constraints in auto manufacturing as well as inflation, and the resulting impact on prices for consumers. Additionally, while the section identifies persistent underrepresentation of women

and people of color as a workforce challenge, it is important to add a citation as well as statistics to support these statements.

Key Message 13.3. Co-benefits of Mitigation and Adaptation. The section discusses reductions in air pollution and health benefits, while touching upon exposure disparities. However, this section omits an important discussion on tire and road wear as well as the impact on the electric grid from electrification. Furthermore, similar Chapter 12 (Built Environment, Urban Systems, and Cities), there is an urban focus that lacks rural analysis, such as challenges with expanding the grid to electrify rural areas. One suggestion is to differentiate the co-benefits of fuel switching from coal to natural gas to those involved in a switch to renewable energy and other non-emitting sources.

Key Message 13.4. Transportation Trade-Offs. The section discusses the potential for solutions to differentially impact different groups. One important trade-off to also discuss is the decreased need for maintenance of electric vehicles, including the need for reeducating the workforce and the potential for displacement of workers who tend to have lower socioeconomic status.

Comments on Traceable Accounts

The traceable accounts do not support key messages or supporting text in this chapter as there are currently no citations. The section is missing a discussion of what literature was used to draw conclusions in the key messages and does not identify gaps in the literature. Revisions are needed in order to support the credibility of the key messages. Authors should refer to the recommended framework on traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

The traceable account for Key Message 13.1 mentions precipitation guidelines for hydraulic design. However, that topic is not well represented in this chapter, including examples of loss and damage as well as instances of new design practices and results. The traceable account should not introduce new literature that is not already in the chapter; instead, it should explain support for the key messages. The effects of CO_2 on cognition is a major research gap that should be mentioned. For the traceable account for Key Message 13.2, CO_2 emission implications of design and construction choices, sourcing of low-emission materials, and verification of their emission profiles and attendant costs should also be added as major gaps in knowledge. The traceable account for Key Message 13.4 should mention the implications of different battery chemistries, such as iron versus lithium, in the gaps section.

Comments on Graphics and Boxes

Overall, the figures are well done, and some minor changes would make them even more effective.

For Figure 13.1, black text for the figure labels would make it easier to read.

In general, icons and graphics should only be used when they help communicate the ideas. In Figure 13.4, the trucks and planes make the overall figure more complicated where a simple bar chart might be better. Instead, icons next to words/bars could be added to enhance understanding by reinforcing the words with a visual.

Figure 13.5 is not effective and could be deleted if more room were needed.

References are needed in the caption of Figure 13.6. Schematic figures like Figure 13.6 should have captions with some indication of how/where the findings in the figure were generated. "George Washington University and Jacobs" tells the reader very little about where the data in this figure came from.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout chapter. The Committee appreciates that there is some discussion of self-determination. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters where possible.

Comments on Data and Analyses

The caption for Table 13.1 indicates that some areas have a scarcity of research. However, the current literature and traceable accounts suggest that the literature review was not comprehensive enough to conclude that there is a scarcity. There has been extensive research since NCA4. There are so many potential citations, they would overwhelm the audiences. Yet, much of the literature cited is pre- (e.g., 2008) or around NCA4. Including more recent data would make the table more effective. Also, this table attempts to list three types of information: vulnerabilities, impacts, and adaptations. This is likely to be missed or misunderstood by broad audiences. Consider using icons or some other device to clearly distinguish these. The warning in the last sentence of the caption should add adaptations. Lastly, the marine transport section misses non-marine water transport, such as rivers and the Great Lakes. Examples are there, but the "marine" label is not inclusive. An alternative label is "waterborne."

Comments on Literature Cited

The chapter is well sourced. However, the sentence that cites the White House fact sheet 13-4, Roadmaps to Net Zero by 2050, should include specific examples with additional citations.

Other Recommended Changes

The chapter does not address the connection between land-use decisions and transportation. For example, Key Message 13.1 does not explain that transportation is the largest source of GHG emissions because of auto-centric planning; and Key Message 13.2 does not mention how land-use and housing considerations are being integrated into transportation decisions to reduce GHG emissions (i.e., transit-oriented development). This discussion could be added briefly by cross-referencing relevant chapters.

This chapter is also an important opportunity to note the emerging evidence that CO_2 affects human cognition at levels observed in vehicles, including cars and airplanes. This has been missed in previous NCAs and even in IPCC AR6. Associated with this is transportation's large contribution of CO_2, and higher concentrations in cities along arterials where minorities are disproportionately represented (Allen et al., 2018; Du et al., 2020; Karnauskas et al., 2020; Wang et al., 2021). A good place to mention this is in Key Message 13.3.

This chapter is notable in sharing focus reasonably equally between adaptation and mitigation. One thing to note, however, is that it does tend to mix marine with waterborne transport even while focusing on river transport and ports.

CHAPTER 14: AIR QUALITY

Summary

Overall, the chapter is a high-quality assessment of the knowledge base and covers several important topics. The key messages are well stated and adequately supported by the details in the chapter; however, confidence and likelihood levels are inconsistently used throughout the chapter and not sufficiently clarified or supported in the traceable accounts. The chapter is written at an appropriate technical level for the intended audiences, and the Committee particularly appreciates that the introduction clearly defines and provides context for concepts such as $PM_{2.5}$. However, there is an imbalance in the amount of attention for each topic. For example, it is not clear why certain topics received an independent key message (e.g., aeroallergens) and others did not (e.g., dust). While the chapter discusses how addressing climate change could improve air quality, more attention should be given to the petrochemical industry and the clean energy transition, which are very important to environmental justice. Furthermore, there are many broad statements throughout the chapter, and not enough emphasis on specific examples. For example, in either Key Message 14.2 or Key Message 14.3, there is an opportunity to discuss air filters and inequitable access to such health-protective measures. Additionally, while it is important to highlight negative impacts, the chapter could also expand on the positive examples of emission reduction efforts.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

Overall, the introduction does a good job highlighting the importance of air quality for human and ecosystem health. While the introduction appropriately introduces terminology that helps provide context for the rest of the chapter, the Committee suggests the chapter authors include a statement about anthropogenic sources of ozone and $PM_{2.5}$ to better illustrate anthropogenic contributions to air pollution.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language

Overall, the authors have developed well-articulated key messages around relevant themes. However, consistent with the recommendation in Chapter 2 of this report, the Committee suggests that key message titles be short, informative statements rather than topics, making them more effective and impactful, in particular for Key Messages 14.1 and 14.3. Key messages

consistently support statements with confidence levels, but many are missing likelihood statements; these should be added if there is quantitative evidence to support these messages.

Comments on Text Supporting the Key Messages

Key Message 14.1. Changes in Ozone and $PM_{2.5}$. The key message is clear, concise, and sufficiently supported by the text. The title of this key message could be modified to include the direction of change so that the title itself is more descriptive. The Committee suggests, however, that authors address how air quality consideration can significantly impact water resources, for example, that soot (black carbon particles) deposition onto snow or ice could drive more rapid snow/glacier melt. The chapter can do this succinctly and then cross-reference relevant chapters such as Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity), Chapter 9 (Coastal Effects), and Chapter 10 (Oceans and Marine Resources) to highlight the broad range of cascading impacts that soot can have.

Key Message 14.2. Protecting People from Wildfire Smoke. This section discusses the possibility of the risks of wildfires increasing in the future, partly due to climate change. The topic is very important; however, the chapter omits a discussion on emergency response measures, warnings, and related issues. There are several examples where a significant number of deaths were related to paucity of escape routes and lollipop development plans. For example, Paradise, California had only one route for escape, and the Oakland Hills fire in 1991 had limited escape routes.[6] Additionally, the Committee suggests clearly articulating that wildfires occur naturally, but that climate change may increase the risk of fires in some ecosystems and cause associated poor air quality.

Key Message 14.3. Air Quality Environmental Justice. This section discusses inequitable exposures to poor air quality by race and socioeconomic status by source. The title of this key message could be revised to be a short, descriptive statement to strengthen the key message. Overall, the Committee commends the chapter authors on this well written section, and highlights that the specific case example of Houston, Texas, is particularly insightful. However, this section is framed with an urban focus and there is little attention to rural areas, so the Committee suggests expanding the rural discussion, or explaining why rural areas are not discussed significantly. Additionally, the last paragraph mentions that there are solutions for addressing air pollution equity (page 14-11, lines 3-4). It would be helpful to support this claim with an example.

Key Message 14.4. Impacts of Climate Change on Aeroallergens and Health. The section discusses how climate change will lead to a longer pollen season and increased pollen levels. The Committee suggests adding more about how mitigation of climate change could impact air quality and environmental justice concerns. In addition, as presented, it is unclear why two pollen maps are needed. Allergies are not as devastating as asthma, which receives little attention, or cancer, which is only briefly mentioned in Figure 14.5. The Committee suggests putting more emphasis on more serious health effects associated with degraded air quality. Finally, there is an imbalance in figures throughout the chapter. This key message has three figures associated with it while others only have one or two.

Key Message 14.5. Improving Air Quality While Addressing Climate Change. This section discusses how climate change actions will also improve air quality, but as written, it does

[6] See https://www.wildfirelessons.net/orphans/viewincident?DocumentKey=ead9d69e-300e-4881-80dc-7b5ac71a232b.

not incorporate an equity analysis as was done in Key Message 14.3, which highlights that the distribution of benefits depends on the mitigation approach (e.g., previously cited Cushing et al. paper). The Committee suggests adding a couple of sentences to tie this concept back in. Additionally, Figure 14.10 and the associated discussion of co-benefits is important but not very accessible to broad audiences. The Committee suggests chapter authors rephrase this section discussion so that the message "save lives and money" is more effective. Furthermore, the statements on page 14-17 are difficult to discern as written. It would help clarify that while earlier technologies to reduce ground-level pollution were important, more recent shifts from coal to gas, wind, and solar have greater co-benefits of reducing GHGs and other pollutants.

Comments on Traceable Accounts

The Committee appreciates the emphasis on work since NCA4. However, the traceable accounts need more consistent citations. Some paragraphs are well cited, while others (e.g., those on page 14-20, "Description of Confidence" paragraphs) lack citations. Chapter authors should refer to the recommended framework for traceable accounts in Chapter 2 of this report to ensure consistency and credibility across NCA5.

Comments on Graphics and Boxes

Overall, the figures are effective and appropriate, but could use more detailed captions so that figures can stand alone. For example, the different models used in Figure 14.2. should be explained in the caption. Specifically, the caption should state that the values represent concentrations of important air pollutants and reference the models or papers. In Figure 14.3, the caption should include a statement about what the colors represent.

Figure 14.3, showing smoke across the United States on September 13, 2020, is very compelling, and it may be worth mentioning that this caused one of the worst air quality days in New York City a few days later. Figure 14.3 also does not show impacts to the US Caribbean.

The maps of Figure 14.5 are very important, but they are small and noisy, making them difficult to interpret. This figure would be more effective if simplified.

Figures 14.6 and 14.8 are not very effective and could be removed. Figure 14.9 offers important insights. Perhaps it could be redrawn so it could stand more powerfully on its own.

The traceable accounts on Figure 14.9 are appreciated. However, something similar needs to be built for Figure 14.1.

Comments on Equity and Justice

Equity and justice are embedded in the discussion effectively, though equity and justice-related issues could be framed more strongly in the introduction. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Other Recommended Changes

Dust is only mentioned once in the first key message, but the discussion is limited, and it is unclear if that is due to a lack of understanding about dust or because it is not very important.

The Committee suggests clarifying this lack of discussion and including an appropriate amount of text depending on its importance for air quality, compared with similar natural aerosols such as wildfire or pollen.

With the odds of wildfires increasing, COVID, and more widespread allergies, high-quality home air filters are now present in many homes across the west and are becoming more common in new heating, ventilation, and air conditioning (HVAC) installations. Home air filters have health, energy use, cost, and other implications, particularly for those with low income, and the Committee suggests that this adaptation be emphasized.

Additionally, the Committee suggests mentioning the improved indoor air quality associated with all-electric buildings. This is especially prevalent in the west where municipalities are moving away from methane hookups for new structures and are requiring new buildings to be all electric.[7] However, electrification will require additional considerations.

CHAPTER 15: HUMAN HEALTH

Summary

Overall, this chapter captures many of the challenges and some of the opportunities presented by climate change for the United States population, and for vulnerable populations. However, the chapter does not yet fully meet the requirements of Section 106 of the GCRA due to omissions in content and its lack of documentation for the findings in a consistent, transparent, and credible way in the traceable accounts section. While the key messages of this chapter are generally well stated and supported by the detail in the supporting text, there are opportunities to use more accessible language and improve the graphics. In general, further cross-referencing of and by other chapters would help keep this chapter condensed and focused on human health and highlight the important connections between this chapter and other chapters (see discussion below).

This chapter has a few major omissions that are needed to fully contextualize the climate discussion, including (1) discussion of public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; (2) the limitations of the US medical system (made very clear by the COVID-19 pandemic); (3) discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health; (4) the implications of adaptation and mitigation decisions on human health; and (5) the contributions of the health sector to climate change. These major omissions should be included as part of existing content or perhaps as new key messages. Understanding that the chapter authors are constrained by word count limitations, the Committee makes recommendations where these omissions may be included throughout this chapter and where text may be scaled back to accommodate these suggested additions. Additionally, suggested literature for inclusion is referenced throughout this review.

[7] See https://www.bizjournals.com/sacramento/news/2021/06/02/sacramento-city-council-building-electrification.html.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction to this chapter is concise; however, it could benefit from using more accessible language (e.g., repercussions versus impacts) and providing more context for the climate discussion. Specifically, the Committee suggests chapter authors add two short paragraphs to the introduction. First, the Committee suggests chapter authors begin the introduction with a short paragraph discussing "what is human health." In this paragraph, the Committee suggests the chapter authors define human health broadly[8] (IOM, 1988) to frame the climate impacts, adaptation, and mitigation discussion of the chapter. Following this paragraph, the Committee suggests adding a brief paragraph discussing public health trends in the United States and the importance of environmental, economic, and social factors that create conditions that foster public health; and the limitations of the United States medical system (Morris et al., 2021a,b).[9,10,11,12,13] These topics provide necessary context for the rest of the discussion in Key Message 15.3 regarding the ability to adapt to climate impacts. The existing introduction paragraph would fit nicely after the paragraph discussing current public health trends and limitations of the US medical system. The introduction would benefit from more specifically referencing overburdened groups, such as persons with disabilities, children, sexual and gender minorities, BIPOC, the elderly, and those in communities that are and have been under-resourced and overburdened by health inequities and structural racism.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages of this chapter generally reflect the current understanding about the observed and projected impacts of climate change to human health in the United States The key messages generally reflect supporting evidence, but some statements within each message are missing confidence or likelihood ratings. The Committee suggests the authors add confidence and likelihood ratings (as applicable) to each statement or assertion. Specific instances where language is unclear are identified below. Each key message title should be a short, informative statement, consistent with the recommendation in Chapter 2 of this report, to help make the key messages more effective and impactful. The Committee makes recommendations where the major omissions discussed above may fit within existing key messages and where supporting text may be scaled back to accommodate these suggested additions.

[8] World Health Organization (human health definition): https://www.who.int/about/governance/constitution.
[9] See https://www.tfah.org/article/nations-obesity-epidemic-is-growing-xx-states-have-adult-obesity-rates-above-35-percent-up-from-xx-states-last-year.
[10] Firearms are the leading cause of death: https://www.nejm.org/doi/full/10.1056/nejmc2201761.
[11] References that discuss occupational safety and health impacts: https://www.weforum.org/agenda/2022/11/countries-compare-on-healthcare-expenditure-life-expectancy and https://www.cdc.gov/nchs/pressroom/nchs_press_releases/2022/20220831.htm.
[12] References that discuss US medical system limitations: https://www.theatlantic.com/ideas/archive/2022/06/nih-covid-vaccine-research-studies/661182 and https://www.thenationshealth.org/content/51/8/1.1.
[13] Medical care expenditures growing: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet.

Comments on Specific Key Message Language

> **Key Message 15.1. Climate Change is Harming Human Health**
> Climate change is already harming human physical, mental, and spiritual health through increasing frequency and intensity of extreme events, increasing cases of infectious and vector-borne diseases, and declines in food and water security. Climate-related hazards will continue to grow, increasing morbidity and mortality across all regions of the United States (*very likely*, *very high confidence*).

This key message title is rather broad and generic, though it is also direct and clear. Regarding the message content, the phrase "climate change is already harming … health through …" is not grammatically correct. The first sentence in the message should be rewritten to improve clarity. For instance, the content would be clearer if it read: "Climate change is currently harming human physical, mental, and spiritual health by causing an increase in the frequency and intensity of extreme events and the cases of infectious and vector-borne diseases as well as threatening food and water security." Additionally, confidence and likelihood should be assigned to each assertion within the message.

> **Key Message 15.2 Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination**
> Climate change continues to harm physical, mental, and community health in a number of ways, including by reducing access to quality food, water, and health care. Climate-related hazards disproportionately impact some communities and people, including communities that have been marginalized, low-wealth communities, women, older adults, those with chronic diseases, outdoor workers, and young children (*virtually certain*, *very high confidence*).

Suggested title: "Systemic Racism and Discrimination, Declining US Health, and Medical System Limitations Exacerbate Climate Change Impacts to Health."

This key message title is very similar to Key Message 15.1. Climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening this key message to also include discussion about how declining public health and a limited US medical system may exacerbate climate impacts to human health and to be more inclusive of climate related health inequities in addition to those exacerbated by systemic racism and discrimination. Additionally, the comma should not be included in the title sentence.

Regarding the message content, confidence and likelihood statements should be assigned to each assertion within the message. If this key message discusses how declining public health and a limited US medical system may exacerbate climate impacts to human health, the topic should be added into the content of the key message as well as the supporting text.

> **Key Message 15.3 Adaptation and Mitigation Actions Protect Human Health**
> Creating climate-resilient health systems, implementing adaptation measures, and mitigating greenhouse gas emissions can protect human health (*very likely*, *high confidence*).

Suggested key message revision: "The human health sector contributes to climate change by ____ (*Assign confidence and likelihood*). Adaptation efforts such as ____ protect human health by creating resilient health systems (*Assign confidence and likelihood*). Mitigation efforts can reduce health sector greenhouse gas emissions, which protect human health by ___. (*Assign confidence and likelihood*)."

This key message title and message content are overly broad and simplistic. It would be better to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. The Committee also suggests expanding this key message to discuss, more specifically, the implications of adaptation and mitigation decisions on human health and the contributions of the health sector to climate change. If this is done, the Committee suggests assigning a distinct confidence and likelihood ratings to each claim.

Comments on Text Supporting Key Messages

Key Message 15.1. Climate Change Is Harming Human Health. Overall, the supporting text for this key message is comprehensive and occupies more space than the supporting text for Key Messages 15.2 and 15.3. The topics covered within this key message largely discuss climate-induced impacts to human health now and do not discuss projected impacts to human health into the future (e.g., 25 to 100 years into the future). If possible, the content should also reflect projected impacts into the future, as required by the GCRA.

The Committee suggests that the chapter authors revise the section on "Temperature Extremes" to include a discussion of how impacts will increase over time. This section would benefit from adding citations to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). Additionally, the section would benefit from cross-referencing Chapters 2 (Climate Trends) and 12 (Built Environment, Urban Systems, and Cities) to limit the amount of additional text. In the "Occupational Safety and Health Impacts" discussion, the Committee suggests the authors include emerging information that chronic heat stress and repeated dehydration can lead to kidney disease and even kidney failure in those working in high heat environments (Nerbass et al., 2017). The Committee also suggests authors mention that anticipated future climate heating may cause physical labor to increasingly move to nighttime work. In the "Compounding and Cascading Hazards" section, the Committee suggests the authors include a citation to the US Intelligence Community's April 2022 Annual Threat Assessment where drought and famine, and climate change, are presented as complex threat multipliers in time (ODNI, 2022). This section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify the adverse birth outcomes). The "Drought" section should cross reference Chapter 4 (Water). Finally, the section on "Wildfires" would benefit from adding mention that firefighters who are heavily heat and smoke exposed are often low income or on occasions prisoners released to work and to be paid at a low rate.

In order to accommodate suggested additions to this key message the Committee notes the following areas where text could be reduced. The "Environmental Infectious Disease and Vector Borne Disease" section could be condensed, as it occupies more space than drought, wildfire, and food and water. The "Mental and Spiritual Health" section is quite long and should be condensed. Its summary comment about supporting "agency" among those suffering harm is an important takeaway, but this assertion should include a citation. Box 15.1 would fit more

appropriately under Key Message 15.2; the image does not need to be so large to be effective. The section on "Compounding and Cascading Hazards" is useful, though it could be condensed by using more specific language and only one very specific recent example instead of a few nonspecific examples.

Key Message 15.2. Climate Change Harms Community Health, and That Harm Is Exacerbated by Systemic Racism and Discrimination. The supporting text for this key message would benefit from omissions and additions. This chapter could benefit from citing Chapter 19 (Economics) in the discussion of this key message. For instance, this section should cite Key Message 19.1, which states that the economic impacts of climate change are projected to be distributed unequally across regions, industries, and socioeconomic groups. This section should also cite Figure 19.2, which documents that people with low income and persons of color are and will be powerfully harmed by climate, including educational attainment, damage to income, bankruptcy, and debt repayment.

The Committee suggests consistent usage of low-wealth, low-income, vulnerable populations, and other terms throughout the report and throughout this chapter. The "front lines of climate change" should also be defined; for those that are new to learning about climate change this term may not make sense.

Regarding content, some topics in the supporting text for this key message seem as though they do not fit within this section, and in other areas, this key message is lacking key context. Additionally, climate change may exacerbate or create health inequities apart from those that exist due to systemic racism and discrimination. For this reason, the Committee suggests broadening the Key Message and the Committee suggests additions to the supporting text below.

The "Community Health and Health Equity" section is lacking discussion about how declining public health in the United States and a limited US medical system may exacerbate climate impacts to human health. The Committee notes that this is the only chapter that can address the limitations of the US medical system, the condition of which will determine the ability to adapt and respond to climate impacts to human health. A few notable issues include that clinicians cannot devote the time and energy to issues as global as climate; public health impacts often result from cycles of panic and neglect; medical systems face system-wide workforce challenges; medical and public health systems are often political punching bags; and public health as a practice too often resides only in its own discipline and inadequately reaches out to other sectors like housing, banking, transportation, and agriculture, among others. This section is also lacking discussion of pervasive and increasing poverty in the United States that places more people at increased risk of climate impacts (Aladangady and Forde, 2021; Chetty et al., 2016; Cole et al., 2017; Oscilowicz et al., 2022; Rothstein, 2017; Taylor, 2019). Additionally, this section should mention the need to address mental health impacts of climate change that focus on communities rather than individuals, which will become more important as climate-driven disasters accelerate in scale and frequency. This approach may be even more necessary given the limitations of the US medical system. Finally, this section would benefit from adding a citation to literature documenting disparities in specific health outcomes rather than making vague statements about poor health outcomes (e.g., specify what the health risks are related to chemical and industrial disasters). These components that are omitted from this section are necessary to provide context to the rest of the discussion in this key message.

The supporting text does a great job covering various vulnerable populations, though there are omissions. For instance, children are not discussed. As mentioned above, Box 15.1 would fit more appropriately under this key message. The image should be made smaller to save

space. Persons with disabilities, the elderly, and those with chronic illnesses should also be included in this discussion for more broad coverage of those disproportionately impacted by climate impacts on health. In the "Tribal and Indigenous Peoples' Health" section, the Committee suggests adding discussion of tribal health care system challenges, including of current, ongoing relocations in the United States (i.e., in Louisiana).

In the "Sexual and General Minority Health" section, the discussion about impoverishment does not explain how being impoverished makes a population more vulnerable to climate impacts. The Committee suggests providing more clarity in the language describing the relationship. Also, the discussion should explain differences compared to other impoverished groups. The text should describe why discriminatory beliefs held by faith-based first responders are good or bad, rather than forcing the reader to guess or infer what this means.

Regarding omissions, the inclusion of "Food and Water Security" is strange because most of the supporting text focuses on populations and systems, not topics. It begs the question why other topics covered in Key Message 15.1 are not also included in the supporting text for Key Message 15.2. Because food and water security are discussed in other chapters and the impacts of climate on food and water as they relate to health are discussed in Key Message 15.1, the Committee suggests removing this section (or moving the content up to Key Message 15.1).

Key Message 15.3. Adaptation and Mitigation Actions Protect Human Health. The text immediately following the key message assumes the audiences have preexisting knowledge. The Committee suggests defining mitigation and adaptation as they pertain to health. Proactive and continuing risk management should also be defined. It would be much clearer to discuss adaptation and mitigation separately since they are two distinct actions with distinct impacts to health. There is little to no discussion about mitigation in the supporting text for this key message. The Committee suggests adding pointed discussion throughout the existing sections where mitigation efforts are related to health outcomes.

The sections within this key message would benefit from headers that indicate what is discussed, rather than just a topic. For instance, rather than "Temperature Extremes," perhaps use "Mitigating and Adapting to Extreme Temperatures."

The supporting text for this key message is missing two key topics. Thus, the Committee suggests expanding this key message to discuss the implications of adaptation and mitigation decisions on human health and contributions of the health sector to climate change. The section on "Climate-Resilient Healthcare Systems" omits discussion about the implications of adaptation and mitigation decisions on human health, which should be discussed independently and not grouped together. Furthermore, the new content discussing the implications of adaptation and mitigation efforts on health should highlight the benefits these actions can bring to human health. The contributions of the health sector to climate change would fit nicely before the section titled "Climate Resilient Healthcare Systems." This new section could cite Figure 19.5, which depicts the social cost of carbon from the health sector as equal to the sum of the social costs of carbon from energy, water, and coasts (Eckelman et al., 2020). This section also omits discussion about the need for more support for professional health workers (medical and public health) that work on climate issues (Frumpkin and Jackson, 2020).

The "Disease Surveillance," "Extreme Temperatures," and "Wildfires" sections should pointedly discuss whether the actions discussed are adaptation or mitigation efforts rather than leave the reader to guess. The "Disease Surveillance" section should discuss the limitations elucidated by the COVID-19 pandemic in US disease surveillance capabilities and cite the COVID-19 Focus Feature. The Committee suggests describing why there is a growing at-risk

population rather than stating it as a fact in the "Temperature Extremes" section. Finally, the "Temperature Extremes" section is quite long and could be condensed by focusing only on adaptation and mitigation and omitting the last paragraph, which discusses energy. The Committee is surprised air quality is not discussed as it is a key health benefit of mitigation efforts. If possible, the Committee suggests reducing the "Temperature Extremes" section and adding an "Air Quality" section that should heavily cross-reference Chapter 14 (Air Quality) and expand specifically on human health implications (Chen et al., 2021b; Diaz et al., 2021; Du et al., 2020; Karnauskus et al., 2019; Liu, 2012; Penney et al., 2009; Permentier et al., 2017; Satish et al., 2012; Schmidt, 2019; Scully et al., 2019; Seppanen et al., 1999; Snow et al., 2019; Wang et al., 2021; Zhang et al., 2017).

Comments on Traceable Accounts

The traceable accounts for this chapter do not cover each of the topic areas discussed, have no or limited citations, and do not describe the analytic process used to come to the confidence and likelihood ratings included in each key message. These are essential components to describe how chapter authors arrived at their confidence statements. The Committee's full recommendation on traceable accounts can be found in Chapter 2 of this report.

Because this chapter's traceable accounts section is lacking citations and explanation, the chapter does not identify and provide sufficient context for embedded content and does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message.

Comments on Graphics and Boxes

The chapter's graphics and boxes are generally effective and appropriate, though some may be better placed in different locations within the chapter (see above), and some could be better used. A conceptual model showing direct and indirect pathways through which climate change could impact health could be included, with emphasis where there is supporting evidence. A similar figure illustrating ways that specific mitigation or adaptation efforts can impact health would also be beneficial and could similarly note where evidence is strongest.

Figure 15.1 is about heat but focuses only on certain populations. The Committee suggests leading with the whole population and then offering an enlarged side diagram of the vulnerable groups.

Figure 15.2 is a United States map of increased impacts of climate sensitive diseases. Perhaps a cross reference to Chapters 4 (Water), 14 (Air Quality), 25 (Northern Great Plains), 26 (Southern Great Plains), and 28 (Southwest) would be appropriate. The reference to *Naegleria* (a warm water ameba associated with hot water) accounts for only two or three cases per year.

The Committee appreciates the geographic regional breakdown in Figure 15.2. The list/key could be color coded to match images on the map, and the colors in the figure should be explained. The icons are quite small; consider putting the key at the bottom to enlarge the figure. Schematic figures like Figure 15.2 should have captions with some indication of how/where the findings in the figure were generated. Listing universities tells the reader very little about where the data in this figure came from.

In Figure 15.3, the text is very big, the image and text could be smaller, and percentage numbers could stay the same.

Figure 15.4 mentions intergenerational equity and that topic should be mentioned in the paragraph that immediately precedes it.

Box 15.1 provides an interesting snapshot, but what worries people can change week to week. An example that looked at the progression over time could be more useful.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated into the chapter and this chapter does a great job of dedicating a key message to the topic. Specific suggestions are included in discussions above (Key Message 15.2 and introduction). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

The chapter accurately reflects the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since NCA4. Specific literature recommended for inclusion has been described throughout this review.

Other Recommended Changes

This chapter does not discuss the emerging literature on CO_2 and human cognition, particularly the emerging literature on this impact at ambient levels of CO_2 observed in various settings and likely to be more widely observed in future (see citations provided above).

CHAPTER 16: TRIBES AND INDIGENOUS PEOPLES

Summary

Chapter 16 does not yet meet the requirements of Section 106 of the GCRA, but with the following specified additions and modifications should meet the requirements. At the outset, the chapter attempts to build on previous NCAs but omits context that is essential for readers and assumes a level of preexisting knowledge. The introduction should include an explanation about US recognition of tribal governments and the distinction between federally recognized and non-federally recognized tribes. Additionally, projections of climate impacts on Indigenous peoples and tribes are not discussed. This is a significant omission as projections are essential for any decision-making process. If this is key omission is reflected in the literature, then the research gap deserves attention. If not, chapter authors should add projections and supporting literature citations. Additionally, the key messages lack textual and organizational clarity, and are overly broad, making them inaccessible and ineffective to broad audiences. For example, the Committee cannot distinguish the importance and meaning of sovereignty, self-government, and self-determination in the main text, whereas the terms are defined more clearly in the traceable accounts section. Where relevant, cross-referencing other chapters would improve this chapter (e.g., where the chapter discusses COVID-19 it could cross reference the Focus on COVID-19 and Climate Change). Overall, the traceable accounts inconsistently substantiate the key findings of the chapter and should be revised to include the rationale for confidence and likelihood

statements. Citations of Indigenous-led research and Indigenous scholars are listed below for consideration.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee suggests starting the introduction with a broader statement that puts into context who Indigenous people are and why there is a chapter specifically dedicated to Indigenous peoples and tribes. In the introduction, terms and concepts that might be unfamiliar to readers who do not work closely with tribes should be defined (e.g., sovereignty versus self-determination). Additionally, the introduction should explicitly discuss what knowledge can be found in previous NCAs and what topics will not be covered in the chapter. For example, the chapter authors could reference research on disruption of lives in coastal areas highlighted in NCA4.

The introduction omits discussion about the differences between federally and non-federally recognized tribes and why those differences exist. This omission assumes the reader has preexisting knowledge or has recently read NCA4, which does discuss this topic. The Committee suggests chapter authors add a discussion about the differences between federally and non-federally recognized tribes (see Appendix A for suggested language). Finally, the introduction text is broken up by large images, which makes it hard to read. The Committee suggests that larger groups of text are lumped together so that the information is easier to digest.

Comments on Key Messages, Supporting Information, and Traceable Accounts

In general, the key messages and supporting text could be written at a more appropriate technical level for broader audiences. The Committee notes that all the key messages in this chapter have confidence rankings assigned but not likelihood. The Committee encourages the chapter authors to ensure that the lack of likelihood rankings reflect a lack of quantitative information to support the key messages. If there is quantitative data available to support a finding in a key message, there should be a confidence and likelihood ranking. Additionally, consistent with the recommendation in Chapter 2 of this report, key message titles should be short informative statements so that they are more effective and impactful. Specific suggestions are provided below. Finally, in some cases, the key messages are overly broad, and therefore seem to overlap (e.g., Key Messages 16.2 and 16.3), leaving messages up to interpretation by readers. All three key messages would benefit from more precision and specificity.

Comments on Specific Key Message Language

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities

Climate change is already having negative effects on critical aspects of Indigenous peoples' well-being, including their livelihoods, health, nutrition, and cultural practices, as well as the ecological resilience of their territories. Indigenous peoples are responding

to these climate challenges in a number of ways, including by expanding use of renewable energy and working toward energy sovereignty (*very high confidence*).

Suggested title: "Climate Change Disrupts Livelihoods and Poses Risks to Economies and Health of Indigenous Communities."

The Committee suggests adding a confidence ranking to the first sentence of this key message.

Key Message 16.2. Social Systems and Indigenous Resilience

By exercising their right to self-determination, Indigenous peoples can respond to climate change in ways that meet the needs and aspirations of their communities (*very high confidence*). However, their ability to exercise this right is often undermined by institutions and policies shaped by the legacies of settler colonialism (*very high confidence*). Expanded support from federal and state governments has the potential to uphold Indigenous self-determination to build climate resilience (*high confidence*).

Suggested title: "Indigenous Self-Determination Supports Climate Resilience."

The Committee interpreted this key message in multiple ways. It was not clear whether the intent of this message was to discuss: Indigenous social systems, some of which seems to be covered in Key Message 16.1; how social systems are related to self-determination and supporting resilience; the importance of social systems within Indigenous societies, and the resilience of those systems; or how governmental assistance can be helpful or hurtful toward those Indigenous systems and resilience, depending on how the assistance is provided? In some ways, Key Message 16.2 is similar to Key Message 16.3. To avoid confusion, the Committee suggests the chapter authors clarify this key message and work to distinguish it from Key Message 16.3.

Key Message 16.3. Indigenous Leadership in Climate Change Response

Indigenous peoples lead numerous actions that respond to climate change (*high confidence*). Indigenous-led organizations, initiatives, and movements have demonstrated diverse strategies for climate adaptation and mitigation that are guided by Indigenous knowledge and values and Indigenous rights (*high confidence*).

Suggested title: "Promoting Indigenous Leadership Increases Climate Adaptation and Mitigation Efforts."

Comments on Text Supporting the Key Messages

Key Message 16.1. Climate Impacts and Risks for Tribes and Indigenous Communities. The chapter authors valiantly attempt to include the term "self-determination" throughout the chapter, but sometimes the term seems out of context, or the way it is used is not grammatically correct. The term is a noun, not a verb, and it is the ability to exercise self-determination that is restricted.

The "Indigenous Energy" subsection on renewable energy discusses an Indigenous-led solution, and therefore may be better suited for Key Message 16.3.

The Committee suggests expanding the "Health Risks" section to discuss well-being, which includes the relationship between the environment (other noted values in the Status of Tribes and Climate Change [STACC] report) and mental or emotional health. Additionally, while the section on COVID-19 accurately captures the negative impacts of COVID-19 unique to Indigenous communities, it is very long and could be condensed. In the section "Relocation," the Committee suggests adding text about US government-led Indigenous relocation efforts, not only those happening currently but also citing examples provided in previous national assessment discussions of efforts in Louisiana.

This key message could address projected impacts to better meet the requirements of Section 106 of the GCRA. If there is no literature that describes projected impacts to tribes, chapter authors should clearly discuss the research gap, either here in on the associated traceable accounts section.

Key Message 16.2. Social Systems and Indigenous Resilience. Key Message 16.2 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers. Adding headers will make the supporting text under this key message consistent in structure with other chapters.

Key Message 16.3. Indigenous Leadership in Climate Change Response. Like Key Message 16.2, Key Message 16.3 would benefit from adding headers to the section to break up the long text and organizing the topics discussed within those headers.

In the text supporting this key message, mitigation is discussed in tandem with adaptation and there are no specific examples given for tribal mitigation efforts. The Committee suggests including examples of mitigation efforts in the supporting text and differentiating the two terms.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message. The traceable accounts for this chapter are incredibly short and do not include many citations. The traceable accounts for each key message should include all the citations provided in the supporting text. Because the traceable accounts section is lacking citations, the chapter does not identify and provide sufficient context for the embedded content.

Each key message's traceable account should make modifications based on the outline for traceable accounts provided in Chapter 2 of this report. Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts should be written for more technical audiences (i.e., concise summaries of the literature) and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Overall, the graphics communicate the various locations of tribal and Indigenous peoples. However, many figures are isolated from the text and their intent is confusing. As described in Chapter 2 of this report, figures should be self-contained and understandable by broad audiences. Figure captions should walk the reader through the purpose and main takeaways of the figure.

Figure 16.1 is not a helpful image as presently depicted. It is very busy, and it is hard to tell what purpose the figure serves besides to show that Indigenous peoples have overlapping

homelands across all regions of the United States and its territories. The Committee suggests making this figure an interactive feature online so a user can click on any county and see what Indigenous homelands the county overlaps. Additionally, "Federally Recognized Tribal Land" does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations).

In Figure 16.2, "Federally Recognized Tribal Land" does not represent tribal lands that are held in fee rather than in trust (e.g., Alaska Native tribal lands now held by Native Corporations). The authors could consider showing the locations of all tribal and Indigenous peoples' locations in this figure, but without the overlap of Figure 16.1. Additionally, authors may consider simplifying the figure to show federal land in one color and tribal land in another. The multiple colors and large scale of the map make it difficult to fully grasp the portrayed story. Alternatively, consider adding some "zoom-in" boxes to highlight some specific regions and interactions at the geographic interface of federal lands and tribal lands.

Figure 16.4 is a nice use of space and data, but the caption should explain what dot size represents.

In Figure 16.5, the images should be enlarged so the reader can better see boundaries of tribal lands. The figure caption should note that tribal lands assigned in treaties were often the least productive lands.

The example in Figure 16.6 may be better suited as a box with more details on the Hopi leadership example. If the figure is kept as is, the text should reference the Hopi leadership example and clarify if the project(s) are Hopi government led, a Community-Based Participatory Research project, Hopi scholars, or a Hopi organization.

Tables 16.1 and 16.2 raise more questions than answers. A sentence or two describing each table would be helpful either in the text or in the figure captions. The information could be conveyed better via text. The text could state: "Since 2011, the Bureau of Indian Affairs (BIA) has awarded 837 awards totaling more than $61 million for tribal climate resilience through training and workshops, adaptation planning, ocean and coastal management planning, capacity building, youth engagement, and relocation, managed retreat or protection-in-place planning." If the chapter authors retain the tables, the Committee makes the following suggested revisions: (1) in Table 16.1, the columns should be the same size so categories and number are in line with one another; (2) in Table 16.2, the caption should be updated to describe that awards are divided by regions; and (3) the caption and/or headers should answer the following questions: are awards higher in some regions because of higher submissions or greater awareness of funding opportunities? For each award, how many applicants were there? How many awards were offered by BIA? Should a BIA region map or explanation be included in the text? If the chapter authors are not prepared to provide explanations for such questions in the caption or main text, they may consider eliminating the tables.

Comments on Equity and Justice

The chapter generalizes to all US Tribes and Indigenous peoples when there is an expansive range in geography, wealth, self-determination, and cultural and environmental knowledge. Even within tribal organizations there is a range of knowledge. Therefore, the chapter could explain that the examples provided are mostly representative of the wealthier, well-known and recognized Tribes, Indigenous peoples, and Indigenous organizations. Although some of this is mentioned in the traceable accounts section, this context should also be provided

in the introduction and/or text supporting the key messages as it is important context for all audiences. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

There is a growing body of literature that discusses mental and emotional stress (or solistalgia) among Indigenous peoples and youth due to changes in their environment that could be included (e.g., Ford et al., 2020; Galway et al., 2019; Hatala et al., 2020; Lines and Jardine, 2019; Sanson et al., 2022; Spiegel et al., 2020).

Other Recommended Changes

The authors should consider contextualizing the discussion of "federally recognized tribal lands" and "non-federally recognized tribal lands" by describing why they are recognized and non-recognized. Many Indigenous lands are restricted by the various legal methods that were used to allocate lands. Additionally, the Committee suggests noting that most lands were not high quality and that "American Indian and Alaska Native" (AIAN) is a political not racial category. This discussion would fit nicely in the chapter introduction. See Appendix A for more details on this suggestion.

In addition, chapter authors could consider broadening the discussion in the chapter to low- and zero-carbon energy development, not just renewables, to ensure consistency with Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation).

Chapter authors may consider the following additional references: Billiot et al. (2019a,b), Burns et al. (2021), and Johnson et al. (2022).

CHAPTER 17: CLIMATE EFFECTS ON US INTERNATIONAL INTERESTS

Summary

Overall, this chapter is well-stated, though there are opportunities, described below, to expand some of the discussion to in order to better support the charge of the chapter to focus on climate effects on US international interests. For the most part, this chapter meets the requirements of Section 106 of the GCRA. However, projections that extend 100 years in the future are nearly absent from this chapter as a side effect of the historical tendency for the scientific community to concentrate its attention up to the end of the current century rather than a fixed duration in the future.

The key messages in the chapter are clearly stated and generally supported by the detail and sourcing provided within the chapter. The discussion of key messages prioritizes newer literature (since NCA4) and generally includes citations after each assertion.

Overall, the chapter is written at the appropriate technical level. The chapter does contain some technical language that may be difficult for some audiences to follow, and specific suggestions are provided to maintain clarity and accuracy. Chapter authors may consider using the first sentence to introduce the purpose of the chapter, as done in the traceable accounts section.

There are issues with geopolitical and climate jargon throughout. Examples include "nexus approaches," "enabling environments," "geostrategic," "net zero," and others. Authors should be careful to use terminology that is accessible to broad audiences. In general, the chapter authors should reduce the use of jargon and define terms in the glossary or in the chapter where they are used.

Additionally, the chapter omits important international treaties and dynamics, discussed below. The chapter focuses on impacts and adaptation with a more limited discussion of mitigation (except for Table 17.1). Added emphasis on mitigation would be appropriate given the growth of global GHG emissions outside the United States with implications for the United States. The Committee suggests the authors consider whether developments relative to international treaties as well as those relative to GHG mitigation warrant greater consideration within one of the existing key messages.

There is also little mention of the regional differences across future climate projections and too much focus on global metrics. Climate change will affect regions in different ways partly due to heterogenous changes in precipitation and temperature patterns (e.g., currently fertile regions may become less fertile and vice versa). Such redistributions of resources may contribute to geopolitical instability, but these issues are not included. The authors could do a better job citing the scientific literature to highlight specific at-risk regions and how they map onto US interests. Arctic warming and the loss of Arctic sea ice has clear geopolitical implications for energy and trade and more references are needed to support this point.

The representation of Chapter 17 (Climate Effects on US International Interests) in Chapter 1 (Overview) is not evenly balanced. The word "international" is only mentioned in passing, and Chapter 1 (Overview) only mentions one key message from this chapter. The Committee is concerned that a single report that is not fully supported by other literature (discussed below) about how much global economic output could be affected by climate change is given focus. Chapter 19 (Economics) should guide findings in this domain.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The Committee appreciates how the introduction directly references the key messages, providing a roadmap to the chapter. This model could be adopted for other chapter introductions. Overall, the introduction does an excellent job of succinctly summarizing the key messages, except that page 17-3, lines 19-23, does not cite any literature, in contrast to the highly credible and persuasive sources provided in the rest of the section.

There is a good discussion of international climate services (Box 17.1), but it lacks any specific examples. The Committee suggests that NCA5 authors reconsider the relative importance of this box compared to other messages that are not present. While it is interesting, it is not critical and could be removed to make space for a discussion on migration, which is a more important topic. Additionally, as written in the draft NCA5 report, Box 17.1 could also be interpreted as policy prescriptive.

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted below, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change internationally that affect key interests of the United States. The key messages are written in a consistent and appropriate way and reflect supporting evidence well. However, the key message titles would be more impact as short, informative statements (see below for suggestions). Key Message 17.1 includes confidence without likelihood in one statement while all other statements in the other key messages provide both. Descriptions of the evidence base in the traceable accounts section does not include citations across all four key messages.

Comments on Specific Key Message Language

> **Key Message 17.1. Interdependent, Systemic Climate-Related Risks**
> In a globally connected world, climate impacts on US interests are multifaceted, interconnected, and frequently exacerbated by social unrest and environmental degradation (*likely*, *high confidence*). The interdependent nature of global economic and natural systems, and the projected intensification of climate change, are expected to increase the scale and speed of these impacts (*likely*, *high confidence*). Emerging systems- and scenarios- based approaches to integrative planning, as well as improved climate services, can help alleviate these challenges (*high confidence*).

Suggested title: "The US Faces Increased Interdependent, Systemic Climate-Related International Risks."

The text of Key Message 17.1 is not well phrased, and chapter authors should consider revising the statements. The first two sentences conflate several concepts and do not transmit a clear message. The ideas could be more simply stated: "The world is interconnected and events in one part of the world can affect US interests." The second sentence does not note whether the increased speed and scope of climate change impacts is the result of the world becoming more interconnected or of increased frequency and severity of climate impacts. The key message could more clearly state cause and effect. The last sentence of the message could be perceived as policy prescriptive because it appears to recommend greater use of climate services. This key message uses confidence likelihood metrics consistently except for the final sentence, which only cites confidence. The Committee questions the high confidence level ascribed to the final sentence, and appropriate supporting evidence should be provided in the traceable account.

> **Key Message 17.2. National Security**
> Climate change can contribute to political and social instability and, in some instances, to conflict (*likely*, *high confidence*). It impacts the operations and missions of defense, diplomacy, and development agencies critical to US national security (*very likely*, *high confidence*). The US government, bilaterally and in collaboration with international partners, is increasingly addressing these implications through a range of diplomatic, development, and defense responses (*very likely*, *high confidence*).

Suggested title: "Destabilization of Other Countries by Climate Change Affects US National Security."

The text of Key Message 17.2 is carefully crafted, clearly stated, and accurately reflects the complicated state of the science on climate change and conflict. It is very similar to a key message in NCA4. Since the US military, diplomacy, and foreign assistance are already addressing the effects of climate change (e.g., planning for climate change impacts, providing relief for extreme events which have been made more severe by climate change), the confidence level for the final sentence should be *virtually certain*.

Key Message 17.3. Economics, Trade, and Investment
Climate change is increasingly impacting global economic growth, trade, and investment, with significant implications for US economic interests (*very likely*, *high confidence*). Global mitigation and adaptation responses by governments and businesses will likewise significantly impact US economic interests, presenting both risks and potential opportunities for the US economy (*likely*, *high confidence*). Enabling environments, including regulation, incentives, financial support, and public–private partnerships, will influence the degree to which climate responses negatively or positively impact US economic, trade, and finance interests (*likely*, *high confidence*).

Suggested title: "Disruption of Economies, Trade, and Investment Outside the United States by Climate Change Creates Challenges and Opportunities."

In the text of Key Message 17.3, the Committee considers the confidence likelihood levels ascribed to the first sentence on climate change affecting economic impacts to be too high and not supported by the traceable account. A key issue is what is meant by "significant." If this refers to absolute dollars, then the cost of weather and climate extremes is clearly increasing. However, another approach is to examine losses as a share of global economic output. Alternatively, it is unclear if this statement is meant more about how international climate change mitigation, rather than impacts or adaptation, is affecting the US economy. Additionally, the phrase "Enabling environments," has a specific meaning[14] that may not be widely known, yet it is used in Key Message 17.3. This term should be defined somewhere in the text and should not be used in a key message.

Key Message 17.4. Sustainable Development
Climate change is undermining the world's ability to develop sustainably, reversing development gains, and exacerbating inequities (*very likely*, *high confidence*). Climate finance is not keeping pace with current needs, even though proactive investments in climate-resilient development are more cost-effective than reacting to the impacts of climate (*likely*, *high confidence*). Climate-resilient development actions look to implement greenhouse gas mitigation and adaptation responses for the benefit of all and can identify opportunities to leapfrog development hurdles on a path toward sustainability (*likely*, *medium confidence*). Knowledge of effectiveness of mitigation and adaptation responses is sufficient to take action (*likely*, *medium confidence*). Evidence points to best practices, grounded in equity and justice considerations, and the principles of locally led and co-development that underpin pathways to strengthen the feasibility of achieving sustainable, climate-resilience development at scale (*likely*, *medium confidence*).

[14] See http://uis.unesco.org/en/glossary-term/enabling-environment.

Suggested title: "Climate Change Challenges the Sustainable Development Paradigm."

While the language of this key message is clear and simple, it is very long, particularly compared to other key messages. Chapter authors could consider splitting up this key message to be more easily digestible.

The first sentence of Key Message 17.4 discusses an emerging area of research, so the confidence levels may not be as high as stated, and it would be appropriate to note the need for more research in the text. For example, there are other contributing factors such as COVID-19 and the war in Ukraine that make it difficult to tease out causation.

Comments on Text Supporting the Key Messages

Key Message 17.1. Interdependent, Systemic Climate-Related Risks. The text supporting Key Message 17.1 is well written and notes interconnections among issues and approaches such as food imports, decision making that recognizes interdependencies, incorporating adaptation and mitigation early in systems-level planning, vertical and horizontal integration of responses, scenario development, and participatory approaches. The Committee suggests the authors consider noting in the traceable accounts for this key message that more experience and testing of such approaches is needed. On the other hand, the discussion of this key message does not mention population growth as a compounding risk, a topic with a rich textual basis.

The text mentions cascading tipping points, compounding risks, and the scale of impacts as areas of concern. It provides breadbasket failures as an example and specifically cites the Ukraine war as an example of compound and cascading impacts. The Committee appreciates these as examples of compound and cascading impacts, but the connection to climate change is not clearly stated. The Focus on Compound and Complex Events should also be cross-referenced.

This section could reduce the number of examples of international impacts to save space and put more emphasis on implications of these impacts on US interests. The chapter can reference IPCC (2022a), which addresses the impacts mentioned in this key message, among others. Such a reference would save space to address comments about topics insufficiently addressed in the chapter.

Key Message 17.2. National Security. In Table 17.1, the authors are encouraged to consider how much confidence there is in the projections presented. Table 17.1 and Figure 17.2 rely upon single sources, which suggests incomplete integration of the existing literature. The data appear to show dramatic difference in risk levels and the findings appear to be somewhat speculative. The authors should note whether there is any assessment of baseline conditions and what scenario the information is based on. It is surprising that the study finds such dramatic changes in a few decades.

Topics that are not covered in the discussion of this key message include the discontinuity of approaches to foreign policy as US administrations change. The discussion infers trends in approaches of the US government presumably based on one year of literature concerning actions of the current administration, which is not sufficient for inferring trends. The discussion does not include literature that discusses how international impacts and responses to those impacts shape US domestic policy. Another missing topic is the implications of declining fossil fuel use in major industrial economies for the international order and US interests, as well as the emergence of the United States as a major fossil fuel exporting country. There is little

mention of stranded assets and the implications of that as an emerging policy issue. This compounds the lack of discussion of research on the role of major international fossil fuel producers in the energy transition. Three topics are discussed but lack any connection to real cases without any citation of examples: disruption of supply chains, collaborative multilateral forums, and concept of operations.

Key Message 17.3. Economics, Trade, and Investment. Of the four key messages in this chapter, the Committee suggests the text supporting this key message requires the most attention. In general, it presents an overly optimistic interpretation of scant data and assignments of significance without support. The Committee suggests avoiding phrases such as "increasing priority," "increasingly view," "significantly increased," and "increasingly focused" unless corresponding evidence can be provided.

The Committee questions if it is appropriate for this chapter to attempt to summarize global economic impacts, particularly based on just one study. This topic was not covered in NCA4, and IPCC adequately covers that topic. Furthermore, there is much literature estimating potential impacts of climate change to global products. The Swiss Re study (which is incorrectly cited in the citations) is an outlier and uses questionable methods to estimate losses (i.e., it addresses uncertainties by multiplying quantitative estimated impacts by 10 with no justification of that multiplier). The Committee suggests the chapter address the consequences of projected decreases in global GDP for the United States.

The statement that growing economic losses from climate change exceed economic growth and increase in assets is misleading (page 17-12). Pielke (2021) argues the increase is entirely explained by economic growth and Botzen et al. (2021) offers a different explanation of the data that does not rule out a climate signal. A more accurate reflection of the literature would be to point out that there is not a consensus in the literature on whether a clear climate change signal has emerged in global economic damage data.

Significant gaps in the text include discussion of the growing use of carbon offsets by several orders of magnitude since NCA4 and the implications of the published guidelines for Article 6 of the Paris Agreement for offset use.

The discussion also lacks a documented assessment of the failure to raise the international finance needed to address climate change. It would be appropriate to discuss the implications of countries raising funds to address only one-third of their stated need. The only metric given is GDP loss and there is no discussion of the criticisms of GDP as a metric for development.

Key Message 17.4. Sustainable Development. In the text supporting Key Message 17.4, the literature cited supports the assertion about projected impacts on sustainable development goals. However, the discussion of this key message fails to note that world development suffered losses during the COVID-19 crisis and implications due to the Ukraine war, although the impacts of the Ukraine war are mentioned previously. The text also does not address baseline development trends, which are a critical factor affecting the vulnerability of developing countries to climate change.

The text supporting this key message appropriately mentions that financing is far short of needs. However, it does not present literature with projections of how this will likely play out, leaving audiences with the implicit assumption that this will be corrected. Examples of the challenges not addressed include military challenges, supply chain disruptions, instability, displacement, and food shortages.

The text suggests that one solution to hunger is redirection of development funds to food purchases but fails to connect the dots to further impediments and risks to future development due to the resulting lack of funds.

This key message is general and does not focus on how sustainable development impacts will affect US interests. For example, there are likely implications for national security (Key Message 17.2) and foreign assistance. The latter topic is discussed as a global matter instead of focusing on specific implications for the United States. The text mentions IPCC AR6 but could rely on it more and remove citations already sufficiently discussed there. Lastly, as presented, it is not clear that Table 17.2 is necessary to support this key message.

Comments on Traceable Accounts

Generally, the discussion of traceable accounts is reasonable. The traceable accounts are concise, but hardly ever explain how the authors arrive at a confidence assessment based on the strength of evidence and agreement of independent sources, which is the task of the traceable accounts section. The descriptions of the evidence base in the traceable accounts section do not include any citations, which should be rectified.

There is no discussion in the traceable account for Key Message 17.3 about the literature on global economic impacts of climate change. Since the Committee suggests that the chapter not attempt to summarize the literature on global economic impacts, then having no discussion would be appropriate. If the chapter is going to discuss global economic impacts, then it could better utilize IPCC and cite studies such as Diffenbaugh and Burke (2019) and Tol (2018).

Comments on Graphics and Boxes

The figures are designed well but, the captions should be self-contained. The captions should tell audiences how to read the figure and the message of the figure.

Figure 17.1 is clear and useful. The Committee suggests changing “economic disruption” to “economic losses” to make the language consistent with the right side of Figure 17.1 and avoid use of the more inflammatory term “disruption.”

Figure 17.2 is effective but relies on a single source and is not integrated into the text discussion well.

Table 17.1 is an effective table and the demonstration of change over time is helpful for an assessment. Consider adding colors to the boxes (i.e., green-yellow-red scale) so audiences can easily see patterns. Additionally, some specific examples or photos to make this table a more compelling story. Also consider moving the box to within one of the key message sections.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter. The Committee suggests that authors ensure that assertions concerning equity and justice are documented as fully and carefully as with other scientific assertions (see Appendix A for specific examples). Well-documented statements offer substantial support for addressing the concerns of the communities involved. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The chapter relies on data analyses reported in the existing literature and other sources. The chapter authors do an acceptable job applying the data from the existing literature in a consistent, transparent, and credible manner.

When discussing data availability, there is little note of the rise in application and availability of satellite data. There is a particularly unfortunate gap regarding GHG measurements and related developments for source attribution studies. This is an important topic when considering enforcement of international agreements and tracking the impacts of international funding for mitigation efforts (e.g., NASEM, 2022b).

Comments on Literature Cited

In general, citations refer to literature that post-dates NCA4. Exceptions are not problematic.

Other Recommended Changes

The chapter fails to cite treaties and commitments—a key element of human social systems—outside the normal climate suspects (e.g., United Nations Framework Convention on Climate Change, Paris Agreement, Sendai, Sustainable Development Goals), so there is a lack of analysis of how climate change may affect those international commitments. The rethinking of the Energy Charter Treaty is a perfect example to discuss here. The implications of the Jones Act are also a good target for discussion regarding disaster recovery.

The chapter also does not note that the United States left and reentered the Paris Accord and fails to mention developments on Article 6 of that Accord and its import for international carbon markets and the use of offsets in and by US interests. It misses recent impacts of climate change (e.g., drought in the western United States) on transboundary water agreements with Canada and Mexico. New developments on border adjustments for carbon content in traded goods such as the European Carbon Border Adjustment Mechanism and the relation to the Global Agreement on Trade and Tariffs, and in transboundary pollution treaties such as the Basel Convention deserve mention.

In general, discussion of population growth and growth differentials between countries and the implication of that growth for climate change, both in terms of mitigation and adaptation as well as internal and cross-border displacement, are not addressed, and the relevant literature is left unexplored.

There is little discussion of migration, a very important risk from climate change. Chapter 19 (Economics) and Chapter 28 (Southwest) discuss migration and could be cross-referenced. The matter of whether climate change can or will spur more migration, particularly to the United States, has received increased attention in the literature. NCA4 was equivocal on the role of climate change and migration, finding that the information base was limited. An important matter is whether the new literature supports a different finding. Some examples of recent literature include de Koning and Filatova (2020) and Wrathall et al. (2019).

At minimum, references should be added to the statement concerning the Arctic (page 17-9, lines 12-14). If none exist, this should be noted as a research gap in the traceable accounts. In this context, discussion of the impact of higher temperatures on permafrost and impact on

transport and oil and gas production and transport, buildings, and water would help. The impact of climate change on US military infrastructure located abroad is not explicitly mentioned in the section on national security (Key Message 17.2). SLR, drought, wildfire, and other hazards pose risks for US military infrastructure on US soil and abroad, and the impact on military readiness should be mentioned. SLR as a systemic economic risk to international order is not mentioned.

Chapter authors are cautioned to take care in discussing risks, hazards, and impacts. These are mixed up in some places and should be defined when used. Consider replacing the phrase "risks impact" with "hazards impact." Other concerns include imprecise use of the term "significant," which is an overused and undefined term; confusion of climate and climate change; confusion of climate impacts and climate change impacts; failure to provide concrete examples except as implied by citation; and incorporation of neologisms such as "climate intensification" and "cascading risks."

CHAPTER 18: SECTOR INTERACTIONS, MULTIPLE STRESSORS, AND COMPLEX SYSTEMS

Summary

The Committee commends the NCA5 authors for including this chapter, and attempting to communicate complex interactions and multiple stressors, because understanding the relationship between complex systems and vulnerability to climate change is critical to understanding risks and decision making. Additionally, the Committee appreciates the discussion of governance and decision making, multiple types of knowledge, interdisciplinary and transdisciplinary research, and intersectional identities. However, this chapter misses an opportunity to effectively communicate how complex systems are interrelated, and how to think about complexities in an integrated context relevant to climate change impacts.

As written, this chapter does not achieve its objective to integrate information, and instead provides a list of issues and contexts. As a result, this chapter does not yet meet the requirements of Section 106 of the GCRA. After making the recommended changes below, the Committee believes this chapter will meet those requirements. The key messages do not satisfy the criteria, outlined in Chapter 2 of this report, for effective key messages. The information is not presented in a logical, consistent, or credible way. The most important information that should be included in each key message is instead buried in the supporting text. Additionally, the supporting text does not clearly connect back to the key messages, and often, individual paragraphs appear to be written as disconnected ideas. Readers would expect this chapter in particular to show inherent connections between the topics discussed. The Committee suggests chapter authors tackle specific concepts within each key message, improve cohesion between paragraphs and key messages, assure supporting text relates back to each key message, and integrate this chapter with other chapters in the report. Some cross reference opportunities the Committee noticed include: add Chapter 4 (Water) and Chapter 28 (Southwest) references to the western United States discussion in Box 18.1; add references to Focus on Western Wildfires and Focus on COVID-19 and Climate Change in Box 18.2. Global change is not mentioned in this chapter, and it may be appropriate to discuss the complex interactions between climate change and climate change, as is done, for example, in Chapters 6 (Land Cover and Land-Use Change), 8 (Ecosystems, Ecosystem Services, and Biodiversity), and 10 (Oceans and Marine Resources).

There is also an opportunity to include interactions between climate change, climate variability, and impacts, such as on the agriculture sector. In some cases, climate change may result in changes in variability; in other cases, such as the western US megadrought, climate change is exacerbating variability. Adding discussion of these complex issues and impacts may make the chapter less academic and more appropriate for broad, practitioner audiences.

In addition, the text is written at a technical level that is inaccessible to the broadest possible audiences, as defined in Chapter 2 of this report, and contains a significant amount of jargon that makes important information difficult to untangle.

Finally, the figures in this chapter are well done, and are a valuable tool for illustrating complexities and uncertainties in an accessible format. The Committee suggests better integrating the figures into the text to help clarify some of the complexities discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction does not provide the necessary background or context to make it effective. "Complex systems" is an incredibly broad topic, and the Committee suggests chapter authors use the introduction to provide a roadmap to the chapter, including a brief statement describing what will be covered in the chapter, and what will not be covered, and why. Noticeably, the introduction is not written at a technical level that is appropriate for a broad audience. There is a lot of jargon, and the Committee suggests using language that is more direct and clearer. For clarity, "complex systems" and "multiple stressors," including "non-climate stressors," should be defined from the outset, with relevant examples referring to the other chapters in the NCA5.

The chapter may create confusion as written because each key message is discussing different topics; they do not seem integrated as written. For instance, key message 18.2 discusses compounding impacts and the limitations of models as well as vulnerable populations. Key message 18.3 introduces completely new topics: competing perspectives, uncertainties, relevant knowledge, outcomes, and inform research needs, and knowledge creation. These topics do not appear connected at all. The Committee suggests revising the key messages to build upon one another, to relate to one another, and to be more cabined within one subtopic of complex systems. Each key message, as presently written, takes on many different topics, which makes it difficult to come away with a takeaway.

The first paragraph of the introduction could be expanded on slightly to provide more context for readers, including explicitly connecting the rest of the topics in this report (e.g., physical science, national and regional topics) to the key messages of this chapter (see Chapter 2 of this report). Along these lines, the chapter has next to no references to other chapters despite being the chapter on intersectional issues. The last paragraph of the introduction is unclear. The Committee suggests chapter authors revise the last paragraph of the introduction to use more specific language. For instance, the first sentence could be modified to say: "There is growing evidence *that shows using a complex-systems analysis can support and bolster* research and decision making." The second sentence uses the phrase "new results"; however, it is unclear what new results chapter authors are referring to. The Committee also suggests that chapter authors cross-reference to other NCA5 chapters to illustrate the importance of using a complex-systems analysis/framework.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages throughout this chapter use a lot of technical language and jargon, and the Committee suggests simplifying the language and replacing jargon or defining technical words in line if they cannot be replaced. Additionally, as outlined in Chapter 2 of this report, the Committee recommends rephrasing titles of key messages so that they are short, informative statements, thereby making them more effective and impactful. It is also essential that chapter authors provide confidence and/or likelihood levels for each assertion in the key message to give important context to the audiences. Many statements in the key messages in this chapter are not supported by confidence/likelihood levels.

Comments on Specific Key Message Language

> **Key Message 18.1. Characteristics of Complex Human–Natural Systems**
> Interconnected networks of people, infrastructure, commodities, goods, and services are increasingly vulnerable to climate risks and compounding stressors. The vulnerabilities in these networks, and their effects on human–natural systems, are dynamic and complex. Decision-makers seeking to reduce climate change risks will have to navigate diverse, sometimes competing objectives and perspectives across many actors, institutions, and geographic scales while reconciling deep uncertainties and limits to predictability (*high confidence*).

The title of this key message should be reworded to be a more informative, short statement. Additionally, a confidence level is only provided for the last statement in the key message, but it should be provided for every statement in the key message. As written, the last sentence of the key message stands out as being the most impactful, and the Committee suggests rearranging this key message to make this the first sentence.

> **Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems**
> Climate impacts exacerbate the vulnerability of already-disadvantaged groups, especially given compounding and cascading effects among nature, societies, and the built environment. Complex-systems models and decision-making tools do not yet account for the role of social dynamics in data collection and availability, governance strategies, and vulnerabilities relevant to climate change. Decisions based mostly on readily available data that can be easily incorporated into analyses may disadvantage particular groups (*high confidence*).

The key message title should be rephrased to be a short, informative statement, synthesizing the supporting text. Additionally, the key message includes three sentences that have a single "high confidence" assigned to them. It is not clear whether this confidence level is specific to each individual claim. The key message should be revised to assign confidence and, if applicable, likelihood to each claim.

This key message seems to tackle too much. In fact, the first sentence of this key message tries to say so much that the sentence loses clarity. It is hard to track what the intended key message actually is. Is it that vulnerabilities are compounded due to complex interactions of

climate impacts? Is it that social dynamics are not accurately modeled in data? Or is it that models do not account for the compounding impacts of climate change?

The first sentence uses the phrase "compounding and cascading effects among nature, societies, and the built environment," which could be described using simpler words to improve understanding by a broad audience base. The first sentence also omits discussion of how climate impacts also create vulnerabilities for those who were previously not vulnerable to climate impacts. It is unclear why social dynamics are discussed in the third sentence since the key message previously discussed compounding climate impacts to nature, society, and built environments. It is similarly unclear what the chapter authors are trying to convey in the last sentence.

Suggested revised key message: "Climate change causes impacts to nature, societies, and built environments that exacerbate vulnerabilities of already-disadvantaged groups and create vulnerabilities for people who were previously not vulnerable to climate impacts. Often these impacts interact and build upon one another, which can increase the overall severity of the impacts. Complex models and decision-making tools do not yet account for the interactions between climate impacts or for vulnerabilities, which limits the accuracy of models that inform decision making."

> **Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making**
> Responding effectively to climate change benefits from approaches suited to complex systems and matched to specific contexts and needs (*high confidence*). Participatory and collaborative approaches can help decision-makers accommodate competing perspectives, address uncertainties, increase the use of relevant knowledge, improve outcomes, and inform research needs and knowledge creation (*medium confidence*).

The title of this key message should be rephrased to convey a meaningful message, rather than a heading. As for the message, the Committee suggests rewriting this key message, and before doing so, clearly deciding on the scope and message trying to be conveyed. A rewritten key message may want to omit the first sentence entirely and break apart the second sentence. As written, this key message is rather abstract. It would greatly benefit from using clearer, more specific, and grammatically correct language. For instance, as written now, there is no noun in the first sentence, which creates a great deal of confusion. The second sentence of the key message includes a list with many parts. The list is also confusing because the list seemingly has nothing to do with the previous key message. It is also unclear if each claim in the list is being assigned medium confidence—this should be clarified by including confidence and, if applicable, likelihood statements for each claim. Additionally, this key message includes a lot of jargon, such as "transdisciplinary" and "co-production." The Committee suggests either rephrasing these statements to include definitions of these terms or replacing the terms with clearer language. The text supporting this key message could better connect to and cross-reference Chapters 19 (Economics) and 31 (Adaptation).

> **Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems**
> Climate change presents challenges for different levels of government, the private sector, and civil society. Current governance entities are often unable to resolve conflicts posed by the wide-ranging interactions and complexities of climate change and more localized

compounding stressors (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but thus far there is only preliminary evidence for their effectiveness (*low confidence*). These and other innovations developed for climate mitigation and adaptation (and their interactions) may well present opportunities for replication and broader successes in other locations and different local contexts (*medium confidence*).

Suggested title: "Climate Change Presents Challenges for Different Levels of Government, the Private Sector, and Civil Society."

The key message title does not convey meaningful information. The first sentence of the key message would make a more appropriate title: "Climate change presents challenges for different levels of government, the private sector, and civil society." This key message is quite wordy, but it is clearer than the other key messages. The Committee suggests removing unneeded additional words (see above). Additionally, the Committee suggests emphasizing that the "other innovations" in the last statement of the key message may present broader opportunities. However, "other innovations" is vague, and could be sharpened to convey more meaningful information.

Suggested revised key message: "Governance entities are often unable to resolve conflicts presented by the wide-ranging interactions of climate change (*high confidence*). Local and regional governments have experimented with alternative institutional arrangements, funding mechanisms, and decision coordination, but there is only preliminary evidence for their effectiveness (*low confidence*). These efforts and other innovations developed for climate mitigation and adaptation and their interactions may present opportunities for replication and broader successes (*medium confidence*)."

Comments on Text Supporting the Key Messages

For each section of supporting text under each key message, the Committee suggests the chapter authors create sub-headers to group the text into meaningful sections of text. This change would make the chapter consistent with other chapters in the report and will make the text easier to review for broad audiences.

Key Message 18.1. Characteristics of Complex Human–Natural Systems. In addition to adding sub-headers, this section would benefit from either moving Box 18.1 down to a different key message or including related information in the supporting text under Key Message 18.1. As written, the box does not seem to fit well with the information in this section. In place of Box 18.1, additional examples of interdependencies could be included.

Additionally, it is not clear in the text if the increasing vulnerability is a result of increasing linkages, climate change, or both. The Mora et al. (2018) reference, for example, points to the magnitude of climate change as increasing vulnerability.

Key Message 18.2. Distribution of Vulnerability and Impacts in Complex Systems. Sub-headers should be added in the supporting text. In addition, the text should clarify how this section relates to complex systems.

Key Message 18.3. Actionable Knowledge for Complex-Systems Decision-Making. The text supporting this key message is not currently written for broad audiences. The key message does not demonstrate that any systems are "responding effectively" to complex climate

change risks to reduce vulnerabilities. Instead, it addresses how systems are analyzing the risks. The text shows evidence of applications of analytic approaches to understand and manage complex interactions; however, it is not clear how effective these approaches are nor whether their results are being applied.

Additionally, sub-headers should be added in the supporting text. The term "megalopolises" should be defined in text for broad audience comprehension (Box 18.3).

Key Message 18.4. Knowledge Gaps and Principles for Managing Complex Systems. The Committee suggests adding sub-headers in the supporting text.

Comments on Traceable Accounts

The purpose of traceable accounts is to describe how the authors arrived at their confidence and likelihood statements in each key message, thereby making the chapter findings credible and transparent. Overall, the traceable accounts in this chapter are of uneven quality and the Committee suggests following the recommended guidance for traceable accounts provided in Chapter 2 of this report. Specifically, the traceable account for Key Message 18.1 refers to the main text instead of outlining the evidence base and uncertainties using citations in detail and dedicates most of its space to describing the development of a figure, which is not the purpose of the traceable accounts section. Similarly, the traceable account for Key Message 18.3 makes broad statements about the literature without specifics and describes the development of figures and boxes. Confidence statements in the key messages lump together multiple claims, and the description of confidence and likelihood in the traceable accounts should elaborate on why the designations are made, particularly form Key Message 18.1. Because the traceable accounts section is lacking citations, this chapter does not identify and provide sufficient context for the embedded content in the traceable accounts section.

Chapter authors should revise the traceable accounts to demonstrate *which* references support *each* confidence and likelihood statement under each key message. The traceable accounts for each key message should include all of the citations provided in the supporting text, should be written at a more technical level than supporting text, and chapter authors should include any technical details and/or key omissions not discussed in the supporting text.

Comments on Graphics and Boxes

Generally, the figures and boxes are well done, though some are too abstract, and figure captions need work to stand on their own as readers may only look at the figures and/or boxes. Self-contained descriptions of what the figures show are needed, including context in the text that refers to the figures. To be successful in illuminating how to understand all of the complexities, the captions should show audiences how to read the figures within context. There is an opportunity for figures in this chapter to better illustrate how complex relationships across systems, peoples, and other non-climate stressors affect vulnerability to climate change.

Figure 18.2 is excellent. More figures like this that help simplify the complexities explained would enhance this chapter. On the other hand, Figure 18.4 is quite abstract.

This chapter makes good use of boxes, which connect themes through real-world examples. Box 18.1 is a nice story to illustrate the concepts in the chapter, whereas Box 18.3 seems more like report text rather than a specific case example. Box 18.3 could also better connect with and cross-references Chapters 19 (Economics) and 31 (Adaptation). Box 18.2 is

timely; however, it references the Camp Fire of 2018 as a case study—well before COVID-19 appeared. There were plenty of 2021 and 2022 fires in California that packed people into evacuation centers. These could be used as more recent examples that directly intersect with COVID-19. For these boxes specifically, the Committee also suggest cross-referencing the relevant focus features, such as Focus on Western Wildfires and Focus on COVID-19, as appropriate.

Additionally, it may be appropriate to create a box about the history and value of the recent advance in the creation of "Chief Resilience Officer" positions around the country.

Comments on Equity and Justice

Equity and justice issues are well integrated in the introduction and throughout the chapter, and overall, the Committee commends this chapter's strength on data justice and governance issues. Specifically, the Committee appreciates how Key Message 18.2 articulates how historical and contemporary policies make certain groups more vulnerable to direct and indirect climate impacts and clearly identifies research gaps with respect to vulnerability. However, given the inherent connections this chapter has with other chapters, there is an opportunity to better connect with and cross reference equity and justice issues raised in a number of other chapters including Chapter 19 (Economics), among others, benefiting both the chapter as well as the report as a whole.

Comments on Literature Cited

This chapter cites papers from well-respected journals and agencies, many of which were published since NCA4. Additionally, the Committee appreciates how the authors frequently referenced NCA4 in this chapter rather than reproducing information.

CHAPTER 19: ECONOMICS

Summary

The Committee commends the new and valuable addition of Chapter 19 (Economics) as a standalone chapter in the draft NCA5 report. Overall, Chapter 19 (Economics) is a standout chapter that is carefully and precisely written to accurately reflect the current state of knowledge with regard to the inherent connection between climate change and the economy, and it adequately meets the requirements of Section 106 of the GCRA. The language is clear, concise, and accessible to the widest possible audiences (as defined in Chapter 2 of this report), which provides credibility and transparency to the findings. Additionally, the effective use of traceable accounts in this chapter could be used as a model for other chapters throughout the report.

The Committee does, however, offer some minor suggestions for improvement. While Chapter 19 (Economics) does a comparatively exemplary job of cross-referencing other chapters, there are additional opportunities to link with other chapters and focus features, which would help emphasize the inherent connection between the economy and all chapters included in NCA5. Specifically, pointing to examples within other chapters with modest explanations would demonstrate how economics informs understanding of the diversity of projected regional and

sector impacts. Additionally, the Committee highlights a few topics that should be noted. For example, the market disturbances associated with a sudden event such as the collapse of the West Antarctic Ice Sheet. These disturbances include the supply chain risk through the distribution process, which the Securities and Exchange Commission (SEC) reports as "material risk" to potential stockholders. Topics such as inequitable impacts of climate change and climate change impacts on recreation could also be more comprehensively assessed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction for this chapter is concise, well written, and provides the appropriate background and context on economics as it relates to climate change and the three key messages presented. However, the introduction should also mention which topics are not covered in the chapter (e.g., economics of mitigation).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages are clear, consistent, and written at the appropriate technical level for the intended audiences. The Committee commends the authors for their use of appropriate language, short sentence structure, and the inclusion of confidence/likelihood statements to support each claim. Additionally, the titles of each key message are appropriately concise and informative, and the traceable accounts are exemplary. This chapter is a paragon of communicative writing.

Comments on Specific Key Message Language

> **Key Message 19.1. Climate Change Will Affect the Economy Directly**
> Climate change directly impacts the economy through increases in temperature, rising sea levels, and more frequent/intense weather-related extreme events (e.g., wildfires, floods, hurricanes, drought), which are expected to generate substantial economic costs in many sectors (*likely*, *high confidence*). These impacts are projected to be distributed unequally, affecting certain regions, industries, and socioeconomic groups more than others (*very likely*, *high confidence*). Adaptation can mitigate some impacts by reducing vulnerability to climate change, but adaptation strategies vary in their effectiveness and costs (*medium confidence*).

The Committee suggests that the first sentence of Key Message 19.1 state that climate is currently affecting the US economy because climate-related impacts are already being observed. For example, there is evidence that rising seas have compounding effects with extreme events such as hurricanes as well as more mundane coastal storms. Additionally, extraordinary precipitation events or long periods without rain have caused measurable economic harm, and wildfires have caused catastrophic loss across wide regions of the country.

The Committee commends the chapter authors for including a statement about projected impacts in the key message as future projections are a requirement of the GCRA.

> **Key Message 19.2. Markets and Budgets Will Respond to Climate Change**
> Markets are beginning to respond to current and anticipated climate changes, and stronger market responses are expected as climate change progresses (*medium confidence*). Climate risks are projected to change asset values as markets and prices adjust to reflect economic conditions that result from climate change (*very likely*, *high confidence*). New costs and challenges will emerge in insurance systems and public budgets that were not originally designed to respond to climate change (*high confidence*). Trade and economic growth are projected to be impacted by climate change directly and through policy responses to climate change (*likely*, *medium confidence*).

The title of Key Message 19.2 is about projected impacts, but the first sentence discusses observed impacts. To reconcile this discrepancy, the Committee suggests rephrasing to say that markets are "expanding their initial responses" instead of "are beginning to respond to." Some markets, like agriculture, have been responding to observed and anticipated longer-term trends for decades, but these responses are difficult to measure because they are buried in price signals.

> **Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change**
> Climate change is projected to impose a variety of new or higher costs on most households and to impact their employment, income, and quality of life (*very likely*, *high confidence*). Climate change will disrupt the economic landscape that businesses face, generating new risks but also creating new opportunities (*likely*, *medium confidence*). Institutions and governments are expected to see existing programs used more intensively or in new ways as populations cope with climate change, generating new system-wide risks (*medium confidence*). Design, evaluation, and deployment of adaptation technologies and policies will strengthen our national preparedness for climate change (*high confidence*).

Key Message 19.3 states that "climate change will disrupt the economic landscape businesses face." The Committee finds the word "disrupt" to be too strong and suggests softening the language accordingly to be consistent with the knowledge base. While there is no doubt COVID-19 disrupted markets, there is little evidence that this will lead to widespread disruption.

Comments on Text Supporting the Key Messages

Overall, the text supporting the key messages is very effective. The Committee provides only minor suggestions.

Key Message 19.1. Climate Change Will Affect the Economy Directly. For the text supporting Key Message 19.1, the Committee suggests that the chapter authors provide specific examples of adaptation measures that have been made and associated measurable economic impacts if they exist in the adaptation section.

Key Message 19.3. Economic Opportunities for Households, Businesses, and Institutions Will Change. Regarding economic impacts of climate change and recreation, relevant to the text supporting Key Message 19.3, the Committee suggests providing a more precise discussion about totality of potential climate impacts on recreation. There is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus

et al., 2017), however, the chapter lacks literature on the potentially positive effects on warm weather recreation. Some new literature has been published in recent years to fill this gap (e.g., Chan and Wichman, 2020, 2022; Gellman et al., 2022). These studies find that there could be net benefits to annual recreation nationwide. However, the literature has not fully considered the impacts of high heat, increased precipitation, and fire. Additionally, in the section on economic vulnerability and inequality, the Committee suggests noting that many regions and socioeconomic groups are already seeing diverse levels of personal and food insecurity.

Comments on Traceable Accounts

The traceable accounts for Chapter 19 (Economics) provide accurate and sufficient support for the embedded content and are good examples for other chapters and future assessments.

Comments on Graphics and Boxes

In general, the figures should be self-contained, describing in the caption the message of the figure and how to read it. The Committee suggests referencing the recommendation in Chapter 2 of this report for more guidance on enhancing figures.

Figure 19.1 is informative; however, the data are not traceable to individual studies making the figure difficult to reproduce and indicating a level of original synthesis. It would be beneficial if the data used to create this figure were clearly traceable to individual studies, for example, the way Figure 19.2 uses different panels to trace back to individual studies. If original analysis or synthesis was done to produce this figure, a description of this analysis should be included in the figure caption.

Figure 19.2 is not particularly communicative. Specifically, Figure 19.2 could better emphasize the connection to environmental justice, and it would be beneficial to cross-reference Chapter 20 (Social Systems and Justice).

Figures 19.3 and 19.4 are particularly communicative. However, the caption of Figure 19.4 should include data sources or at least mention the sources of the figures.

Table 19.1 is particularly instructive at displaying the range of direct effects across a breadth of examples. Chapter authors could consider breaking the table into smaller tables, by sections, so it is less overwhelming. Additionally, the table conflates RCP4.5 (~2.7°C median warming) with 2°C warming, and RCP8.5 (~4.5°C median warming) with 3°C warming; these are not identical scenarios and distinctions should be made clearer in the table. The icons in the table would be more helpful in conveying information if they were larger and easier to see and if a key was provided to define the icons. When multiple scenarios are used in the economic estimate column, consider putting each scenario estimate on a separate line, or split the cell horizontally, so it is easier to read the numbers. Finally, the phrase “Relocating Native Alaskan communities” should read “Relocate Alaska Native communities.”

Box 19.1 could add specific examples to make the box tell a concrete story that is less abstract.

Comments on Equity and Justice

The authors should provide some equity- and justice-related framing in the introduction. Specifically, the different dimensions of equity (distribution of benefits and burdens, procedural,

recognitional, and intergenerational equity) as they relate to economics should be integrated. The Committee identified a number of gaps relating to the discussions of equity and justice across Chapter 19 (Economics), including the health and economic costs of climate change and mitigation that are fundamental to the improvement of human health and well-being, such as the economics of heat mortality and economics of the transition to zero-carbon economies; costs and health impacts from air pollution and how that is projected to change with improved air quality; investment or incentives for fossil fuel extraction; employment in low-carbon and high-carbon industries and how this can vary across populations; the economic and financial dimensions of public health and climate change, which are essential to any comprehensive mitigation and adaptation efforts; the social cost of carbon and distribution equity; and the economic aspects of intergenerational equity. The Committee suggests that many of these topics be integrated into the subsection "Economic Vulnerability and Inequality" under Key Message 19.1 and topics focused on investments and employment be integrated into Key Message 19.3. Equity and justice issues on air quality and health could be succinctly mentioned by cross referencing Chapters 14 (Air Quality) and 15 (Human Health). Additionally, the Committee suggests incorporating or at least mentioning the White House Council on Environmental Quality Climate and Economic Justice Screening tool in the chapter (CEQ, 2023). The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible. Finally, specific gaps in equity- and justice-related literature with respect to the chapter focus should be noted.

Comments on Literature Cited

This chapter appropriately reflects the knowledge base, with a focus on publications since NCA4, however, there are a few additional references provided in this review the Committee suggests the authors include to best support the key messages. In particular, the Committee suggests citing more literature published after NCA4.

Other Recommended Changes

The economics of mitigation is a critical omission from this chapter. The Committee suggests including this important topic or providing an explanation for why it is not included in the chapter. The chapter would also benefit from the mention of the potential for market disturbances associated with a rapid global SLR of more than a foot in less two decades. The US Federal Reserve Board (FED) raised this risk in Box 4 of its November 9, 2020, Financial Stability Report (FED, 2020), wherein they warned about risk of "abrupt repricing of assets" and the need to provide information to help markets reflect such risks in asset prices. The chapter could reference Chapters 2 (Climate Trends), 3 (Earth System Processes), or 9 (Coastal Effects) concerning risks of high SLR. The Committee also suggests that chapter authors consider the new Strategy to Develop Statistic for Environmental-Economic Decisions,[15] which is intended to quantify nature's contribution to the economy for the first time and serve as a tool for decision making.

Additionally, this chapter should reference the Focus on Risks to Supply Chains regarding how enhanced climate risk reporting to financial markets can help abate climate

[15] See https://www.whitehouse.gov/wp-content/uploads/2023/01/Natural-Capital-Accounting-Strategy-final.pdf.

change risks. See, for example, WRI/WBCSD (2011) regarding reporting rules on emissions from companies as well as from upstream and downstream supply chains.

CHAPTER 20: SOCIAL SYSTEMS AND JUSTICE

Summary

The Committee commends the inclusion of this new chapter in the draft NCA5 report. The chapter provides six key messages within the interdisciplinary research of social sciences and climate change. These key messages relate to human understanding; human drivers; communication, engagement, and governance of climate change; adaptative strategies of migration; and just transitions. The chapter integrates equity and justice principles consistently throughout the text. The principles of inclusion and justice could be better addressed by expanding the discussion of Indigenous peoples to include all marginalized populations. Overall, the chapter is written using highly technical language making it difficult for general audiences to follow and includes many statements that could be interpreted as policy prescriptive, which are not appropriate for NCA5.

Additionally, the key findings are inconsistent and unclear. Therefore, the Committee suggests revising the chapter with a clearer message for the intended audiences, as defined in Chapter 2 of this report, consistent with the state of knowledge. For these reasons, this chapter does not meet the requirements of Section 106 of the GCRA as written.

A noticeable absence in this chapter—which should assess climate change-related social science findings—is research specifically geared toward helping policy makers to determine which regions and communities are disadvantaged. One standout resource, which uses secondary data to assess resilience and social vulnerability to hazards and risks, is the BRIC Index. These tools are mentioned in Chapter 11 (Agriculture, Food Systems, and Rural Communities), but given their relevance, the Committee suggests they be presented in this chapter and then referenced by the other chapters.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction sufficiently defines relevant terms for the chapter, but otherwise, as written, it does not provide adequate, relevant context or background information that would be useful when reading the chapter. For example, while the introduction begins by stating that other chapters discuss environmental justice, and this chapter will focus on social systems, it ends with an explanation of environmental justice and an outdated framework on dimensions of environmental justice. It is possible the chapter authors intended to use these dimensions of justice as a framework for delineating justice analysis on the presented social systems, but if so, that should be clearly stated and integrated into the chapter. The Committee also suggests the introduction mention fields within social sciences doing work relevant to this chapter (e.g., sociology, social work, geography, policy, psychology, science communication).

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages and supporting text could be written at a more appropriate technical level for broader accessibility. In addition, all key messages only have confidence statements but not likelihood statements, which should be added if there is quantitative evidence to support any of the claims.

Comments on Specific Key Message Language

> **Key Message 20.1. How People Know and Think About Climate Change**
> People's social positioning, histories with their environments, and cultural background help determine how they interpret and experience climate change (*high confidence*), including the relationship between climate change and environmental justice (*high confidence*). Knowledge that exists through diverse forms of expression and practice, and that emerges from distinct social and historical contexts, may produce different insights, which in turn give rise to different adaptation strategies and goals—a potentially important resource in society's response to climate change (*medium confidence*).

This key message could be more informative if it incorporated the intended message as explained in supporting text. The Committee suggests making the title of the key message a more informative statement such as, "Values and Beliefs Influences Understanding of Climate Change."

Comments on Text Supporting the Key Messages

Key Message 20.1. How People Know and Think About Climate Change. A major issue with this key message is that epistemological studies only reveal how people *interpret* climate change rather than what and how people *know* what it is about. For example, Taddicken et al. (2018) demonstrates this distinction in which they measure different dimensions of knowledge and confidence in that knowledge (where epistemology comes into consideration). While this study discusses how to measure knowledge, it demonstrates the vast area of social science research into climate knowledge not presented in the chapter.

The last paragraph in this section could be revised to be less policy prescriptive—particularly the last sentence. The paragraph could lay out the state of the literature instead of making judgments on the state of knowledge. If this paragraph does not in fact support Key Message 20.1, it could be moved to the traceable accounts.

Key Message 20.2. Human Drivers Shape Greenhouse Gas Emissions. The supporting text includes the correct statement on page 20-6, line 31-33 that "Higher emissions generally occur in nations and US states with relatively larger populations and growing urban centers," however the statement omits an additional point in the cited work that population density and urbanization often coincide, and therefore the net effect is unclear (Liddle, 2014).

Key Message 20.3. Governance Influences Risk, Adaptation, and Equity. There is a lack of discussion about the roles and dynamics between federal and non-federal (i.e., state, city, and other subnational entities) governance. The Committee suggests adding this discussion. Additionally, on page 20-7, lines 24-26, the discussion and citations of veto points in US governance could be expanded beyond the citation of Madison (1788).

Key Message 20.5. Federal Policy Is Critical to Just Outcomes When Migration Is Necessary. The text supporting this key message would benefit from a short discussion on "disaster capitalism." The Committee also suggests giving specific examples of migrations after disasters throughout this section to illustrate the ideas presented. In addition, the Committee suggests adding the discussion of probable future significant outcome of migrating populations out of South and Central America toward the United States in the face of increasing climate-change pressures.

Comments on Traceable Accounts

This chapter does not appropriately identify and provide sufficient context for embedded content nor does this content reflect current scientific understanding. The traceable accounts section lacks citations and does not describe which literature applies to which section, discuss uncertainties in the literature, nor how and why the authors arrived at the confidence and likelihood statements. Additionally, new ideas and literature are introduced throughout the traceable accounts that are not included in the main body of the chapter.

Other chapters mention a stakeholder or public engagement workshop. The Committee suggests a statement about whether or not a public engagement session was held for this chapter in the process description, and if not, the statement should provide an explanation for the decision.

The traceable account for Key Message 20.1 states that the authors concentrate on Indigenous peoples' knowledge for the sake of simplicity to represent US peoples. This method of assessment is incongruent with the requirements of Section 106 of the GCRA. This is a non-scientific assessment method to generalize one small heterogenous population to the other 90 percent of the greater heterogenous population. Indigenous epistemology presented in the text is incomplete. For example, interpretations of knowledge also include the mythical (e.g., expressed through art, stories, dance), experiential (expressed through sensory information), and spiritual (e.g., expressed through reverence, faith). Additionally, this traceable account does not include any citations.

Comments on Graphics and Boxes

Figure 20.2 is not effective, and the information could be conveyed by adding two sentences to the previous paragraph. The Committee suggests removing this figure to make room for one that is more impactful; however, if it is necessary to include, perhaps the image could be smaller.

Figure 20.3 intends to demonstrate that social systems influence migration, and that climate change may exacerbate inequalities, causing more harm, but planned relocation could increase just outcomes. The message is not well understood through the Bronfenbrenner ecological framework and more recent frameworks have been presented in literature (e.g., McMichael, 2020).

Comments on Equity and Justice

The chapter introduces a number of core concepts that are used throughout the report but are not well-defined such as risk, exposure, and justice. The Committee suggests providing

definitions for these terms either in a glossary (consistent with recommendations made in Chapter 2 of this report), or in the Front Matter, and then using them consistently throughout the report. Consistent with the recommendation in Chapter 2 of this report, this chapter should also include the concept of intergenerational justice. The chapter integrates the principles of equity and justice, and the Committee appreciates the key message dedicated to a just transition. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Overall, the chapter does not adequately represent the breadth of knowledge on human systems and justice in relation to climate change.

CHAPTER 21: NORTHEAST

Summary

Overall, this chapter meets the requirements of Section 106 of the GCRA, with a few specific exceptions noted below. The key findings in the chapter are clearly stated but unevenly and incompletely supported by the detail and sourcing provided within the chapter. The five key messages inconsistently include both levels of confidence and likelihood and claims of confidence may be conflated with the extent of adoption of actions. The traceable accounts briefly and concisely address key uncertainties and knowledge gaps underlying the findings; however, many important uncertainties are not defined in the text supporting the key messages. The Committee appreciates that the chapter prioritizes newer literature (since NCA4), and that the supporting text includes citations after each assertion. However, the findings are not documented well in the traceable accounts section. The traceable accounts require revisions to include citations and more details about how and why confidence and likelihood were determined based on the literature.

The chapter does contain some technical language that may be difficult for broad audiences to follow. The Committee suggests being mindful of terminology and defining specific terms when introduced in the text. Additionally, the term “mitigation” is used interchangeably with “hazard mitigation,” which is confusing, and the Committee suggests building consistency in terminology across the chapter and the report.

Broadly, this chapter would benefit from more attention to agriculture, given its preponderance in the Northeast. For example, USDA maintains a climate hub focused on the northeastern United States. Additionally, there are many opportunities to provide more attention to climate impacts on transportation, human health and welfare, and human social systems without significantly increasing the wordcount by referencing the associated national chapters. This approach would be especially relevant for coastal areas since impacts of climate change on coastal communities are not covered in Key Message 21.2.

This chapter succeeds in analyzing current trends in climate change in the Northeast and projecting those trends to mid-century and the end of the century. However, it does not project 100 years in the future, as outlined in Section 106 of the GCRA, but tends to end at the year 2100. This chapter presents strong and powerful messages on impacts and adaptation as well as

projections. However, while the chapter focuses on impacts and adaptation, it omits an important detailed discussion on mitigation. For example, the Regional Greenhouse Gas Initiative (RGGI) is not mentioned when mitigation leadership is discussed.

Finally, the chapter authors note that the findings presented in the corresponding chapter of NCA4 remain valid and that the region is making important progress both in adaptation and mitigation efforts and in many ways leads the United States in these efforts. The Committee commends the authors for referencing NCA4 so as not to repeat information, and for focusing the key messages in the draft NCA5 report on actions under way to address issues identified in NCA4. The key messages in the chapter also stress how these efforts increasingly reflect equity and justice concerns identified in NCA4. What is new in the draft NCA5 report is a clearer focus on the need for adequate funding to sustain and expand such efforts as climate continues to change and stresses accumulate.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introductory text to this chapter provides appropriate context for the discussion that follows. It is well written at an appropriate technical level for broad audiences. Excellent prose explains which states and tribal entities are included in the northeast region and its economic and geographic variety. Readers get a brief background and context on the northeast and its relevance to climate change.

The introduction asserts that much of what was in NCA4 is still true, begging the question "what is not?" Although it mentions additional points, it is not clear these are all new knowledge since NCA4 since the literature cited includes some in the NCA4 window. It implies that the chapter will cover both adaptation and mitigation, although the former is emphasized. Otherwise, it does not indicate what it will not cover. It makes no effort to define scientific terms where they are used (e.g., "compounding threats").

Comments on Key Messages, Supporting Information, and Traceable Accounts

With the exceptions noted elsewhere in this review, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change in the Northeast as well as the challenges, opportunities, and ways to address risk directly. The titles of the key messages are well written as short, informative statements, which can be a model for other chapters. What is missing is the understanding that mitigation is a means to address risk at a more fundamental level. The opportunities to convey the importance of mitigation and review the relevant findings of the literature on this topic that postdate literature included in NCA4 are mostly missed. Relatedly, there is limited discussion of how climate change is producing impacts in this region that make mitigation more challenging or countervail efforts to reduce emissions. Examples range from increased use of air conditioning to decreased CO_2 uptake in ocean waters to disrupted forests and soils. Such issues can be brought to attention in part by cross-referencing other chapters as appropriate.

The key messages generally are written in a consistent and appropriate way and reflect supporting evidence very well, but the text does include some jargon that could be simplified.

All key messages present confidence metrics. However, likelihood is reported only in Key Message 21.3, and should be added to other key messages if there is quantitative evidence to support the claims being made.

Key Messages 21.1 and 21.2 are emphasized more than the other three key messages. This apparent imbalance in focus impedes the support and integration of ideas across the key messages. While Key Messages 21.1 and 21.2 are many pages long with careful documentation, the supporting text for Key Message 21.3 is shorter and less well-sourced. The text supporting Key Message 21.4 relies on a table to convey much of the information, but the ideas are poorly communicated by providing a recitation of facts with little integration.

Comments on Specific Key Message Language

> **Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses**
> People in the Northeast continue to be confronted with extreme weather, most notably extreme precipitation, which has caused problematic flooding across the region (*very likely*, *high confidence*). In response, adaptation and mitigation efforts, including nature-based solutions, have increased across the region (*high confidence*), with a focus on emissions reductions, carbon sequestration, and resilience building (*medium confidence*).

The first sentence of this key message should emphasize the extreme weather to the region rather than the people. As currently written, the first sentence could imply that the topic is mental stress, so the Committee suggests clarifying this sentence by removing "people" and starting with "The Northeast continues…." Additionally, the final sentence of this key message, "In response…" is unnecessarily vague but removing reference to "including nature-based solutions" might clarify and tighten the language. Adaptation and mitigation are both mentioned in this key message with a heavy emphasis on mitigation in the last sentence but the text that follows mainly reflects adaptation measures (mainly nature based). The Committee suggests expanding on mitigation efforts or possibilities in the region.

> **Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change**
> The ocean and coastal habitats in the Northeast are experiencing changes that are unprecedented in recorded history, including ocean warming, heatwaves, sea level rise, increases in heavy precipitation events, and ocean acidification (*high confidence*). Changing ocean conditions are causing significant shifts in the distribution, productivity, and seasonal timing of life-cycle events of living marine resources in the Northeast (*high confidence*). These impacts have spurred adaptation efforts such as coastal wetland restoration and changes in fishing behavior (*medium confidence*).

Overall, this key message is well written and informative, however, the Committee suggests including likelihood statements if possible. Additionally, it is not always clear which part of the sentences the confidence statement is referring to, and the Committee suggests carefully providing confidence and/or likelihood for each assertion.

> **Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies**
> Extreme heat, storms, flooding, and other climate-related hazards are causing disproportionate impacts among historically marginalized communities in the Northeast, including racial and ethnic minorities, people of lower socioeconomic status, and older adults (*very likely*, *very high confidence*). These communities tend to have less access to health care, social services, and financial resources, and to face higher burdens related to environmental pollution and preexisting health conditions (*very likely*, *high confidence*). Social equity objectives are prominent in many local-level adaptation initiatives, but the amount of progress toward equitable outcomes remains uncertain (*very likely*, *high confidence*).

The Committee appreciates that this key message addresses equity (disproportionate impacts), but the wording of the last finding, "the amount of progress toward equitable outcomes remains uncertain (*very likely*, *high confidence*)" as stated may be misinterpreted as progress is very high. Perhaps rather than "uncertain" the authors mean to say "uneven."

Comments on Text Supporting the Key Messages

Key Message 21.1. Impacts from Extreme Weather Events and Chronic Stress are Driving Responses. This key message is discussed in four pages packed with up-to-date references. The Northeast is heating faster than most regions of North America, and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts. The chapter authors may be able to tighten up some of the paragraphs addressing flooding and add in some perspectives on implications for people. Additionally, while the text supporting this key message does mention increased pest ranges, the Committee suggests briefly expanding the discussion on the impact of invasive insect species, especially with regard to climate-mediated migration or dispersal, in the context of forest health, given that it is such a prevalent issue in the Northeast.

Key Message 21.2. Ocean and Coastal Impacts Are Driving Adaptation to Climate Change. The discussion on this key message is unbalanced, with five pages on impacts and only one page on projections. Similarly, this key message is somewhat short on adaptation examples, which appear mostly as citations. The Committee suggests the chapter authors consider shortening the discussion on marine biological impacts and including more discussion of recent literature on social and economic implications of the impacts cited. The Committee appreciates the example of the positive impact of climate change on blue crabs in the Chesapeake Bay.

The broad statement that acidification "may" exert an impact seems too general, but the details and citations that follow are a great example of how to organize a discussion. The discussion of oxygen loss (page 21-12) lacks explanation for broad audiences and introduces related concepts (added nutrient load) without clearly highlighting the connection. Unlike Key Message 21.1, there is no mention of mitigation as a response to the impacts being observed, although there is ample opportunity to do so for example, when discussing coastal wetland restoration. Also missing is a discussion of how some of these changes (e.g., higher ocean temperatures) worsen the mitigation challenge.

Key Message 21.3. Disproportionate Impacts Drive Advocacy and Policies. This key message presents the issues well and the references provided are useful but are sparser. There are

never more than three sources listed in a paragraph, some paragraphs present no references, and one paragraph has one 2003 reference on redlining, for which there is now a very substantial and current literature. The Committee encourages the chapter authors to better define redlining, explicitly noting that it was based on race and poverty. The unevenness of literature employed may send a message that this key message did not get as much attention, as opposed to a lack of attention in the literature. Still, the message is clear and quite powerful overall, but the Committee suggests including additional references to adequately support the text.

On the other hand, the authors miss the opportunity to weave in concerns about mitigation. For example, literature about how these inequities drive advocacy for mitigation could be included. The discussion includes an important message on managed retreat that should cross-reference Chapter 22 (Southeast) at the very least, and harmful terminology should be avoided and made consistent with other chapters. About one page is devoted to adaptation and it is well done, with valuable information on tribal efforts.

Key Message 21.4. Climate Action Plans Are Now Being Implemented. The discussion of this key message includes a four-page table, which summarizes recent planning and action by states and tribes. It is a long list of laws with no context or indication of their content. Such a database, lacking analysis or expanded explanation, may be more useful to cite rather than reproduce in this document. The discussion also includes two boxes. The first box is on innovative municipal actions (Portland, Pittsburgh, Morgantown). The second box presents examples of adaptation efforts lead by Tribal Nations (WAMPUM, Shinnecock, MI'kmaq). Although both boxes are consistent with the guidance provided in Chapter 2 of this report, they read like instructional manuals rather than a review of literature. The key message overall relies too much on the boxes for factual demonstration.

The Committee appreciates the box on municipal adaptation and suggests at least brief acknowledgment of the extensive municipal level planning for climate change under way in cities like Boston, New York, Philadelphia, and Baltimore, among many others. Perhaps municipal-level adaptation to coastal risks was covered in prior NCAs, but some brief discussion would be welcome, and could easily be done by consolidating the analysis of state-level action.

One mention of RGGI is a criticism of issues of social inequity implicit in such systems. This is an important issue, but the Committee encourages the chapter authors to consider the overall impression of mitigation conveyed if this is the only message about mitigation provided. The Committee also suggests that the authors consider the example of the recent passage of the New York State Environmental Bond Act as a worthy example of progress.

Key Message 21.5. The Implementation of Climate Plans Depends on Adequate Financing. In keeping with other key messages in this chapter, mitigation is given short shrift. Mitigation is mentioned in the text of the key message, but the discussion only addresses impacts and risk. Most paragraphs lack references, although some have one or two, including dated ones. The high confidence in the key message should indicate that there is significant literature on these topics. If that is true, more literature should be cited throughout the supporting text and corresponding traceable account as evidence for the ranking.

Most of the discussion of the topic is at the national level with only some of it focusing on the region. Three topics that seem relevant to this key message are not covered or not adequately covered. First, the Committee suggests the text discuss the literature about who has access to financing and funding, who benefits, and whether benefits reach the most vulnerable populations. Second, literature on access and distribution of burdens and benefits should be

represented. Finally, a mention of literature on the role of land trusts in conservation might fit in this key message.

Comments on Traceable Accounts

The traceable accounts require attention. As written, they are concise, but they do not sufficiently explain how the chapter authors arrived at a confidence assessment based on strength of evidence and agreement about process, nor do they explain the basis of the likelihood statements.

The section "Description of Evidence Base" does not cite literature. It would seem more appropriate to focus on the scientific demonstration of the basis of the key messages in the traceable accounts section and use the expanded discussion of the key messages in the body of the text as a place to explain the key messages to broad audiences and provide context and implications.

Comments on Graphics and Boxes

The figures are well done, but minor revisions, especially of the captions, are necessary to ensure that they are self-contained, even if that repeats text. Consistent with the recommendation in Chapter 2 of this report, captions should provide an explanation of the figure message and explain how to read the figure.

Figure 21.3 is mislabeled. Additionally, the Committee found Figure 21.3 challenging to interpret and difficult to read because of its fuzziness. The Committee suggests expanding the explanation of the figure in the caption and making sure that the numbers in the legends are clearly defined and described. For example, it would be helpful to explain the "relative log of biomass."

Figure 21.4 as presented is somewhat confusing with varying numbers of images without connection to messages. The Committee suggests labeling the panels: 1985, 2015, 2050. Additionally, the right panel suggests that cod have increased by 2050 but will decline after. The middle panel suggests herring have increased by 2015 but then will decline by 2050 and after. Similar with lobster and puffin. It seems that the art in this scenario may not be connected to the science, and the Committee suggests trying to better align the two. If the figure already does align the art and science, these apparent enigmas should be clarified in the figure caption.

Comments on Equity and Justice

Overall, the chapter could benefit from some clear framing (perhaps in the introduction) on vulnerable regions and populations, as well as the structural, environmental, and social factors that contribute to vulnerability, and just transitions. Please refer to Appendix A for other specific suggestions. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The section relies on data and analyses reported in the existing literature and other sources. The chapter authors do a good job applying the data from the existing literature in a consistent, transparent, and credible manner.

Comments on Literature Cited

In general, citations refer to literature that post-dates NCA4. Exceptions are not problematic. There does seem to be an overreliance on self-reported advances, such as reports by cities of their own activities rather than objective, independent assessments from the peer-reviewed literature. The Committee suggests providing a discussion on how literature was selected in the traceable accounts.

There is duplication between the bullets on page 21-19 and table entries. Boxes 21.1 and 21.2 have the basic documentation expected. But Box 21.2 suffers from only relying on the originator of plans to describe them and lacks a sense that a meta-analysis is available or even desirable. Most content (and documentation) is restricted to the table and boxes.

Key Message 21.5 suffers more from a paucity of sourcing and has some questionable sources burdened by age or lack of peer review. For example, page 21-29, line 14, cites "USA facts 2021" as the only source for the paragraph. There is too much emphasis on accepting the word of exemplar institutions for their actions as opposed to a professional appraisal of such actions.

In general, the Committee found that significant literature relevant to the key messages of this chapter is not cited in the supporting text. Some of this literature may be cited by referencing the IPCC AR6. Examples of literature that the committee suggests (full citations are provided in the References chapter) chapter authors may consider include the following: Bhattachan et al. (2018); Booth et al. (2021); Chen et al. (2019, 2021a); Dougherty and Rasmussen (2019); Ebi et al. (2021); Ellena et al. (2020); Farr et al. (2021); Foster et al. (2019); Friedland et al. (2021); Gaichas et al. (2018); Holmquist et al. (2021); Houghton and Castillo-Salgado (2019); Huang et al. (2018, 2021); Jeanson et al. (2021); Kjesbu et al. (2022); Knighton et al. (2019); Leonard (2021); Letson et al. (2021); Lotze et al. (2022); Mayrhuber et al. (2018); McMullin et al. (2019); Molino et al. (2020); Nazarian et al. (2022); Nunfam et al. (2018); Olafsdottir et al. (2021); Overland et al. (2021); Papaioannou et al. (2021); Pershing et al. (2021); Piecuch (2018); Powell et al. (2019); Reckien and Petkova (2019); Robertson et al. (2022); Rogers et al. (2019); Rosenau et al. (2021); Runkle (2022); Schattman et al. (2021); Setzer and Vanhala (2019); Shen and Chui (2021); Sicard et al. (2018); Thomas et al. (2019); Thorne et al. (2019).

Other Recommended Changes

The introduction makes the point that the findings of NCA4 are still valid and relevant, and that the literature cited there is still useful. While this is surely mostly the case, some cautionary note is appropriate in the absence of a critical retrospective. See comments provided in Appendix A for more suggested detailed clarifications.

CHAPTER 22: SOUTHEAST

Summary

This chapter describes the patterns of risk, social vulnerability, and climate adaptation in the Southeast region. The writing throughout this chapter is inconsistent, with some sections that are clear and concise (e.g., Key Message 22.2), while others are written at a more technical level. These sections should be revised to be appropriate for broad audiences. Additionally, the findings are not particularly consistent nor are they transparent, and suggestions provided below would improve this chapter's compliance with Section 106 of the GCRA. The traceable accounts section could be revised to describe processes of the literature review and how the authors assigned confidence levels. The chapter could also list the climate changes unique to the Southeast region.

The chapter spends a great deal of space on the health of people in the region broken out by risks yet does not include the widespread use of harmful natural resource extraction practices. The chapter could also build on NCA4 to report an updated assessment of the region's infrastructure. For example, the region's lack of disaster preparedness and response infrastructure given the increased frequency of climate-related disasters could be discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction of this chapter is generally well written. However, the introduction should define which states are included in the Southeast, perhaps by showing a map of the region. The introduction could also provide more discussion on specific climate changes in the region. The Southeast is a unique region that has experienced a long-term cooling over the past century under the background of global warming. This phenomenon is sometimes called the Southeast US "warming hole." Whether the cooling will continue into the coming decades or reverse remains uncertain and can potentially affect the aspects covered in the chapter. Therefore, disaster preparedness and response infrastructure will be particularly critical. It may be worthwhile mentioning this in the chapter and including a few references. Another unique aspect to the Southeast worth mentioning is its diversity in landscapes and economy.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Comments on Specific Key Message Language and Supporting Text

The key messages are generally well written, consistent, and appropriate. They reflect the current understanding of the impacts of climate change in the Southeast on the economy, food systems, and human health. Assessments of likelihood are included in some key messages, but not in others—this should reflect the knowledge base rather than omissions. Additionally, key message titles are topics and should instead communicate a short message, making them more impactful.

The text supporting the key messages is generally well written and contains sufficient details that provide further evidence. Some detailed comments are available in Appendix A.

> **Key Message 22.1. Regional Growth, Change, and Equitable Climate Adaptation**
> The Southeast's population is growing, mostly in urban areas and along its coastline, putting more communities and their assets into harm's way from increasing risks related to climate and land-use changes (*very high confidence*). Decision-makers preparing for current and future risks frequently use outdated and/or limited information on climate-related risks (*high confidence*). Climate adaptation efforts tend to be concentrated in high-capacity communities, leaving under-resourced and more rural populations, communities of color, and tribal nations at a growing risk (*high confidence*).

The use of data included as part of this key message is not well explained in the text supporting this key message. The last section, "Uneven Use of Tools at Hand to Ensure Equitable Adaptation," could apply to every region and it is not necessary to include here, or at a minimum, should be cross-referenced with Chapter 31 (Adaptation).

> **Key Message 22.2. Human Health and Well-Being**
> Human health and climate stressors are intimately linked in the Southeast (*very high confidence*). Community characteristics, such as racial and ethnic population, chronic disease prevalence, age, and socioeconomic status, can influence how climate change exacerbates, ameliorates, or introduces new health issues (*very high confidence*). Climate change is already impacting health in the region (*very likely*, *very high confidence*). There are effective strategies to address the health impacts of climate change in the Southeast that have multiple benefits across social and environmental contexts (*high confidence*).

The last statement in Key Message 22.2 is not sufficiently explained in the supporting text.

> **Key Message 22.3. Livelihoods and Economy**
> Over the last few decades, economic growth in the Southeast has been concentrated in and around urban centers (*high confidence*) that depend on climate-sensitive infrastructure and regional connections to thrive (*medium confidence*). Simultaneously, rural and place-based economies that rely on the region's ecosystems are particularly at risk from current and future climate changes (*high confidence*). Global warming is expected to worsen climate-related impacts to the region's economic systems and labor, with disproportionate effects on under-resourced and historically marginalized communities (*high confidence*). A coordinated approach that recognizes present-day inequities and the interdependencies between rural and urban communities will be necessary to secure the region's economic vitality (*high confidence*).

No likelihood language is provided in this key message, which is also quite long compared to others in the draft NCA5 report. Additionally, the term "marginalized" can be harmful as it perpetuates feelings of inadequacy, and the Committee suggests instead, using standardized language across the report, such as "historically overburdened." In the text

supporting this key message, there should be more discussion about climate impacts on recreation.

Comments on Traceable Accounts

The quality of the traceable accounts varies. For some key messages, the description of the knowledge base is more thorough with citations, while other sections are short with no citations. The description of confidence and likelihood sections read as a restatement of the key messages rather than explaining the how and why of confidence/likelihood language. While the process described at the beginning of the traceable accounts section is thorough, the rest of the section should more consistently describe how the knowledge base supports the claims in the key messages. Relatedly, likelihood statements were assigned unevenly in this chapter, and if there are knowledge gaps that limit the use of likelihood statements, these should also be noted in the traceable accounts.

Comments on Graphics and Boxes

Graphics in this chapter are generally effective and appropriate, and many are easy to interpret for the intended audiences. Figure 22.5 is not specific to the region and unnecessary. In general, figure captions should be self-contained and walk the reader through the message of each figure. For example, Figure 22.10 is highly complex and requires additional explanation about how future warming would impact $PM_{2.5}$ concentrations (not shown) and lead to excess premature deaths. Figure 22.16 is another example of a complex figure where only passing mention of the time period and warming scenarios are provided, proactive versus no adaptation are not defined, potential additional costs to energy consumers are not explained, and cost per megawatt hour over an unknown time period may not be understandable for general audiences.

Comments on Equity and Justice

The authors provide strong framing of equity- and justice-related issues in the chapter introduction. Important historical context is given, as well as the perspective of complex systemic interconnections. Vulnerabilities are not limited to racial and socioeconomic classes, but also include occupational and geographic vulnerabilities. Environmental justice issues are consistently integrated throughout the chapter. Additional attention can be given to the different dimensions of equity (i.e., distributional, procedural, recognitional, intergenerational) and how they relate to specific issues discussed. In addition, the importance of data justice, the equitable availability and access to relevant data to support community climate action, should be addressed. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The data and analyses adopted from other sources and presented in this chapter seem appropriate.

Comments on Literature Cited

Overall, appropriate literature is cited. However, some references are outdated, particularly for those on past hurricanes. The region has experienced many more disasters since NCA4, and more recent literature should be cited accordingly.

Other Recommended Changes

The chapter spends a great deal of space on the health of people in the region broken out by risks yet does not include the widespread use of harmful natural resource extraction practices. The chapter could also build on NCA4 to report updated assessment of the region's infrastructure, for example, the region's lack of disaster preparedness and response infrastructure given the increased frequency of climate-related disasters.

Hypoxia is a major issue along the Gulf states, which affects the economy, commercial fishing, recreational fishing, and ecosystems. Climate change is considered a contributing factor, and this chapter should mention this issue.

More generally, there is very limited discussion on the Gulf of Mexico. Topics that could be added include salt-water and fresh-water inundation of coastal areas from tropical storms, hurricanes, general SLR and land subsidence, and hydraulic-induced encroachment of salt water into aquifers and communities in Florida.

CHAPTER 23: US CARIBBEAN

Summary

Overall, the Committee commends the chapter authors on a standout chapter and for developing a translation of this chapter into Spanish to make it more accessible and inclusive (the Committee did not independently review the translated chapter). The chapter focuses attention on the vulnerability of the region to extreme weather events (hurricanes) and SLR and frames the vulnerability of people and infrastructure in terms of historical inequalities. Examples of adaptation highlight community-based grassroots efforts. The key findings, as well as information gaps, are clearly communicated at an appropriate technical level and are supported by evidence that is documented in a transparent and credible way. Additionally, the chapter analyzes the impacts of climate change on the US Caribbean (Puerto Rico and the US Virgin Islands) by integrating the evidence regarding current trends as well as projected trends for the future. The chapter, therefore, meets the requirements of Section 106 of the GCRA.

The chapter's key messages accurately reflect the current understanding of impacts and future vulnerabilities. The Committee commends the chapter authors for including a section on emerging issues, highlighting uncertainties in the main body of the text, not just the traceable accounts, noting the lack of climate data and research specific to the region—for example, the lack of high-resolution climate projections, and flood maps—making it difficult to accurately quantify impacts.

It is important to note, however, that Chapter 1 (Overview) does not completely reflect the climate justice emphasis of this chapter, although it does give examples of adverse climate impacts (Table 1.2) and threats to the economy as well as examples of community action (Table

1.1) from this region. Chapter 1 (Overview) does refer to this and many other chapters as giving examples of dispossession of Indigenous people (pages 1-20 to 1-21).

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The chapter introduction is exemplary. It is explicitly framed by the unique political history of the US Caribbean, where colonization, systematic inequalities, and racism have rendered natural environments, people and infrastructure particularly exposed to the impacts of climate change on health and well-being. The introduction, detailing the geography and history of the region, sources of social vulnerability, and observed and project climate change, provides important context and the appropriate background for audiences who may be unfamiliar with the US Caribbean. The Committee suggests, however, that the introduction also include a brief statement noting topics that are not covered in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the five key messages are comprehensive and encompass the key climate-related impacts on the region; the natural ecosystems and services they provide; food and water systems; and critical infrastructure. The key messages are similar to NCA4 but reflect updated events and information since 2018. However, consistent with the recommendation in Chapter 2 of this report, the Committee suggests formatting the titles of key messages such that they are short, informative statements rather than headers, thereby making them more effective. The Committee also suggests that authors consider including the discussion on climate change (pages 23-6 through 23-8) as a key message, which is the foundation of the following key messages. Chapter authors should then also include traceable accounts for the additional key message. This suggestion would help build consistency with some of the other chapters. Alternatively, the structure could remain as is because there are already five key messages, and the introduction to the region was useful in framing the chapter and key messages.

Comments on Specific Key Message Language

> **Key Message 23.1. Human Health, Quality of Life, and Well-Being**
> Traditionally underserved and disadvantaged communities suffer disproportionate impacts from climate change because they have been systematically excluded from social services, secure livelihoods, quality education, and other social benefits that help sustain health and well-being (*high confidence*). Hurricanes and other climate-related extreme events have been associated with higher rates of disease, mental illness, and overall mortality, as well as loss of cultural heritage that is central to community identity (*high confidence*). As extreme weather events become more intense and more frequent, residents will continue experiencing increasing levels of noncommunicable diseases, excess mortality, behavioral health challenges, and loss of quality of life (*high confidence*).

The Committee suggests making the title more explicit and impactful by adding "are Threatened by Climate Change Impacts" at the end.

> **Key Message 23.2. Ecology and Biodiversity**
> Coastal and terrestrial ecosystems provide a large number of goods and services that are vital to the islands' economies and to the health and well-being of their residents (*high confidence*). These essential systems are degraded by human actions and climate change, thereby reducing the benefits they provide to people, as well as their functionality as habitats for protecting biological diversity (*high confidence*). Climate change is expected to exacerbate the degradation of ecosystems (*very likely*, *high confidence*). The success of climate adaptation strategies will depend on reducing all sources of stress on ecological systems (*medium confidence*).

The Committee suggests making the title more explicit and impactful by adding "are Unique and Vulnerable" after "Biodiversity."

> **Key Message 23.3. Water and Food Insecurity**
> US Caribbean food and water systems are becoming increasingly vulnerable to the escalation of climate change, including stronger hurricanes, more severe drought, warmer air temperatures, and other extreme weather (*high confidence*). Because the territories are heavily reliant on imported foods, they are affected by climate changes occurring both within and outside of the US Caribbean region (*high confidence*). Mean rainfall reductions, increasing air temperatures, and sea level rise will adversely affect freshwater availability in the future (*medium confidence*). Better understanding of the ways food and water systems interrelate and of the cascading impacts generated by climate change is needed to improve adaptation efforts (*medium confidence*).

The Committee suggests making the title more explicit and impactful by changing it to "Climate Change Worsens Water and Food Insecurity." Lower rainfall, higher temperatures, and SLR mean less freshwater available in the future. Reliance on imported food (80-90%) makes the region vulnerable to climate change impacts elsewhere. More drought and large hurricanes mean more crop failure and soil erosion.

> **Key Message 23.4. Infrastructure and Energy**
> Climate change has created profound risks for the US Caribbean's critical infrastructure, already weakened from years of disinvestment and deferred maintenance (*high confidence*). Increasingly powerful storms, along with rising sea levels, are severely impairing infrastructure systems, with increasing damage projected in future years (*likely*, *high confidence*). Dependence of fossil fuel imports increases energy insecurity (*high confidence*). Infrastructure improvements, coupled with a new paradigm focused on decentralization, adoption of distributed solar, and shared governance, could help limit residents' vulnerability to health and other risks associated with loss of essential services (*high confidence*).

The Committee suggests making the title more explicit and impactful by adding "are Vulnerable but Decentralization Could Improve Resilience." Years of disinvestment have left

critical infrastructure vulnerable to extreme climate events. These systems and their governance are centralized, increasing their vulnerability. Decentralized systems with shared governance, and less reliance on fossil fuel imports (e.g., distributed solar), would increase redundancy and flexibility and people's climate resilience and local self-determination.

> **Key Message 23.5. Planning and Adaptation**
> Climate adaptation in the US Caribbean is challenging because of multiple interacting factors, including high risk exposure, limited or misaligned funding, insufficient institutional and organizational capacity, and siloed approaches to risk reduction and resilience (*high confidence*). Effective adaptation to support resilience in the US Caribbean could be enhanced through co-development and integration of robust global, regional, and local climate science and risk-based knowledge into planning and implementation, as well as improved governance arrangements (*high confidence*). US Caribbean capabilities in planning and adaptation can be enhanced by strengthening partnerships across the wider Caribbean region and the US mainland (*medium confidence*).

The Committee suggests making the title more explicit and impactful by adding "Face Institutional Barriers and Needs Improved Governance Structures." Key Message 23.5 states that high risk exposure plus limited and siloed institutional capacity challenge planning and adaptation. Developing and integrating global- regional- and local-scale institutions, and regional partnerships, will support effective, equitable adaptation. This will require greater uptake of climate change information in public-sector planning and decision making.

Comments on Text Supporting the Key Messages

Overall, the text supporting the key messages is very effective, communicated at the appropriate technical level, and well cited, reflecting the knowledge base. The Committee appreciates the thoughtful work that the chapter authors put into crafting this chapter.

Key Message 23.1. Human Health, Quality of Life, and Well-Being. The Committee highlights that mentioning the "One Health" approach to mobilize collaborative work among communities, stakeholders, practitioners, sectors, and disciplines was a unique aspect of this chapter. Additionally, the Committee suggests that chapter authors consider adding one additional reference to support this key message, though noting that it is not region specific (Ibanez et al., 2022).

Comments on Traceable Accounts

The chapter authors describe the process of developing this chapter by assembling a large, diverse multidisciplinary team, hosting a public engagement workshop, and developing an evidence base founded in peer-reviewed literature, and acknowledge that much more literature is available for Puerto Rico than the US Virgin Islands. The confidences and likelihood statements expressed in the key messages are clearly explained in more detail in this section, and there is an important emphasis on needing high resolution climate change projections for the region.

However, the traceable accounts section does not cite any literature. As is consistent with the Committee's recommendation in Chapter 2 of this report, the chapter authors should apply

robust evidence (i.e., literature cited) to justify both the confidence likelihood assigned to each qualitative statement within each key message, and the supporting text, thereby providing credibility to each assertion. This chapter should strive to be consistent with other chapters in terms of citations in the key message text and in the traceable accounts section.

Comments on Graphics and Boxes

The graphics are generally informative and useful, but some of the captions should be expanded to better communicate the meaning of the figure.

Figure 23.4 is useful but does not appear to be cited in the text.

Figure 23.10 shows infrastructure at risk of flooding in the US Virgin Islands. It is very welcomed to see data from the US Virgin Islands in this chapter, but the figure could use more detail, if available. Additionally, the proportion of critical infrastructure in flood zones is shown, but there is no information about how a flood zone is defined, and if future SLR or storm intensity are taken into account.

Figure 23.11 shows the water use in Puerto Rico for human consumption versus power production but is relatively ineffective as a figure. The information could simply be stated in the text (it looks like power generation uses about one-third of water used) and the figure could be removed, making room for another figure. For example, if there are any models predicting climate change effects on aquifers, those projections might make a nice illustration. If not, it underscores the lack of data for the region.

Comments on Equity and Justice

This chapter does a standout job using an equity and justice framework and could be a useful example for other chapters. The chapter explicitly uses a framework of equity and justice to show that the vulnerability of the region results from a history founded in colonization and slavery leading to systematic inequalities and racism that have resulted in natural environments, people, and infrastructure that are particularly vulnerable to the impacts of climate change on health, resilience, and well-being. Impacts on cultural resources and traditional ecological knowledge are discussed. Adaptation and planning based on grassroots organizing, community-based responses, and distributed inclusive governance are assessed to be most likely to succeed in the region. The only recommendation is that the chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Not all the literature cited is new since NCA4, although almost all of it is published in the past ten years. This may reflect a lack of available literature for the region that is more recent. Perhaps by necessity, much of the material is based on Puerto Rico, and the Committee suggests expanding the literature on the US Virgin Islands, if possible.

Other Recommended Changes

This chapter utilizes SLR projections from the IPCC AR6 report. This is not an issue in of itself, but Appendix 3 does not list IPCC SLR projections as a standard source of information.

Rather, SLR scenarios from the US Interagency Taskforce (ITF) Report (Sweet et al., 2022) were provided to chapter authors (see Chapter 9 Coastal Effects, although the authors of Chapter 9 were asked to include additional information about the IPCC SLR projections). To increase consistency across the report, an overall suggestion from the Committee is that authors across all chapters agree on an approach for discussing SLR, including agreeing on the sources of information to be used. Utilizing SLR information from both the IPCC and ITF is a good approach—each has its own use case—but care should be given to properly connect them, as the ITF scenarios do not map directly onto a single emissions scenario. More specifically, the IPCC SLR projections are most appropriate for providing information about uncertainty (or the range of possibilities), which this chapter does not discuss in detail. The Committee suggest that the authors of this chapter include more discussion of uncertainty (not only in regard to SLR) and that they do so beyond the context of the Very High Emissions scenario. Other emissions scenarios are possible and reasonable to include in a decision-making context. A good resource for chapter authors to explore the IPCC-based projections is the National Aeronautical Space Administration tool.[16]

Additionally, there may be opportunities for this chapter and Chapter 30 (Hawai‘i and US Affiliated Pacific Islands) to cross-reference each other given the similarities of the socioecological challenges the regions face driven by climate change.

CHAPTER 24: MIDWEST

Summary

This chapter addresses climate change risks, impacts, and adaptation in the Midwest region across five sectors or thematic areas. The chapter is well done, with a reasonably good connection between the key messages and the traceable account, and it addresses Section 106 of the GCRA. The key messages are provided in a logical sequence and provide a notable change from NCA4, which makes appropriate consolidation, but in so doing may have decoupled it from the sector-based chapters. It would be useful to reconcile and cross reference against Chapter 1 (Overview) and other chapters, particularly since the key message in NCA4 on transport and infrastructure is framed here as built environment, water is new, and forest and biodiversity have been combined. This chapter is improved by its inclusion of adaptation measures described within each key message as part of an internal structure that works well. Each key message is framed around a key message statement, risk, impacts, and an example domain for adaptation (and mitigation), although the Committee suggests considering a term other than risk, such as importance or significance.

The individual key messages use IPCC scenarios, which is a very good way to introduce the basis for prognostic analysis, but the authors should not use older SRES, since they are not mentioned in Chapter 1 (Overview), Chapter 3 (Earth System Processes), nor in Appendix 3 (Scenarios and Datasets). Key messages are well referenced but there are no references in the traceable accounts. The technical level of writing is appropriate, but authors may consider cross-referencing the IPCC scenarios found in Appendix 3 (Scenarios and Datasets). There is a tendency to write about climate conditions both empirically and through projections, so it should be made clear the distinction between natural variability and attribution to climate change (also

[16] See https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool.

land-use change). For the most part this is well done, and references are useful for this (e.g., Key Message 24.1). The absence of discussion on biofuels is notable; the Committee suggests some additional text.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction provides a brief overview of the importance of climate change to the region but does less to summarize the findings or key messages, or the general message on climate change impacts. The basis for the introduction is that numerical models estimate increasing temperatures and more precipitation. It may be better to frame the introduction based on findings and important messages from other chapters that are examined here, such as Chapter 11 (Agriculture, Food Systems, and Rural Communities), Chapter 7 (Forests), and Chapter 12 (Built Environment, Urban Systems, and Cities), among others. The Committee recognizes that often material presented in this chapter is more extensive and perhaps more comprehensive than in the sector-based chapters, so cross referencing with sector chapters could make the overall report more consistent and more useful to the reader.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter examines the impact of climate change in the Midwest region. There are five key messages, which are presented in a logical sequence. The titles of the key messages are brief headings, although the descriptions are framed as messages. Agriculture is heavily emphasized and documented, which would be expected, but it is incomplete in its central focus on row crop agriculture. Perhaps this is due to there being less information on climate impacts for specialty crops and livestock, but more consideration would be good; Figure 24.2 is notable, providing a good starting point. Projections of climate change impact on natural resources and sectors are given (e.g., soil erosion, agricultural production, growing season characteristics), but far less on their economic impact. When done, they are good examples with high impact for the reader, and it would be interesting to include economic impacts for all these regional assessments. The treatment of natural resources impacts is done well, but many of the statements of impacts are very general, and there is little in the way of projection. The inclusion of the built environment is useful since the regional land-use and cover is diverse, with many urban centers that are large and growing. Community health considerations are good if somewhat general; analysis of inequities across communities and incomes should be emphasized more. Lastly, water is treated as an important key message, but the most important water element is the Great Lakes and that is not done as well as needed; some critical issues are in the climate impacts in the Lakes that could have profound regional and national impacts, including shoreline erosion, fisheries, and other indirect effects other than the stated direct effects (e.g., algal blooms). Key message discussions have a risk-impacts-adaptation format, which is very good, but different than other regional chapters. Cross-references to relevant sector-based chapters would be useful.

Many paragraphs are nicely worded to move from historical conditions and correlations, through current trends, to impacts and then projections of what could come, presented in time frames of mid-century and end of century. In general, although not fully followed everywhere in

text, the resulting discussion would be something readers can grasp, so adopting this style in other chapters would be useful for readership. When stating impacts, it would be better to frame them in language that speaks to the notion that evidence and analysis suggest the increased probability of the impact, but not as a deterministic outcome.

The text supporting the key messages is well written, with considerable and appropriate citations to the scientific literature. The chapter uses a three-part framework of risk, impacts, and adaptation (and example of the latter at work), which is nicely done but may not have been adapted for other regional chapters. The text uses projections to frame the impacts, which is very well done, but could be improved by using a standard time frame and ensuring a consistent use of scenarios. The use of the term "risk" could be substituted with "hazard," "importance," "significance," or some other term that would be consistent with the text. It is important to make it clear in writing that what we know about climate change impacts is that it affects the probabilities of outcomes, rather than certain or deterministic outcomes, particularly in the context of natural variability.

Comments on Specific Key Message Language and Supporting Text

> **Key Message 24.1. Agriculture**
> Increasing precipitation variability, rising temperatures, and increasing atmospheric moisture are shifting crop growing zones, disrupting planting and harvesting schedules, and negatively impacting specialty crop production (*likely*, *high confidence*). Extreme precipitation events and transitions between wet and dry conditions are projected to intensify and reduce yields for some crops (e.g., corn and soybean), while overall increases in cooler-season precipitation will boost wheat production (*likely*, *medium confidence*). Changes in precipitation extremes, timing of snowmelt, and early-season rainfall are expected to pose greater challenges for animal agriculture, including disease transmission, muddier pastures, and further degradation of water quality (*likely*, *high confidence*). Climate-smart agriculture and other adaptation techniques provide a potential path toward environmental and economic sustainability (*medium confidence*).

Suggested title: "Climate Change Is Increasingly Disrupting Agricultural Production, But Adaptation Measures Already Exist."

This is an exceptionally strong section. It uses the scenarios to provide projection information and links a detailed discussion of impacts directly to the risks discussion and key message statements. The adaptation example on climate-smart agriculture is appropriate and useful. The key message is that all aspects of climate change will affect agriculture, from rising temperatures, changes in atmospheric moisture, and shifting growing zones. The importance of extreme conditions and events are also highlighted. There is a heavy focus on differential impacts on corn compared to wheat, where corn is adversely impacted but wheat may benefit, which is a fair statement but perhaps simplified too much. Indeed, the key message notes wheat may benefit in terms of yield increases, but the situation is more complicated—for example, other regions (e.g., Northern Great Plains, Canada) may benefit more and complicate trade dynamics.

The complexities in agriculture are clearly noted, with a fair examination of negative and positive impacts. The reader is given a good understanding that issues are more complicated than simply having hotter temperatures and perhaps more rain. Perhaps this warrants a summary

paragraph which ties together the impacts discussion and relates it back to the key message. One of the complexities for agriculture, among other facets of this chapter, is the interrelationship between climate change and natural variability. It is important in noting impacts that the attribution is clearly pointed to climate change, or the natural background is recognized as appropriate. Similarly, the growing season effects, the so-called warming hole, and land-use change create complexities for management that may warrant a separate statement on complexities and management challenges for farmers and leads into the climate-smart agriculture discussion. The region is notable for specialty crops, and, although mentioned, perhaps more discussion on high-value specialty crops is needed. Similarly, the focus on row crop agriculture, for which most data exist, should be extended to orchards, tree-based systems, and livestock. It is surprising that there is so little discussion of biofuels. The mitigation and adaptation solutions rest on climate-smart agriculture but some reference to climate-smart forestry could be useful here, with reference to Key Message 24.2. The key message statement, "Increasing precipitation variability, rising temperatures, and increasing atmospheric moisture are shifting crop growing zones, disrupting planting and harvesting schedules, and negatively impacting specialty crop production (*likely*, *high confidence*)," is an example of language that could be more precise, because climate change can increase the odds of these events happening, but does not predetermine that they will. This sentence should also clarify whether the confidence and likelihood statements pertain to all items in the list.

This section has a notable lack of information on equity and justice, which could be expanded.

> **Key Message 24.2. Natural Resources**
> Ecosystems are already being affected by changes in extreme weather and other climate-related changes, with negative impacts on a wide range of species (*likely*, *high confidence*). Increasing incidence of flooding and drought is expected to further alter aquatic ecosystems (*likely*, *medium confidence*), while terrestrial ecosystems are being reshaped by rising temperatures and decreasing snow and ice cover (*very likely*, *high confidence*). Loss of ecosystem services is undermining human well-being, causing the loss of economic, cultural, and health benefits (*medium confidence*). In response, communities are adapting their cultural practices and the ways they manage the landscape, preserving and protecting ecosystems and the services they provide (*low confidence*).

Suggested title: "Climate Change Will Adversely Affect a Wide Variety of Species and Ecosystems, with Diminished Ecosystem Services."

This is a well-written section that describes the region's diverse natural resources. This key message appears to replace Forests and Ecosystems (Key Messages 2 and 3) from NCA4, which is a good thing, as it presents a broader framework. It may, however, lose some direct connection to the sector chapters unless they are specifically reflected and referenced in the text (common concepts and conclusions could be made and linked). The context could be broadened to include the Great Lakes ecosystem, and more on other natural systems such as grasslands and wetlands. The heavy emphasis on ice covered lakes and winter use of natural resources may not be necessary, unless more explicitly and clearly tied to warming and if good projections with quantitative impacts can be cited. Natural climate solutions are used as the example of adaptation/mitigation measures with respect to natural resources in this key message, and thus

are distinguished from climate-smart agriculture used in the previous key message on Agriculture. Both frameworks include adaptation and mitigation, and while it is useful to apply both in the way the authors have, it would also be useful to describe why the distinction is made. Perhaps also consider discussing nature-based solutions, since they directly relate to biodiversity. This key message should use language that conveys the idea that climate change increases the odds that impacts will occur.

Key Message 24.3. Health and Community Well-Being
Climate change is already having negative impacts on human health and well-being (*very likely*, *very high confidence*), with wide-ranging effects on livelihoods, health care, and community cohesion (*high confidence*). Because of historical and systemic biases, communities of color are especially vulnerable to these negative impacts (*very likely*, *very high confidence*). Mitigation and adaptation strategies such as increased urban tree cover and improved stormwater management, when developed in collaboration with affected communities, have the potential to improve health and bolster community well-being (*high confidence*).

Suggested title: "Climate Change Will Adversely Affect Human Health and May Enhance Health Disparities."

This is a newly framed key message from NCA4 and benefits from an expansion to include community well-being but could elaborate the text to include a broader health framework, beginning with a cogent definition or description of community well-being. It recognizes the heterogeneity of the region and is strong on the equity and justice elements. The key message relies on a few coherent examples of health effects (e.g., Lyme disease), but could elaborate to include a broader health framework.

Key Message 24.4. Built Environment
Increases in temperatures and extreme precipitation events are already challenging aging infrastructure and are expected to impair surface transportation, water navigation, and the electrical grid (*likely*, *medium confidence*). Shifts in the timing and intensity of rainfall are expected to disrupt transportation along major rivers and increase chronic flooding (*likely*, *high confidence*). Green infrastructure and other public and private investments may mitigate losses, provide relief from heat, and offer other ways to adapt the built environment to a changing climate (*medium confidence*).

Suggested title: "Climate Change Has Costly Impacts on Infrastructure, But Green Development Solutions Exist."

This new key message transforms the previous focus on transportation infrastructure into the built environment and makes the chapter stronger as a result. However, there is an inconsistency with Chapter 1 (Overview), which focuses on infrastructure, as in NCA4. The adaptation example and focal point on investments and finance are very good. The text on green finance should be developed more. There is no mention of mass timber. Also missing are discussions on how the built environment is growing and increasingly converting natural ecosystems and expanding the wildland urban interface.

Key Message 24.5. Water
Climate-related changes to water quantity and quality are increasing the risk to ecosystem health, adequate food production, and recreation (*high confidence*). Projected increases in drought, flooding, and runoff across the Mississippi River basin and the Great Lakes will adversely impact ecosystems through enhanced erosion, harmful algal blooms, and expansion of invasive species (*likely*, *high confidence*). Federal and state agencies and NGOs are cooperating on adaptation efforts related to streamflow, water quality, and other water issues (*high confidence*).

Suggested title: "Climate Change Will Likely Adversely Affect the Quantity and Quality of Water for Consumption, Economic Use, and Recreation."

Water quality and quantity aspects are highlighted in this region, particularly for use in agriculture and in urban areas. The focus is on direct water quality impacts such as erosion and algal blooms. There is less attention to the Great Lakes, which has its own problems that are uniquely important to the region and should be discussed.

Comments on Traceable Accounts

There are no citations in the traceable accounts; the traceable accounts should include citations to explain how the knowledge base supports the key messages. The logic of the traceable accounts, however, is well done. The traceable account section for Key Message 24.1 is the most complete. It is important to make clear to the reader what is known about attribution directly to climate change and what is not. One of the most important challenges in climate change research has been the suitability and certainty of scaling down to regional or local impacts. The science has improved, but it remains a challenge. Therefore, some additional language on how certainty levels off at scale, and where the scale (as opposed to thematic) gaps exist in the literature for this region would be appropriate. It is important to use region-specific data and analysis and describe when proxies are used.

Comments on Graphics and Boxes

The figures and graphics are useful, to the extent that they have been presented. The lack of figures in many cases limited the review and as figures do become available, the author team should be aware of the lack of review.

Comments on Equity and Justice

For consistency, the Committee suggests that the chapter introductions frame equity and justice in the context of the chapter topic and include how different dimensions of recognition, procedure, and distribution are addressed. Consistent with recommendations in Chapter 2 of this report, terminology should be specific and consistent throughout the chapter. The discussion of equity and justice issues could be improved by more consistent integration throughout the chapter. A good review of existing literature on heath and food disparities would help. In the introduction and throughout the sections, more attention needs to be paid to environmental justice concerns. Some statements refer to Indigenous groups, but there should be a stronger emphasis on both Indigenous and other vulnerable populations throughout the chapter. Only Key

Message 24.3 includes reference to communities of color, for example. Page 24-24 does have some discussion that more vulnerable people will be more heavily impacted. In addition, the importance of data justice, the equitable availability and access to relevant data and information to support community climate action, should be addressed. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The chapter uses models to project hazards onto key biophysical parameters such as water temperature and runoff, but less so for other parameters. This chapter does a good job documenting sources of statements (e.g., Key Messages 24.1 and 24.2).

Comments on Literature Cited

This chapter does a reasonably good job documenting sources of statements in the text on key messages, but not in traceable accounts.

Other Recommended Changes

Key gaps include almost no discussion of the growth of biofuel use and production in the Midwest, how climate change is affecting biofuels, and what is projected for the future. Another key gap is the lack of discussion of wind power growth in the Midwest, and its relation to farm incomes, land-use, biological systems, and the distributed grid.

The chapter fails to note connections to other regions. For example, the discussion of major rivers does not mention how dependent the flow of the Missouri and lower Mississippi are to that of the Rocky Mountains and the Ohio and Tennessee rivers.

The “warming hole” text is confusing, and the other interesting aspects should be emphasized more—for example, an increase in spring and fall temperatures would cause an increased growing season, which would impact an early bud break that has an impact on outright crop failure, or the wet early springs would delay planting. Thus, there are complexities, especially in agriculture, that should be discussed; some impacts may not be known, but what is known is that there could be considerable unintended consequences and surprise events. Is it also appropriate for the text and traceable accounts to note knowledge gaps.

Similarly, more attention should be paid to the important role that natural variability plays. For example, page 24-3, lines 15-17, states, “By about 2050, temperatures across the Midwest are expected to increase between 3°F and 5°F under an intermediate scenario (RCP4.5) relative to 1986-2015, with more than an 8°F increase projected by the end of the century under a very high scenario (RCP8.5) (Hayhoe et al. 2018).” There should be caveats on this statement because there are large uncertainties and natural variability in these estimates, and a reference to how uncertainty and interannual variability grows when looking at smaller regions in Chapter 3 (Earth System Processes) would be appropriate. Additionally, the reference for this statement should be revised to reference current climate projections directly rather than relying on results presented in NCA4.

CHAPTER 25: NORTHERN GREAT PLAINS

Summary

Overall, this chapter is well written, thorough, and comprehensive, with only a few omissions that need attention. The Committee commends the chapter authors for including recent developments in this chapter, such as the Inflation Reduction Act. The chapter also has a good balance of both positive and negative aspects of expected impacts from climate change, especially compared to Chapter 1 (Overview). This chapter is close to meeting the requirements of Section 106 of the GCRA, and, with additions and revisions specified here, the Committee believes it will meet those requirements.

For the most part, the key messages are well stated and supported by the detail provided within the chapter. However, some key messages are too detailed or too broad and lack support in the text of the chapter. Additionally, some important regional trends are omitted altogether. Suggested literature and topics for inclusion are detailed below. Mitigation is a key omission in the chapter; one of the last two key messages should discuss mitigation efforts in the Northern Great Plains. The chapter couches the discussion of energy and energy transition topics as "the transition from fossil fuels to renewable energy sources" (see page 25-22, lines 3-4). This is not an accurate representation of what is occurring or the content of other chapters (e.g., Chapters 5 [Energy Supply, Delivery, and Demand], 32 [Mitigation]). In addition to the buildout of renewables, there is a push for low- and zero-carbon technology deployment in the Northern Great Plains region.

Most of the chapter is written at a technical level that is appropriate for the intended audiences. The Committee calls out specific language concerns in Appendix A. The Committee suggests the chapter authors cross reference other chapters where possible (e.g., Key Message 25.4 could reference Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]), which not only emphasizes the inherent connection between topics, but also may help lower the word count in some places to make space for important additions. The traceable accounts section does not document and support chapter's findings in a consistent, transparent, or credible manner and needs significant work to provide sufficient context for embedded content. Specific suggestions are provided below.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction should add context for the reader, especially considering the target audiences may be broad, and as defined in Chapter 2 of this report, includes decision makers, professionals, professors, teachers, and students with varying previous exposure to climate change literature. At the outset, the Northern Great Plains should be defined and the states that fall within the boundaries should be listed. This could also be done with a figure (e.g., "The NGP is one of the ten regions designated in the NCA5. It includes Montana, Wyoming, North Dakota, South Dakota, and Nebraska. See Figure ___."). Additionally, the distinction between natural variability and climate change should be described and better called out throughout the chapter, but also within the introduction. While the topical discussion in the introduction sets the stage

nicely for the key messages that follow, the chronology of the introduction could better match the content of the chapter text.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in the Northern Great Plains chapter reflect the current understanding of observed and projected climate impacts to the United States; however, the Committee suggests improving the clarity of language that describes whether the projected and observed changes are due to climate changes, natural variability, or both. The chapter discusses challenges, opportunities, and success stories for addressing risk and adapting to emerging issues related to climate change. Regarding formatting, the key message titles, as outlined in Chapter 2 of this report, would be more effective if they were short, informative statements rather than headers; the Committee makes suggestions for each key message titles below. The messages within each key message are written in a consistent and appropriate way and they reflect supporting evidence, include an assessment of likelihood, and communicate information effectively. However, some of the text in the findings is too inclusive or broad, and the topics discussed are not reflected in the supporting text (e.g., "spiritual health" in Key Message 25.2 is not mentioned in the bulk of the text under Key Message 25.2). Where there is uncertainty (documented in the traceable accounts) this may be worth mentioning in the supporting text.

Comments on Specific Key Message Language

> **Key Message 25.1. Trends and Extreme Events**
> The Northern Great Plains is experiencing unprecedented extremes related to changes in climate, including severe droughts (*likely*, *high confidence*), increases in hail frequency and size (*medium confidence*), floods (*very likely*, *high confidence*), and wildfire (*likely*, *high confidence*), with alterations in plant community and crop growth (*very likely*, *very high confidence*). Rising temperatures across the region are expected to lead to reductions in soil moisture, even in areas with increasing precipitation (*likely*, *high confidence*), as well as greater variability in precipitation (*very likely*, *high confidence*).

Suggested title: "Climate Change Is Expected to Continue to Cause Unprecedented Extreme Events."

> **Key Message 25.2. Human Health and Ecological Condition**
> Climate-related hazards, such as drought, wildfire, and flooding, are already harming the physical, mental, and spiritual health of Northern Great Plains residents (*virtually certain*, *high confidence*), as well as the ecology of the region (*very likely*, *medium confidence*). As the climate continues to change, it is expected to have increased and cascading negative effects on human health and the lands, waters, and species on which people depend (*very likely*, *medium confidence*).

Suggested title: "Extreme Events Caused by Climate Change Damage Human and Ecological Health and These Impacts Are Expected to Increase."

Key Message 25.3. Resource- and Land-Based Livelihoods
The Northern Great Plains is heavily reliant on agriculture and resource-based economies, placing residents' livelihoods at risk from the impacts of climate change and related policy. While agriculture and recreation will see both positive and negative effects of changing temperature and precipitation regimes (*likely*, *medium confidence*), climate-driven extreme events will continue to cause substantial and unpredictable damages (*likely*, *high confidence*). Energy-sector livelihoods will be affected by climate change as emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources (*likely*, *high confidence*). Climate change is expected to test the adaptive resilience of the region's residents, in particular rural, Indigenous, and low-income immigrant populations (*likely*, *medium confidence*).

Suggested title: "Climate Change, and Climate Adaptation and Mitigation Efforts, Are Expected to Impact Resource- and Land-Based Livelihoods."

The text of this message uses the limiting language "renewable energy sources" and "nonrenewable sources," which is not consistent with other chapters in the report that discuss a wider array of energy generation and do not limit the discussion to renewable and nonrenewable generation. This exclusive focus on renewable energy is also not representative of what is occurring within the region. In addition to widespread renewable deployment, the states in the Northern Great Plains are also undertaking carbon capture, utilization, and storage (CCUS), nuclear, hydrogen, and other low- and zero-carbon technologies. The Committee suggests that chapter authors revise this part of the key message to be more representative of the regional energy portfolio.

The statement in Key Message 25.3, "energy sector livelihoods will be affected by climate change as emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources (*likely*, *high confidence*)," conflicts with Key Message 32.3, "A US energy system with net-zero emissions would rely on widespread electrification of transportation, electrification of heating in buildings and industry, decarbonized electricity systems, and substantial electricity generation from solar and wind (*high confidence*). Low-carbon fuels would still be needed for some transport and industry applications (*high confidence*)," and Key Message 32.3, "Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). The ideal approaches to carbon management—including both carbon capture and storage and carbon dioxide removal—are similarly uncertain (*high confidence*), as is the potential to reduce land-related methane and nitrous oxide emissions through technical interventions (*medium confidence*)." These conflicts between chapters should be resolved, and facts should be cited and mentioned in Chapter 25 (Northern Great Plains).

Key Message 25.4. Navigating Complex Tensions and Trade-Offs
Climate change is creating new and exacerbating existing tensions and trade-offs between land use, water availability, ecosystem services, and other considerations in the region, leading to decisions that are expected to benefit some and set back others (*very high confidence*). Decision-makers are navigating a complicated landscape of shifting demographics, policy and regulatory tensions, and barriers to action (*high confidence*).

Changes in temperature and precipitation averages, extremes, and seasonality will alter the productivity of working lands, resulting in land-use shifts to alternative crops or conversion to grasslands (*likely*, *medium confidence*). Shifts in energy demand, production, and policy will change land use for renewable and nonrenewable energy infrastructure (*likely*, *medium confidence*).

Suggested title: "Climate Mitigation Efforts Require Complex Trade-Offs Because Climate Change Will Likely Alter Resource Availability Differently Across the Region."

This key message is very long and vague and should be refocused on mitigation efforts and trade-offs (see supporting text discussion). The Committee also suggests rewriting the message part of the key message to reflect first what is certain from a mitigation standpoint, then discuss what is uncertain.

Key Message 25.5. Building the Capacity to Adapt and Transform
Early adaptation is under way to address the effects of climate change. Agricultural communities are shifting toward climate adaptation measures such as innovative soil practices, new drought-management tools, and water-use partnerships (*medium confidence*). Several tribal nations are leading efforts to incorporate traditional knowledge and governance into their tribal adaptation plans (*high confidence*). Resource managers are increasingly relying on new tools such as scenario planning to improve the adaptive capacity of natural ecosystems (*medium confidence*).

Suggested title: "Climate Adaptation Efforts Are Already Under Way."

Comments on Text Supporting Key Messages

Key Message 25.1. Trends and Extreme Events. Regarding drought, the text is not clear. The message of this key message says that increased temperatures are expected to offset increased precipitation, while the supporting text states that soil moisture will decrease in the southern part of the region. However, the more in-depth discussion on drought on page 25-10 does not address subregional differences. Thus, the key message implies increased temperatures are expected to offset increased precipitation across the region, but there are nuances not captured by the supporting text. The Committee suggests clarifying whether this trend is expected everywhere or just within some parts of the region. Additionally, this chapter does not cover the trend of corn production (monoculture practice) moving into South and North Dakota. This is a concern for adaptation because corn, which is a trademark of this region, is more sensitive to extreme events and requires higher inputs of chemical treatments than other crops (suggested literature for this topic is included below).

Key Message 25.3. Resource- and Land-Based Livelihoods. This key message uses "likely" and "high confidence" for the statement that "energy-sector livelihoods will be affected by climate change as the emissions-reductions policies drive shifts to renewable energy sources and away from nonrenewable sources." However, there is no discussion of the mitigation efforts under way that are impacting and will continue to impact, energy sector livelihoods. The Committee suggests adding a discussion about mitigation to Key Message 25.4.

Key Message 25.4. Navigating Complex Tensions and Trade-Offs. Mitigation is a critical omission from the chapter. The supporting text for this key message discusses mitigation

efforts, so the Committee suggests stating mitigation in the title of the key message as well as the content of the message and the supporting text. The supporting text for this key message is broken into "renewables" versus "nonrenewables" without consideration of emerging low- and zero-carbon energy technologies (discussed in other chapters, such as Chapters 1 [Overview], 5 [Energy Supply, Delivery, and Demand], and 32 [Mitigation]) and presently being implemented and deployed by commercial, state, and federal actors in the Northern Great Plains region.

The Committee suggests no separate section headers for tensions and trade-offs, and instead to include all topics under no header (they are all tensions and trade-offs) and discuss the following: navigating barriers to mitigation; transition in energy systems; and land-use change and conversion including, agriculture to grassland, energy land-use changes, and shifts in crops.

Key Message 25.5. Building the Capacity to Adapt and Transform. The supporting text for this key message is missing a discussion on energy, particularly given that Key Message 25.3 notes that the region's share of employees working in fossil fuel extraction is four times greater than the nation as a whole. The key message would benefit from a discussion about how adaptation and mitigation will impact this workforce.

Comments on Traceable Accounts

Because the traceable accounts section lacks citations and explanation, the chapter does not identify and provide sufficient context for embedded content, and it does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message. Each key message's traceable account should make modifications based on the outline for traceable accounts provided in Chapter 2 of this report.

In addition to the broad guidance in the introductory chapter, the Committee makes the following suggestions for each key message's traceable account section to ensure the section provides sufficient context for embedded content and reflects current scientific understanding.

In Key Message 25.1, the NOAA State Climate Summaries should be cited in the supporting text if used in the traceable account, and if they are, the same citation should appear here. The Committee offers the same comment for US Geological Survey trend and attribution efforts mentioned. The note that the Northern Great Plains region also includes other water basins is a great distinction. Every time a study, an independent scientific assessment, an analysis, or other documents in the literature is discussed, it should be cited. All mentions of uncertainty and gaps should also have citations. The second paragraph is exemplary and should serve as a model for the whole of the traceable accounts section. The paragraph discussing the productivity of rangelands needs citations and a discussion about how authors came to their conclusions.

For Key Message 25.2, the Committee suggests ensuring literature with a national or international scope noted as such in the text and gaps in knowledge regarding the region as well as differences across the region are noted. For example, the citations on increased mental health in the region (page 25-12, line 31) seem to have a national scope rather than a focus on the Northern Great Plains.

For Key Messages 25.2, 25.3, 25.4, and 25.5, all summary statements referring to "several studies," "NOAA state climate summaries," and "multiple peer-reviewed studies" need citations, and the references should also be cited in the summary text. The traceable accounts should not introduce new literature not already cited in the main text.

Comments on Graphics and Boxes

The graphics and captions are effective and appropriate, but several changes would facilitate greater clarity and utility across audiences. Specifically, the following figures could benefit from modifications outlined below.

The title of Figure 25.1 should have a slash between tribal reservation and trust lands to improve the clarity of the text "Rurality Measures and Tribal Reservation/Trust Land in the NGP."

The Committee suggests including state boundaries in Figures 25.2, 25.4, and 25.5 in grey/black on regional images so that it is clear where impacts are most severe. Likewise, Figure 25.6 should include state boundaries in grey/black on regional images to emphasize geographical differences across states. Additionally in Figure 25.5, the Committee suggests moving change to the bottom, so the image reads start (2004-2010) to end (2011-2015) and with change after. Figure 25.6 should indicate for each that they are displayed by county (or whatever regional delineation is used) for the farmland map and the social vulnerability map. Additionally, indicate what A, B, C, D, and E refer to on the social vulnerability map (e.g., "Examples detailed in later text are called out using A-E").

In Figure 25.3, notating the watershed regions with lines instead of brackets would make the figure clearer. In the caption, instead of "less than 0.85" use "less than 85 out of 100" for consistency with the previous sentence.

In the caption for Figure 25.10, change "averages" to "means." This image may be trying to do too much. Consider naming each image A, B, and C to differentiate that they are all different pieces and not one image. Alternatively, label the bottom image the key. Additionally, the Committee suggests moving the image to after all the text in this section.

Comments on Equity and Justice

This chapter could benefit from some framing of equity and justice-related issues in the introduction, including the different dimensions of equity. Specific issues should then be integrated throughout the chapter. Identify the range of vulnerable populations and provide some systemic context. The chapter contains a discussion of adaptation by Indigenous communities and has some examples of tribal adaptation and vulnerable population risk due to extreme events caused by climate change. It contains some discussion of the vulnerability of Indigenous communities to adaptation, particularly in food and agriculture. However, risks to vulnerable communities, particularly energy-sector workers (see discussions above) and low-income rural communities are not addressed and should be added. The Committee also suggests using consistent terminology to discuss vulnerable populations, tribal populations, and other populations of concern across all chapters, as there is a great deal of variety across chapters. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter does accurately reflect the peer-reviewed scientific literature or other source information cited, with a particular focus on literature since NCA4, but there is one concerning citation. The water rights discussion in "Adaptations in Agriculture" needs clarification, revision,

and additional attention. There is a citation to "confusing water law" in the "Navigating Barriers to Adaptation" section (Charnley et al., 2020) that does not support the sentence it is used in—it does not discuss water rights in detail and to the extent it does, they are not applicable because the paper's case study is in the Northwest, not the Northern Great Plains.

The Committee also suggests clarifying language throughout the chapter to reflect where the trends are national versus regional. For instance, the mental health section text states that climate change is expected to amplify risks to mental health. This statement could be interpreted as applicable to the Northern Great Plains region since this is a regional chapter, but the citations are national-level and global-level studies (this section is citing Burke et al. [2018] and Yazd et al. [2019]). The Committee suggests looking for additional resources that are newer than 2014-2016 or refining confidence language to reflect older literature, particularly in the "Water Quality" discussion.

Other Recommended Changes

The chapter authors may consider the following notes for further improvements to the chapter. The chapter reads somewhat choppy and disjointed, especially compared to other chapters. Some sections would benefit from transition phrases, words, and sentences to add clarity and ensure broad comprehension. Using active voice where possible will also help; some sentences could benefit from an active voice rewrite (identified in Appendix A where possible). Other sections read very smoothly and have adequate active voice. Some other regional chapters (e.g., Chapter 22 [Southeast]) have addressed baseline trends and a discussion of "trends" in population, land-use, urban growth, etc., which if provided here could nicely set the context for the regional discussion.

For the most part, this chapter accurately reflects the peer-reviewed scientific literature. However, a few topics are not discussed. Mitigation is a critical omission from the chapter and is discussed above. The literature on the movement of the corn belt is also an omission and is discussed above. The Committee also suggests mention of wildfire impacts to albedo, snowmelt, and compounding impacts to flood risk and landslides.

CHAPTER 26: SOUTHERN GREAT PLAINS

Summary

Overall, the Committee commends the chapter authors for developing an exemplary chapter. The chapter does a great job of discussing the issues facing the Southern Great Plains region and is written at an appropriate technical level for the intended audiences. The chapter meets the requirements of Section 106 of the GCRA. In general, the key findings are well stated and supported. However, the key message titles are headers and should be revised to short, informative statements. Additionally, the chapter uses football to provide tangible connections to climatic extremes felt throughout the region, and the Committee suggests varying its examples to include other important activities in the region. The chapter does not adequately incorporate equity and justice principles. Specifically, there are issues associated with tribal lands relating to equity, mitigation and adaptation that should be discussed. There is also no discussion on the

distributional impact of the transition from fossil fuels to zero and low-carbon technologies on workers and industries in the region.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is well written, describes the region well, provides the appropriate background and context to the region as it relates to climate change, and introduces the key messages. However, it would be helpful to introduce which states comprise the Southern Great Plains region, for example, with a figure. Additionally, the introduction should highlight new information since NCA4 as well as note topics that will not be covered in the chapter. Figure 26.1 on precipitation intensity does not support the statement of more frequent high-intense rain events in Kansas and Oklahoma. There are other figures that better illustrate the change in precipitation events. While energy as the driver of the region's economy is emphasized in the introduction, agriculture should also be included as it is a major contributor to the region's economy.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in Chapter 26 (Southern Great Plains) reflect the current understanding of observed and projected climate impacts to the United States; however, the titles of the key messages should be revised to stand out as short, informative statements. This suggestion is consistent with the recommendation provided in Chapter 2 of this report.

Comments on Key Messages and Supporting Text

> **Key Message 26.1. How We Live: Impacts to Place, Culture, and Health**
> Climate change is beginning to alter how we live, putting us at risk from climate hazards that degrade our lands and waters, quality of life, health and well-being, and cultural interconnectedness (*high confidence*). These hazards are expected to become more frequent, intense, prolonged, or broader in spatial extent and to result in more people experiencing costly, deadly, or stressful climate-related conditions in their lives (*very likely*, *high confidence*). Effective climate-resilient actions include implementing nature-based solutions; valuing Indigenous, traditional, and local knowledges; and infusing climate change solutions into community planning (*medium confidence*).

The title of the key message is written as a header instead of a statement. The Committee suggests slightly modifying the first sentence of the key message and using it as the title (e.g., "Climate change is beginning to alter how we live, degrading lands and waters, quality of life, health and well-being, and culture interconnectedness"). In this key message, the chapter authors should also consider the increased incidents of grassland wildfires. Over the past few years, large-scale fires have destroyed cattle herds, and infrastructure (e.g., fencing, homes) and even caused human deaths, and this should be noted.

> **Key Message 26.2. How We Work: Impacts to Business and Industry**
> As climate conditions change, businesses and industries across the Southern Great Plains are experiencing disruptions and losses in productivity and profits—but also new economic opportunities (*high confidence*). In coming decades, warmer temperatures, more erratic precipitation, and sea level rise are expected to force widespread and costly changes in how we work (*very likely*, *high confidence*). Businesses and industries have the opportunity to harness their diverse knowledge, resources, and workers to develop products and services in climate mitigation technologies, adaptation strategies, and resilient design that will enhance the region's economy (*medium confidence*).

The title of the key message is written as a header, but the first sentence of the key message would be an effective title.

This key message emphasizes the transition to renewable energy, stating on page 26-11: "Throughout the region, a major shift in energy generation from fossil fuels toward renewables (KM 5.3) is underway, creating new jobs, cleaner air, and climate change mitigation benefits." The Committee suggests including a discussion of the distributional impact on those workers who used to work in the fossil fuel industry in this section. For example, electricity from coal might not increase, but is it expected to decrease, and the effect on jobs in the region should be noted.

To add a specific example to the text supporting this key message, the chapter authors could use the example of when an early heat wave killed several thousand cattle in southwest Kansas in April 2021. The early heat wave was before the regular notifications went out from NOAA of the heat index for cattle. Another important agriculture issue to note in this section is that the western region of the Southern Great Plains is irrigated agriculture from the Ogallala aquifer. The combination of lower precipitation and a declining aquifer will cause dramatic changes in agriculture production and rural communities' economy. An example of the impact on agriculture that could be discussed is the drought in 2011-2012 that reduced the feed supply to livestock, resulting in the livestock being transported to the Northern part of the Great Plains. This caused an increase in cost (transportation) and, ultimately, a decrease in the cattle herd.

> **Key Message 26.3. How We Play: Impacts to Recreation, Sport, and Leisure**
> Extreme climate-related events are negatively influencing how we participate in outdoor sport, recreation, and physical activities across the Southern Great Plains (*very high confidence*). Climate change is expected to increase heat-related illness and death and reduce outdoor physical activity (*very likely*, *high confidence*). Individuals, communities, and sports organizations can adapt to these hazards through strategies such as modifying the timing, location, intensity, or monitoring of activities (*high confidence*).

The title of the key message is written as a header, but the first sentence of the key message would be an effective title. The Committee appreciates the example where recreational activities are affected by climate change. However, the example of college football being impacted by hurricanes and extreme rainfall events supports a stereotype of the region. A better example would be to show the impact of the relocation of families affected by hurricanes.

Key Message 26.4. How We Heal: Impacts to Justice and Equity
Some neighborhoods and communities in the Southern Great Plains are suffering disproportionately from climate-related hazards because of marginalization, discrimination, governmental policies, and exposure to pollution and environmental degradation (*very high confidence*). Climate change impacts are expected to overburden the people, neighborhoods, and communities with the fewest resources to prepare and adapt (*very high confidence*). Our institutions and governments can improve outcomes for these people and places by adopting climate adaptation and hazard mitigation practices and policies that center on equity and justice for community risk reduction, resilience, and repair from past injustices (*medium confidence*).

The Committee suggests using the first sentence of the key message as the title.

Key Message 26.5. How We Serve: Impacts to Services and Public Infrastructure
The institutions that serve our communities have been challenged to respond and adapt to more frequent and intense weather events (*medium confidence*). Without significant adaptations, climate change is expected to strain water supplies, transportation infrastructure, and emergency services across the Southern Great Plains (*high confidence*). Actions that can enhance our community resilience include substantially reducing emissions; installing or retrofitting climate resilient infrastructure; educating students and the public on climate change impacts; and cultivating the capacity of faith- and volunteer-based aid organizations to assist hazard planning, response, and recovery (*medium confidence*).

The Committee suggests using the first sentence of the key message as the title.

Comments on Traceable Accounts

The traceable accounts for Chapter 26 (Southern Great Plains) provide accurate and sufficient support for the embedded content, including providing sufficient justification of confidence levels based on literature cited. The "Major Uncertainties and Research Gaps" sections should cite literature that was introduced in the main body to support the discussion.

Comments on Graphics and Boxes

The graphics and captions are effective and appropriate; however, the Committee has a few minor suggestions to help make them more accessible to broader audiences.

Figure 26.1 states, "Since 1985, 2-inch precipitation events have occurred more often than in the past in Kansas and Oklahoma." It is unclear, as presented, if this trend is significant. The Committee suggest providing some clarification.

Figure 26.2 should use the standard labels for RCP4.5/RCP 8.5 (intermediate/very high), instead of calling these "lower emissions" and "higher emissions" as was done in NCA4.

The title of Figure 26.4 should reflect whether this figure is for this region only or is more general.

Figure 26.10 lists the sources in its caption as "University of Oklahoma, NOAA NCEI, and CISESS NC." It is important to note if the data used to create this figure also came from these sources, and if so, they should be included in the reference list.

Figure 26.14 extends the stereotype of the importance of football in the region. A more appropriate figure could be used to communicate to the reader the impact of extreme events and society.

Figure 26.17 should define and explain "ILCP."

Figure 26.19 includes examples that are too general and do not specifically address equity and justice. The Committee suggest including more specific examples.

Figure 26.23 is missing clean water access in this framework. During the winter storms, the water supply system might also get interrupted.

Comments on Equity and Justice

The chapter provides some framing of equity in the introduction, but could benefit from connecting related dimensions (distributional, recognitional, procedural, intergenerational) and their implications for climate justice. The Committee appreciates the historical context provided, attention to the importance of data sharing, and the environmental justice focus of a key message, but urges the chapter authors to look for areas to better integrate equity and justice throughout the chapter. In addition, some perspectives and examples to highlight systemic interconnections would be beneficial. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter reflects the peer-reviewed scientific literature or other source information cited and incorporates ample recent literature appropriate for NCA5.

CHAPTER 27: NORTHWEST

Summary

Overall, Chapter 27 (Northwest) is thorough, comprehensive, well written, and documented. This chapter does a very good job focusing on the social and economic impacts of climate change to the region. The chapter clearly addresses the requirements of Section 106 of the GCRA. It provides a brief, but thorough evaluation of the climate research specifically focused on the Northwest and clearly identifies the scientific uncertainties associated with the key findings and messages within the chapter.

The key messages are easily identified, generally well stated, and generally supported by the main text. The findings are consistent and supported by timely and transparent research, with the majority of citations since NCA4. Additionally, the Committee appreciates the broad range of resources that are used and referenced. Chapter 27 (Northwest) is written at a technical, yet accessible, level with engaging language that is digestible and of interest to a broad group of audiences as defined in Chapter 2 of this report. An area which might need some extra work is

related to the rather unique regional climate pattern related to ocean dynamics and temperatures, as this region's biological and ecosystems are particularly influenced by the Pacific modulation of precipitation and temperature patterns. An interesting aspect of this region is the atmospheric rivers, which define much of the ecosystem structure and function, and will be influenced by climate change. These systems also influence snowpack and snow melt, setting up a complex set of interactions related to water flow, aquatic habitat impacts, albedo with receding glaciers and snowpack in evergreen forests. At the same time, regional terrain is important to ecosystems and complicate predictions, such as species migration and future ecological dynamics. More specific data related to these aspects and the concomitant complexities inherent in this region would be useful on the climate impacts from changes in these systems.

The Committee commends the many tribal examples throughout the chapter. The focus on tribal nations and Indigenous people is clear and appropriate for the Northwest region and is an important demonstration of significant climate change adaptations and mitigation developments. A notable example is the climate-smart forestry and carbon emission mitigation projects that the Yurok tribal communities have developed. These activities are good examples of carbon financial markets as well.

The "Built Infrastructure" section has the greatest opportunity for improvement. The focus on water, transportation, and energy (Key Message 27.4) could be better linked, perhaps through a brief discussion about state and local climate planning. The urban section struggles to cover a lot of ground given the word count limitations, however, that section could be more focused to better address housing impacts (Key Message 27.4) consistent with the first key message. Specifically, the section should clarify capacity or constraints related to land-use, housing, multijurisdictional planning, and the pace and scale of implementation.

Finally, Chapter 31 (Adaptation) clearly states that progress being made is not sufficient to meet identified climate goals. This chapter does not have the same emphasis on the work that still needs to be done and should identify additional challenges, limitations, or urgency.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is clear, compelling, and written at an appropriate technical level for broad audiences. Additionally, it provides the context and background on the Northwest region as it relates to climate change; however, the Committee suggests including a brief statement highlighting topics that are not covered in the chapter.

Comments on Key Messages, Supporting Information, and Traceable Accounts

Overall, the key messages in this chapter reflect the current understanding of observed and projected impacts of climate change on the Northwest region, and each key message and associated supporting text appropriately identifies the challenges, opportunities, and success stories with a range of broad to very specific examples and is communicated effectively. The key messages are ordered logically and speak to the issues facing the people who live there. Additionally, the chapter emphasizes the importance of multiple stressors. However, there are

known success stories for activities in this region focused on climate change mitigation, which could be emphasized.

The Committee more specific suggestions below, but as outlined in Chapter 2 of this report, the Committee suggests rephrasing all the key message titles to that they are short, informative statements, thereby making them more effective and impactful. Additionally, the key messages offer confidence intervals, but no likelihood assignments. If there is quantitative data available to support a finding in a key message, there should be a likelihood rating as well as a confidence rating.

Comments on Specific Key Message Language

> **Key Message 27.1. Frontline Communities and Social Equity**
> Climate change exacerbates underlying inequities: frontline communities—those now facing the worst impacts of extreme heat, flooding, and wildfires—have often been subjected to discriminatory policies historically (*very high confidence*). Despite such challenges, frontline communities in the Northwest—including urban low-income communities of color, rural and natural resource-dependent communities, and tribes—have shown strong resilience to climate change and legacies of historical and generational trauma (*high confidence*).

Suggested title: "Frontline Communities Disproportionately Affected by Climate Change Often Show Strong Examples of Resilience."

The statements in this key message are both very high and high confidence but lack specific likelihood language. Likelihood language should be added if there is quantitative evidence to support the statements,

> **Key Message 27.2. Ecosystems**
> Ecosystem structure, composition, and function are expected to change as climate variables like temperature and precipitation change and as the magnitude and frequency of extreme climate events increase (*very high confidence*). Historical and ongoing human activities, which reduce ecosystem resilience and the adaptive capacity of some species, are expected to exacerbate many effects of climate change (*very high confidence*). Adaptation actions founded in ecological theory and data are expected to improve ecosystem functions and services and reduce exposure to climate change hazards (*medium confidence*).

Suggested title: "Climate Change Will Reduce Resilience of Ecosystems in Complex Ways."

The statements in this key message are very high confidence with one medium confidence but lack specific likelihood language. The medium confidence statement references adaptation actions being expected to improve ecosystem function, which is consistent with other confidence levels on adaptation actions but should be addressed more fully whether in this chapter or in Chapter 31 (Adaptation). The Committee suggests coordinating with the authors of Chapter 31 (Adaptation) and cross-referencing accordingly.

Key Message 27.3. Regional Economies and Livelihoods

Climate change impacts to the Northwest's natural resource and outdoor-dependent economies will be variable, given the diversity of industries, landcover, and climatic zones (*very high confidence*). This diversity imparts economic resilience to resource-dependent industries through opportunities for climate adaptation and mitigation (*medium confidence*). Impacts to these industries will have cascading effects on community livelihoods and well-being; however, a just transition can ameliorate some of these impacts (*medium confidence*).

Suggested title: "Climate Change Has Cascading Effects on Job Sectors and Regional Economies."

The assertions in the key message are very high confidence with two medium confidence statements, but they lack specific likelihood language. The medium confidence statements reference the economic resilience of resource dependent industries, and the Committee suggests rephrasing these.

Key Message 27.4. Built Infrastructure

Recent climate-related events have stressed water, housing, transportation, and energy infrastructure across the Northwest (*very high confidence*). Extreme precipitation events, droughts, and heatwaves, intensified by climate change, will continue to threaten these interrelated systems (*very high confidence*). Given the complexity and interconnectedness of infrastructure systems, an impact or a response within one sector can cascade to other sectors (*high confidence*). Cross-sectoral and multisystem planning, which can include reengineering and redesigning aging infrastructure, can increase resilience to future climate variability and extremes (*high confidence*).

Suggested title: "Climate Change Puts Critical Infrastructure at Risk."

The statements in the key message are very high and high confidence but lack specific likelihood language. Additionally, it is unclear if the "very high confidence" rating in the second sentence refers there being extreme events, or that climate change is intensifying them.

Key Message 27.5 Public and Community Health

The Northwest's climate has historically been temperate and relatively mild but shifting weather patterns associated with climate change are adversely affecting physical, mental, and community health (*high confidence*). The incidence of illnesses and death during extreme heat events and wildfire smoke days is increasing, and climate change is compromising health-protective community infrastructure (*high confidence*). Climate related health risks disproportionately affect certain individuals and groups (*very high confidence*). Climate resiliency efforts can be leveraged to improve health, especially among the most vulnerable populations (*high confidence*).

Suggested title: "Climate Change Has Costly Impacts on Public and Community Health."

The statements in the key messages are assigned very high and high confidence but lack specific likelihood language.

Key Message 27.6 Heritage, Sense of Place, and Amenities
Climate change has disrupted sense of place in the Northwest, affecting non-economic amenities like proximity and access to nature and residents' feelings of security and stability (*high confidence*). Place-based communities, including tribes, face additional challenges from climate change because of cultural and economic relationships with their locale (*very high confidence*). Leveraging local or Indigenous knowledge and value systems can spur climate action to ensure local heritage and sense of place persist for future generations (*medium confidence*).

Suggested title: "Climate Change Has Disrupted Sense of Place in the Northwest."

The statements in the key message are very high and high with one medium high confidence but lack specific likelihood language. The Committee appreciates the inclusion of the medium confidence statement related to the leveraging of local or Indigenous knowledges to ensure local heritage and sense of place persist for future generations.

Comments on Text Supporting the Key Messages

Key Message 27.1. Frontline Communities and Social Equity. The Committee appreciates that the first key message in the chapter emphasizes environmental justice, and that there are separate sections on urban, rural, and tribal communities**.** However, in the section "Climate Action and Social Equity," authors use the term "climate gentrification." Various terms have been used throughout the draft NCA5 report, including "eco-gentrification" and "green gentrification," and as outlined in Chapter 2 of this report, the Committee suggests standardizing terminology across chapters. Additionally, there are notable examples of successful community-based forestry carbon management projects and programs, which would be useful to highlight as existing cases of mitigation that benefit local communities and family forest owners directly. King County is one example, which could be featured by highlighting novel local government activities in carbon financial markets with projects focused on communities and family forests. It was the first local authority to offer carbon credits to local forest managers and demonstrates mitigation and adaptation initiatives already under way. Links to Chapter 7 (Forests) could also be used to highlight work done by tribal communities related to mitigation and adaptation.

Key Message 27.2. Ecosystems. In addition to discussing ecosystems, this key message could also expand its discussion of climate change impacts on natural resources, which are important aspects of the regional economy. There could be more discussion of climate impacts to agriculture and forestry in particular. This discussion could heavily reference what is already written in Chapter 7 (Forests) and Chapter 11 (Agriculture, Food Systems, and Rural Communities) and then focus on specific examples for this region. This discussion should include the impact of invasive insect species, especially regarding climate-mediated migration or dispersal, in the context of forest health. An additional area to consider expanding relates to the discussion of regional climate dynamics. The dynamics of climate change are complex in this region. The warm Pacific currents and the notable atmospheric rivers are discussed, and how this system will respond to climate change presents difficult management and adaptation issues. These complexities are reinforced by SLR, topographic effects, and changes in snowpack and melt water runoff. The response by ecosystems, many of which are economically important, such as forests, is difficult to forecast. Thus, this section could be strengthened with more discussion of the regional climate regime and how it may affect ecosystems under climate change. One way

to describe complexity against a backdrop of natural conditions, climate-change impacts, and land-use pressures would be to expand the example boxes. Box 27.2 could be a basis for this kind of discussion. Figure 27.4 could also be integrated into this box with more elaboration on exactly how climate change exacerbates the effect of other stressors on salmon.

Lastly, although the introduction included an interesting overview of the atmospheric rivers' influence on total winter precipitation, there is very little discussion of how this relates to climate change, if at all. It is sufficiently interesting to the reader that some discussion of it seems warranted in this key message.

Key Message 27.3. Regional Economies and Livelihoods. This key message lays out the importance of natural resources to the regional economy and livelihoods of the people who live there; it benefits the audiences' understanding of the direct importance and impact of climate change by use of economic impact indicators such as crop losses and rising insurance costs. It also considers fisheries and forestry, which is useful for showing diversity of the natural resource-based economy. Box 27.3 is an excellent example of the climate impacts on tribal economies that provides equity and justice perspectives as well. However, the narrative could be expanded here to use examples of successful tribal responses. Tribal communities in the NW region have developed extremely good and notable climate change adaptation and mitigation demonstrations, which could be described, since they provide positive examples of current activities that have been quite successful. A notable example is the climate smart forestry and carbon emission mitigation projects the Yurok tribal communities have developed. These activities demonstrate excellence in carbon financial markets as well.

Key Message 27.4. Built Infrastructure. This section focuses on water, transportation, and energy clearly with challenges, opportunities, and success stories, but is too narrowly focused on infrastructure planning and design without additional discussion on the built environment or planning beyond these identified infrastructure categories. Instead, there should be a discussion on the capacity of local, regional or state entities to plan and implement adaptation and mitigation measures. The Committee suggests that the section on "Urban Areas and Urban Infrastructure" be focused more specifically on housing rather than urban areas and infrastructure. As a topic, urban areas and urban infrastructure is too expansive to adequately be addressed here given word count limitations, and therefore, focusing on housing would be more impactful. The Committee also suggests expanding paragraph 2 of the "Energy Infrastructure" section to include a statement that references Figure 27.8, particularly in relation to transportation electrification, hydropower, and clean energy transition.

Key Message 27.5. Public and Community Health. The Committee commends the authors for providing a good overview of health, from physical to mental to community. Other chapters do not discuss mental health, which is an emerging focal point for discussions on climate change impacts on health issues, so this chapter is outstanding in this regard.

Comments on Traceable Accounts

Generally, traceable accounts for this chapter provide accurate and sufficient context for the embedded content. However, although the traceable accounts are well cited, a number of the "Major Uncertainties and Research Gaps" as well as the "Description of Confidence and Likelihood" sections lack citations. The Committee suggests that the authors make clear what literature is used to specifically distinguish human-cause climate factors from natural factors.

Comments on Graphics and Boxes

Many images and graphics in this chapter were not available for the Committee to review, which makes them difficult to evaluate. The captions, however, are clear and robust, so hopefully the images and graphics match the descriptions well. The charts and maps are clear.

The graphics and tables in this chapter are effective and appropriate, however, they could be better integrated into the text overall. The Committee suggests separating Table 27.1 into two tables (i.e., Tables 27.1 and 27.2). Additionally, the sea-level projections shown in Table 27.1 use neither IPCC nor Sweet et al. (2022) projections; sea-level projections should be presented consistently throughout NCA5 as described in Chapter 2 of this report.

The chapter's use of boxes for examples is good but note that there is no Box 27.1. The box examples could be used to demonstrate the complexity of climate change in this region, for example, the interactions of climate and land-use change, atmospheric rivers, topography, and other factors.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated. Environmental justice, tribal nations and Indigenous challenges, opportunities, and success stories are integrated throughout the chapter. The authors have offered a strong depiction of vulnerable communities as well as their historical and systemic connections. The consistent integration of equity and justice issues throughout the chapter warrants stronger framing in the introduction. Where the different dimensions of equity are described, they should be named. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Data and Analyses

The data shown in figures are clear, credible, and applied appropriately.

Comments on Literature Cited

This chapter appropriately reflects the knowledge base and does incorporate ample recent literature appropriate for NCA5.

Other Recommended Changes

The chapter mentions potential federal-tribal partnerships a few times (e.g., Box 27.3, Key Message 27.6). The Committee suggests adding an example(s) of successful, impactful partnerships.

CHAPTER 28: SOUTHWEST

Summary

This chapter meets the requirements of Section 106 of the GCRA, except for its lack of focus on conditions 25 to 100 years from now, similar to other chapters. The key messages are well written and supported by the details provided in the chapter or by other chapters. The documentation of the key findings is well written at levels mostly appropriate for the intended audiences. More coordination with, and reference to, other chapters is needed in cases where other chapters address some of the issues discussed here in greater detail or from broader perspectives.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction is structured as an introduction to the region and to the variety of challenges and (some) opportunities in the region. As such, it helps to motivate and provide a foundation for the chapter. The final two paragraphs provide an overview of climate change (and adaptation efforts) in the region, which is useful, but care should be taken so that this discussion sets up, rather than attempts to provide a summary of, the chapter's contents. It would be more helpful if these paragraphs were less summary material and more explicitly structured to introduce and prepare the readers for what the remainder of this chapter will focus on and how it will be structured, and then let the remaining text do its job.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The five key messages address water scarcity; the coastline and coastal ecosystems; impacts on agriculture from heat and drought; impacts of heat and wildfire smoke on human health especially in vulnerable populations; and wildfire impacts on ecosystems, people and water. These key messages capture the high-priority issues for the region and are ordered in a logical way (water is at the heart of everything in the Southwest). The supporting discussions are lengthy and occasionally technically dense; they could be broken up with additions of topical subsection titles, as in some other chapters. Key message titles should be written as short, informative statements rather than phrases, and suggested alternative titles are provided below.

Comments on Specific Key Message Language

Key Message 28.1. Water Resources
Climate change has reduced surface water and groundwater availability for people and nature in the Southwest (*very high confidence*), and there are inequities in how these impacts are experienced (*high confidence*). Higher temperatures have intensified drought (*high confidence*) and will lead to a more arid future (*likely*); without adaptation, these changes will further stress existing water supply–demand imbalances (*very likely*). Flexible and adaptive approaches to water management have the potential to address

changing risks, mitigating impacts on people, the environment, and the economy (*medium confidence*).

Suggested title: "Water Availability in the Southwest Is Declining with More Declines to Come."

This key message provides a quick outline of climate change challenges to the region's water resources. As short as it is, the listing of challenges and linkages is generally good.

Key Message 28.2. The Coast

Large-scale marine heatwaves and harmful algal blooms have caused profound and cascading impacts on marine coastal ecosystems and economies (*high confidence*). Without implementation of adaptation or emissions reductions measures, human-caused warming will drive marine heatwave temperatures even higher (*very high confidence*, *very likely*), amplifying negative coastal effects (*medium confidence*). Sea level rise, along with associated impacts such as flooding and saltwater intrusion, is *likely* to have severe and disproportionate effects on infrastructure, communities, and natural resources (*very high confidence*). California state government has applied climate science to planning and decision-making for sea level rise, and multiple regions are moving toward climate-informed and adaptive strategies for fisheries (*high confidence*); however, climate planning and adaptation solutions for aquaculture are less clear (*high confidence*).

Suggested title: "The Coast Is Being Impacted by Rising Ocean Temperatures, Acidity, and Sea Levels."

Although a lot of information is packed into this key message, it is well written and mostly at a level appropriate to the audiences. Nonetheless, references to Chapter 10 (Oceans and Marine Resources) could be used to reduce the length and technical density here, to focus this section on Southwest specific issues. The key message is well supported and makes good use of confidence statements. However, some statements describe historical and current conditions and others describe future projections, so confidence and likelihood labeling might both be needed, and could help to signal which claim is better. This key message (and supporting discussion) focuses on warming ocean waters and acidification initially, and then turns to SLR. Notably, this key message mentions mitigation. The negative impacts of marine heat waves and harmful algal blooms on fisheries are emphasized. SLR will disproportionately affect poor people in affordable housing in the region.

Key Message 28.3. Food and Agriculture

Continuing drought and water scarcity will make it more difficult to raise food and fiber in the Southwest (*high confidence*). Extreme heat events will increase animal stress and reduce crop quality and yield, thereby resulting in widespread economic impacts (*likely*, *high confidence*). Because people in the Southwest have adapted to drought impacts for millennia, incorporating Indigenous knowledge with technological innovation can offer solutions to protect food security and sovereignty (*medium confidence*).

Suggested title: "Food, Fiber, and Agricultural Production in the Southwest Are Becoming More Difficult."

This key message is simple and clear. Both descriptions of high confidence in this key message are not necessarily supported in general, but a caveat like "without major adaptation or new methods and strategies" would help justify the confidence levels given. This key message (and supporting discussion) does not treat forestry as a form of agriculture, although upon reading just the key message, it seemed like "fiber" might include wood. This is not unusual, but the chapter authors could consider making an exception to include forestry in this section because climate change threatens the region's forests and wood industry in ways not handled under Key Message 28.5 alone. This key message would be an appropriate place to inject some of those other forestry issues (e.g., bark beetles and loss of productivity) that also will plague "agriculture proper" without adding many words. Other chapters could be cross-referenced (e.g., Chapter 7 [Forests]) so there would only be a need to briefly mention specific forestry impacts in this region. This key message does not consider urban water supplies and vegetation much, which motivates the need to retain (and minimally expand) the discussion of urban water supplies under Key Message 28.1.

Key Message 28.4. Demographics and Human Health

Increases in extreme heat, drought, and wildfire activity are negatively impacting the physical health of Southwest residents (*high confidence*). Climate change is also shaping the demographics of the region by spurring the migration of people, primarily from Central America to the Southwest (*medium confidence*). Individuals particularly vulnerable to increasing climate change impacts include the elderly, outdoor workers, and people with low income (*high confidence*). Local, state, and federal adaptation initiatives are working to respond to these climatic and demographic changes and help people and communities become more resilient (*medium confidence*).

Suggested title: "Personal and Population Health Are Adversely Impacted in Many Areas by Climate Change."

This is a reasonably well written description of the human health costs of climate change in the Southwest. Climate change is one of several factors driving immigration to the region from Central America. These immigrants can add to vulnerable populations (i.e., poor, outdoor workers). Health impacts include air pollution from wildfires (i.e., $PM_{2.5}$), extreme heat, high ozone, and dust, causing acute and chronic illness with very high costs. As written, this key message is ordered as "Human health and demographics" rather than as titled, "Demographics and human health."

Key Message 28.5. Wildfire

In recent years, the Southwest has experienced unprecedented wildfire events, driven in part by climate change (*high confidence*). Fires in the region have become larger and more intense (*high confidence*). High-severity wildfires are expected to continue in coming years, placing the people, economies, ecosystems, and water resources of the region at considerable risk (*very likely*, *high confidence*). Opportunities for adaptation include both pre- and post-fire actions that reduce wildfire risk and facilitate ecosystem restoration, including supporting the application of Indigenous cultural fire and other traditional land stewardship practices (*medium confidence*).

Suggested title: "Wildfire in the Southwest Is Increasing in Size and Intensity Due in Part to Climate Change."

This key message is well written, at an appropriate level, and the most densely packed overview in this chapter. The key message (and supporting materials) is restricted entirely to wildfires in forests, despite the fact that far more of the region, more of the wildland-urban interface, and more of the region's wildfire occurs in chaparral, sagebrush steppe, shrubland, grassland and savanna, and other landscapes (e.g., Westerling et al., 2003). This missing perspective is problematic because at least some of the generalizations and statements apply to woodland forests but not to the other settings. Much of this content could be drawn in by more allusions to Chapters 7 (Forests) and 8 (Ecosystems, Ecosystem Services, and Biodiversity) with little addition to this chapter's length. Although the key message highlights Indigenous practices, the discussion is notably lacking in discussion of that topic.

Comments on Text Supporting the Key Messages

Key Message 28.1. Water Resources. Direct citations of (and more coordination with) Chapter 4 is needed, given the necessary brevity of the discussion here, but no such citations appear in the present draft. The supporting text begins with a description of current megadrought conditions over the Southwest but is implicitly a description of the Colorado River basin. The Colorado River was already in trouble, now it is in big trouble. This issue appears prominently in the supporting materials for this key message but should not be treated as "representative" of what is happening in the region as a whole without explicitly supporting citations or qualifications. In other words, brief additional mention of megadrought conditions in other parts of the region would be helpful.

This initial paragraph, along with Box 28.2 (which appears to be misnumbered—there is no Box 28.1), appropriately focused attention on the recent and ongoing water shortage on the Colorado River. This problem has come to the fore in the past several years, following streamflow declines that have spanned the past two decades and brought the river's reservoirs to the brink of disaster. The box strictly avoids direct mention of climate change, which is a problem, leaving that issue to the beginning of Key Message 28.1 (page 28-5, line 28), where the causes of the drought are only partially laid out. In other words, the impacts of warming on this megadrought are summarized, but the contributions of long-term precipitation deficits are sidestepped. The assertion that water supplies have been reduced by climate change already is well supported in the literature (e.g., Gangopadhyay et al. [2022], and references therein), but failure to mention that not all the current drought is confidently ascribed to warming is likely to mislead readers. The paleorecord (not mentioned here, but implied in Key Message 4.5, Figure 4.19, though not cited or discussed in this chapter) indicates clearly that long-term precipitation deficits like the one contributing to the current megadrought have happened naturally in the past. Beyond that, current projections of future precipitation are for more precipitation (Figure 4.2) across the northern half of the region, including the Upper Colorado River basin, so that attributing recent, prolonged precipitation deficits to climate change would be hard to justify. Thus, although the current "megadrought" in the Colorado River Basin bears the signature of climate change, in that warming and an associated increase in evaporative demand and evapotranspiration (as a fraction of precipitation) is larger than historical norms, this is one part of the cause of the drought. This is a climate-change-enhanced drought, or a hot drought as in Williams et al. (2020, 2022). However, any reader who is not well acquainted with the large

paleoclimate literature regarding past droughts in the Colorado Basin is likely to interpret the discussion here and later in this chapter as attributing the entire drought to climate change, and that is misleading.

One way to link climate change and impacts in the Colorado River basin into ongoing adaptation would be to mention that, as of summer 2021, the US Bureau of Reclamation has adjusted some of its probabilistic outlooks for major Colorado River reservoir conditions to explicitly explore the drier conditions of the past several decades rather than relying entirely on the full range 20th century climatic conditions for its probabilities.

The key message discussion appropriately emphasizes that snowmelt is important and will be earlier, leading to flooding and decreased water resource availability for energy and water use. The paragraph discussing groundwater impacts (especially related to levels of confidence) should be sure to coordinate directly with the discussion in Chapter 4 (Water). Flooding in the Southwest is caused by both extreme precipitation (mentioned here) and by extreme snowmelt conditions (not included in the paragraph on flooding on page 28-7, line 18), including winter storms that are increasingly rainfall rather than snowfall-dominated and rain-on-snow events. More importantly, the strong emphasis on drought in this key message leads to too little attention to flood issues. A single paragraph mentions the flood threat in the Southwest, and only explicitly describes future increases in terms of atmospheric-river storms. Intensifying atmospheric rivers are of particular importance to future Southwestern water supplies, hydrologic hazards (e.g., floods), and even wildfires later in the year (e.g., Albano et al., 2020; Westerling et al., 2003). This section should explicitly make the connection between increased atmospheric rivers (and other storm) intensities and increased floods, flood risks, and other risks and benefit (Huang and Swain, 2022). The section should also briefly outline the fact that preparations for, and recoveries from, floods are expensive and difficult, and will challenge many existing infrastructures of all kinds (e.g., not just water infrastructure as many examples from the winter of 2023 now show). The chapter appropriately discusses how drought will intensify in the Southwest, but an even more important; however, the chapter should also emphasize that both droughts and floods are expected to intensify, leading a future that is fraught with both extremes.

The key message discussion ends with a listing of examples of adaptation approaches that have been implemented and planned around the region. This list notably does not include explicitly nature-based approaches, and is mostly drought oriented, ignoring challenges to water quality and from flooding.

Key Message 28.2. The Coast. The level of detail and diversity of impacts and some adaptation strategies described is impressive in such a brief section, although some of the terminology used (in interests of concision) is highly technical and not self-explanatory. It might be worth noting that usage of the term “marine heat wave” is a recent development in the literature and especially in the public view, which gives some suggestion as to how quickly coastal and oceanic conditions are being observed to change (as recently as 2015, the common usage in both the media and scientific meetings was “The Blob”). Nature-based solutions are included along with the hard-engineering options in this key message. Reference to other chapters, that have more space to address these coastal issues (e.g., Chapters 9 [Coastal Effects], 10 [Oceans and Marine Resources]) is lacking and might help to free up space for even more discussion of adaptation and specific impacts.

Key Message 28.3. Food and Agriculture. In California’s Central Valley (Figure 28.6 and related discussions) and in other important riverside agricultural settings elsewhere in the region, flooding of agricultural lands is likely to be an increasing risk, but both here and in Key

Message 28.1, most attention and verbiage is focused on droughts. The Southwest is projected to increase the occurrences of both extended droughts and occasional but extreme floods, and this discussion should reflect that complexity.

On page 28-17, the characterization of problems at the Salton Sea due to competition between urban and agricultural water demands is incomplete and problematic. The Salton Sea is declining—to the extent that urban demands are playing a role—because historical inefficiencies in (and leakage from) agricultural water conveyances and irrigation methods are being reduced, to free water for urban uses, but they were water delivery and application inefficiencies corrected, not supplies taken away. Thus, challenges facing the Salton Sea are not the best example of competing urban and agricultural water demands; rather, the challenges illustrate a possible maladaptive outcome from efforts that limit water supplies farther. In other words, the Salton Sea is not as direct an urban-rural water competition as, for example, the Owens Valley or competition between Phoenix and agricultural developments in Arizona (Karimi, 2023).

Key Message 28.4. Demographics and Human Health. Page 28-22 mentions annual average $PM_{2.5}$. While this metric is relevant to National Ambient Air Quality Standards, this broad metric may obscure important episodic spikes in $PM_{2.5}$ that are important to note. The text does make the point that average $PM_{2.5}$ was decreasing until the wildfires raged. This point should not obscure the importance of air pollution mitigation actions.

Also on page 28-22, there is an assertion of "a lack of occupational health standard for farmworkers and outdoor workers." There is no federal heat standard that ensures the safety and health of workers who are exposed to dangerous heat conditions in the workplace, which is a particular concern in the hot, arid climates of the Southwest. California, Minnesota, and Washington, as well as the US military, have adopted their own heat stress standards successfully. The Occupational Safety and Health Administration is working on rulemaking nationally (*Federal Register*, 2021b). This full context should be noted.

Also on page 28-22, line 19-20, it speaks to loss of drinking water sanitation after fires, but experience in California is that more often, there is loss of water supplies for months. In this section, it is also important to identify landslide risks with heavy rain on recent burn areas. It is mentioned in the wildfire section, but it is beginning to amount to a public health hazard.

On page 28-24, it is helpful to mention the Centers for Disease Control and Prevention's Building Resilience Against Climate Effects program, which is now up to 10 states with small funding allocations, though this is expected to increase under the Inflation Reduction Act. While the program has been small, it has developed methods and strategies that can be scaled up.

Key Message 28.5. Wildfire. The stage-setting literature references (i.e., first paragraphs of the supporting material) tend to be evaluations by climatologists of climate impacts on wildfire risks, rather than literature from the forestry or fire community itself, which may have led to overgeneralizations based on their woodland forest focus. The discussion of this key message should start by pointing out the diversity, and maybe proportions, of wildfires in different types of vegetation (e.g., grassland, shrubland, forests) in the region and that some Southwest ecosystems are fire adapted, and some are not; this statement comes a bit late.

The section on adaptation should acknowledge that strategies of reducing tree density and wildland fuels only pertain to certain forested ecosystems in the west and are noneffective and counterproductive in other ecosystems. There are other strategies to reduce human ignition risk in addition to fuels reductions (which does not even appear in the list on page 28-26, line 29), such as land-use planning and zoning that reduces low density housing in the wildland-urban interface and makes properties fire resistant without extensive and counterproductive clearing of

vegetation. Furthermore, invasive species control will reduce fire risk in desert ecosystems not adapted to fire where invasive grasses have promoted fire in the Southwest region. Finally, the comment that "prescribed fire may be curtailed due to public concerns" (page 28-28, lines 8-9) could be strengthened to emphasize that it is extremely difficult to use prescribed fire at the scale necessary to manage forest fuels and counteract the historical effects of fire suppression because of concerns (and laws) about air quality, human health, and losses of structures and human life.

Very large areas are being impacted by the enhanced wildfires being experienced, especially where multiple fire scars accumulated over the recent decades. This discussion of impacts seems to be focused on what happens within the footprints of individual wildfires, including extremely large footprints recently, but the cumulative footprints are increasingly changing whole drainage basins, watersheds, and landscapes (e.g., Williams et al., 2022). Cumulative area-wide impacts have risen to levels where they require some attention and discussion here.

The discussion of this key message is focused almost entirely on how to reduce wildfire occurrence and property impacts. Another increasing concern, following several recent megafires in the Southwest, is how to reduce human mortality, for example, by requiring new buildings and communities to have appropriate escape routes.

Comments on Traceable Accounts

This chapter has a more complete and consistent use of citations to support the assertions of the traceable accounts than some other draft NCA5 chapters. Among the traceable accounts, the Key Message 28.4 is the best cited and justified and may be a good model for chapter traceable account revisions generally. The traceable account for Key Message 28.5 has the most readable description of confidence levels. However, some additional discussion to justify—rather than just state—the likelihood assignments is warranted, as discussed in Chapter 2 of this report. Furthermore, the key messages mostly offered confidence assignments and very few likelihood assignments, and explanation for how the authors made these assignments is needed.

The traceable accounts for this chapter use citations are inconsistently and the emphasis on particular topics does not sufficiently support statements in the key messages and supporting text. The overall "Process Description" provides good context for understanding the chapter contents. The "Descriptions of Evidence Base" for Key Messages 28.1 and 28.3 (and, to an extent, Key Message 28.2) are notable for their brevity and thus how little they say, which is a problem. Key Message 28.2 "evidence base" is described without a single citation, while the others use and provide citations more sensibly. The "Major Uncertainties and Research Gaps" section for Key Messages 28.1 and 28.5 are sparsely supported by citations, while Key Messages 28.2 and 28.3 use no citations at all; without some literature support there is no foundation (other than personal conjecture) for describing the uncertainties and no basis for judging and describing the gaps.

"Maladaptation" appears once in all the traceable accounts (page 28-30, line 16), but not once in the body of the chapter. This is an important consideration (with respect to all the key messages and their discussions of adaptation strategies) that should not only be introduced in passing in one traceable account.

The discussion on page 28-32, describing how the US average SLR will progress, lacks substance. SLR on the California coast has been progressing more slowly than on the US east coast or even on the other side of the North Pacific (see Chapters 9 [Coastal Effects] and 10

[Oceans and Marine Resources]). Part of this slower change is due to multidecadal North Pacific climate variations that are believed to be natural. Current best understanding is that the natural circulations that have kept rising global water levels away from the west coast, and instead over in the western half of the North Pacific, can be expected to reverse themselves at some point in the future (Bromirski et al., 2011, 2012; Moon et al., 2013). When this happens, the "pent up" SLR Pacific can relax back toward the US west coast so that west coast SLR will tend to catch up (likely rapidly) to the global averages. Thus, US averages of SLR are almost meaningless for the Southwest region. This issue should be included at least briefly in the chapter text and incorporated into considerations in this traceable account. Stated another way, recent SLR and future projections for the Southwest region are nowhere as simple nor certain as this traceable account implies.

Comments on Graphics and Boxes

The figures used here are well done and accessible. Additional infographic-type summaries of processes and risks, such as Figures 28.1 and 28.6, would be valuable for the other key messages, but such syntheses may be hard to come by.

In Figure 28.2a, "reduced soil moisture" (page 28-7, line 2) is in contradiction to what is shown in Figure 28.2a for most places of the Sierra Nevada (as far as this figure extends). When an observed change is in the opposite direction of the projections of future change (see also Figures 4.4 and 4.6), it is important to either avoid attributing the observations to climate change or to provide some specific reasons why the observations are due to climate change despite disagreeing with projected expectations.

In the caption of Figure 28.5 (page 28-13, line 3), "including the Delta" is the only mention in this chapter of this important sea-level risk at the heart of California's large-scale water-supply conveyance systems. Conveyances between northern and southern California are projected to have highly likely, long-term (~18-month) disruptions when SLR-hastened levee breaks occur; a brief mention of this problem in Key Message 28.2 is needed.

The figures supporting Key Message 28.4 are not viewer friendly. Figure 28.7 conveys important and readily understandable information (heat reduces work capacity, and this will increase with climate heating), but the visual requires close reading of a long, detailed caption.

In Figure 28.8, some more explanation of how this resilience measure is estimated is needed (e.g., which risk factors are considered). A brief mention should be made as to how such factors are "modeled" in the caption or text. Finally, it is worth pointing out that some of the areas of highest risk coincide with Indigenous communities.

Comments on Equity and Justice

The authors provide some framing of equity and justice in the chapter introduction, which could additionally benefit from the integration of related dimensions (distributional, procedural, recognitional, intergenerational equity). The extent to which equity and justice issues are integrated into the key message discussions varies a lot. Only impacts on Indigenous communities are discussed in Key Message 28.1 supporting materials, although the topic is raised in the key message itself. A new citation that could provide a starting point for a broader view of key disparities facing urban populations in the Southwest is Sanders et al. (2023). The impacts of SLR on housing for vulnerable (coastal) populations are discussed for Key Message

28.2, while broader perspectives are addressed in Key Message 28.3. The immigrant demographics, and inequities in human health impacts and access to health services, are addressed in Key Message 28.4. The mention of Indigenous practices in Key Message 28.5 is appropriate, but then little discussed in the supporting text.

The final paragraph in Key Message 28.1 outlines the disproportionate challenges faced by Southwest tribes regarding water resources, but neglects consideration of other equity and justice groups and challenges—for example, access to water supply and quality for people with low income in urban and rural areas. These other disadvantaged groups are discussed explicitly in other key messages.

Key Message 28.5 is notable for mentioning Indigenous practices (in the context of wildfire) prominently, and then hardly mentioning them in the discussion. Given the growing literature specifically about actual and potential uses of traditional knowledge in wildfire management, this is a surprising gap. This could be enhanced by cross-referencing Chapter 7 (Forests), which does address this topic with the example of fire management and climate adaptation led by the Yurok tribe. Some relevant references cited in Chapter 7 (Forests) (e.g., Lake, 2021; Marks-Block et al., 2019) can be included. There may be other relevant discussion in Chapters 8 (Ecosystems, Ecosystem Services, and Biodiversity) or 16 (Tribes and Indigenous Peoples) that can be cross-referenced without adding much additional text to this chapter. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

The literature is generally timely with a focus on new findings since NCA5, and appropriate. It would be useful if, in addition to looking at the dates on the citations, the authors could call out some selected major advancements of the science, data, or understanding since NCA4, either in the introduction or in the text.

On page 28-4, line 37, no references are provided regarding improved modeling of invasive species, biodiversity loss, or ecosystem transformations (the provided references all pertain to fire). At the very least, references to other chapters that do provide more information or detail are needed.

In the discussion of Figure 28.5 or in the discussion of SLR adaptation options (page 28-14, lines 13-24), it would be useful to cite important work by Wang et al. (2018) that describes how differences in seawall and levee (height) adaptations to projected SLR around San Francisco Bay are likely to yield disparate flooding impacts from one community to the next unless coastal infrastructures are adjusted in spatially coherent ways. There is a very important lesson, regarding a basic ground rule for adaptation planning, in this example—do no harm to your neighbors—that is worth capturing here.

CHAPTER 29: ALASKA

Summary

This chapter provides a well-written, comprehensive account of how the state will change and is being impacted by climate change. The chapter meets the requirements of Section 106 of

the GCRA. The authors did an exceptional job crafting the narrative of the chapter and not just listing facts, which made it an interesting and easy chapter to read. The chapter authors also did an excellent job cross-referencing other chapters in the draft NCA5 report. The findings begin with current conditions and then look toward the future, albeit not that far into the future given the rapidity of existing changes. The chapter emphasizes societal implications of climate change for Alaskans' health, communities, livelihoods, built and natural environments, security, and its future. The key findings are well stated and supported by details provided throughout the chapter and traceable accounts. The Committee commends the authors for clearly acknowledging arenas where positive changes have occurred and where real opportunities for improvement will emerge.

The Committee suggests that the authors ensure additional context is provided in some of the examples, so that audiences not familiar with Alaska can understand what is being discussed.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction in this chapter is longer than the introduction in some other chapters, and the NCA5 authors should decide on a consistent format for introduction length (see Chapter 2 of this report). Depending on the decision, the authors may consider segmenting out a section of the introduction and adding another key message. It would be helpful if the introduction provided a very brief discussion of findings in past assessments (i.e., NCA4). The large focus on human systems is useful and warranted, but for a reader who is unfamiliar with Alaska, it will seem like a large portion of the chapter related to the physical science and impacts of climate change on the state is missing. Table 29.1 is a great visual tool for organizing information in the introduction and setting the stage for the rest of the chapter and is a model for other chapters to follow.

Comments on Key Messages, Supporting Information, and Traceable Accounts

This chapter is generally written at an appropriate technical level for broad accessibility. However, the first-person language within the key message titles (i.e., "our" and "we") is imprecise for the intended audiences. Revising the language could be an opportunity to develop more informational key message titles (see Chapter 2 of this report for further explanation). The key messages could also be strengthened by including more assessments of likelihood. The detailed information provided within the traceable accounts section is appreciated. However, the tracible accounts should be expanded to discuss the evidence base for the likelihood evaluations which are added to the key messages.

Comments on Specific Key Message Language

Each key message begins with "our" which implies belonging to both the author and the reader or only the author and alienating the reader if the reader does not feel that connection. The Committee suggests revising the key message titles to be short, informative statements will be more impactful for broader audiences.

Comments on Text Supporting the Key Messages

Key Message 29.1. Our Health. This section describes how climate change is impacting the health of Alaskans, and how it might affect them in the future. Throughout this section, it would be useful to clarify when the literature reviewed is specific to Alaska versus studies that are generally about climate change and health. The chapter authors are urged to evaluate the contribution of climate change to the described health impacts more carefully. For example, on page 29-10, lines 32-39, it is not explicit how harmful algal blooms (HABs) affect people. Chapter authors should explain how HABs end up food sources and why these food sources are important. In addition, on page 29-11, lines 3-6, it is unclear whether the lack of indoor plumbing was the primary driver of COVID-19 infections. If more than one factor is described in the study, it might be better to frame this as a contributing factor versus a causal relationship.

Key Message 29.2. Our Communities. This section discusses how (current) residents and communities in Alaska will be impacted but neglects the somewhat longer view of how the state will fare as it becomes a more and more attractive climate for living in the future. Consider using more specific language than "communities"—it is not clear what is being referred to (e.g., Alaska Native communities, intersectional lens on people who live in particular ways and affected by particular drivers). This section would be more precise and less ambiguous if there was a brief discussion about how communities were defined and what language is being used to reference Alaska Native communities specifically. Consider discussing whether and how Alaska is planning for "climate gentrification" and a climate-driven in-migration, which may occur in the future, if evidence is available.

Key Message 29.3. Our Livelihoods. This section read as unbalanced. Figure 29.7 lays out five main economic impacts of climate change on the state, yet two long paragraphs are about fisheries, two short paragraphs are about subsistence, and one paragraph is a catch all. This section could be strengthened by cutting back the discussion about fisheries and including more discussion about the other economic sectors that correspond with each part of Figure 29.7.

Key Message 29.4. Our Built Environment. Overall, this section is well written. Like other sections, it could be more precise with further discussion of what is intended by the word communities. The chapter authors may also consider briefly mentioning the legal and governance challenges related to relocation, in that no one entity is legally responsible to pay for these relocations.

Key Message 29.5. Our Natural Environment. This is generally a well written section. However, it could be strengthened with more references or concrete examples to support the discussion about increasing conflicts over fish and wildlife resources (page 29-25, lines 14-18).

Key Message 29.6. Our Security. Consider expanding the focus of this key message to "safety and security" or define security. As written with a focus on national security, it is confusing to have the Alaska native security also included in this section. Clear definitions could make this section more coherent, despite the different types of security being discussed.

Key Message 29.7. Our Future. This is a very well written section. However, chapter authors may consider briefly mentioning or citing a reference that describes the Alaska Native Claims Settlement Act and the unique tribal governance structure in Alaska. Chapter authors may also wish to expand the discussion about how this complicated governance structure makes climate change decision making more difficult, and even leads to conflicting goals between the corporations and the regional organizations. This section also could be strengthened with an expanded discussion of climate change mitigation activities in the state.

Comments on Traceable Accounts

The traceable accounts for this chapter are generally short and lack references and should be expanded to explain the supporting evidence for each key message. The discussion of how chapter authors determined confidence and likelihood for each key message should also be expanded on.

In the traceable account for Key Message 29.1, the Committee appreciates the inclusion of climate-induced mental health impacts and responses. The chapter authors appropriately note the dearth of studies looking at climate-related mental or emotional health. Therefore, the Committee suggests avoiding the generalization of impacts reported from a few papers from one study in eastern Canada with First Peoples to all Indigenous peoples and Alaska Natives. Suggested edits are noted in Appendix A.

Comments on Graphics and Boxes

The Committee appreciated the effective tables, figures, and boxes in this chapter. Most captions are very well written and include an appropriate amount of detail and references back to the source material. The Committee suggests that all captions have citations back to the source material if they are summarizing the state of the knowledge. The Committee suggests that all maps have scales and key labels. Because many readers may be unfamiliar with the locations discussed throughout the chapter and the nature of Alaska's geography and infrastructure, the authors may consider adding a summary map in the introduction with places called out throughout the chapter identified.

Table 29.1 serves as an introductory executive summary of the chapter and could be a template for the introduction of other chapters.

Regarding Figure 29.2, at the point in the chapter this figure is introduced, it seems odd that these examples are dropped in here. The Committee suggests providing more context and designing the examples to have a similar look and feel to each other. The Denali Park Road figure looks like there is a rock on the road and it does a poor job characterizing the problem. The figure suggests that rocks block the road to the lodges, but that is not really the nature of the problem.

Figure 29.8 could be reassessed as to whether it best represents the authors' intended message of importing seafood into a fishing village. Additional comments are provided in Appendix A.

The authors make a good use of boxes to share examples and firsthand accounts throughout the chapter. The boxes are nice vignettes, but the authors should consider providing some additional detail to the boxes to be more effective stand-alone stories. For each box, include some additional context about the place or ecosystem being referenced (i.e., Kotzebue is a community of X people, located X), the quotations (i.e., where is this person, who is this person, how do they interact in these spaces), and impacts (i.e., sea/river ice trends that make travel more dangerous) so that readers can better understand the vignette. Consider pairing the quotes with some data or a graph to add this context. Some of the best boxes in the draft NCA5 report include firsthand accounts, research, and climate trend information presented together.

Box 29.1 is a good inset box but could be expanded on. The firsthand account would be more meaningful for audiences if chapter authors provided context about this region, the people, and local conditions. For example, a figure with sea ice trends for the region or more information

about how residents have to go on the ice to gather food would help readers better understand the firsthand account.

Box 29.2 could be much more impactful if chapter authors put the fact "snow and cold are expected, rain is not" into context with some data to further show how this was an unusual event. Authors may also consider expanding on how the community was not equipped to respond to these conditions, with power outages for days, lack of road work, etc.

Box 29.6 is thin in context. The Committee suggests adding more information, such as a brief discussion about tribal sovereignty, or further contextualizing the examples. The Knik example could be strengthened by mentioning how much land is in cultivation and how many other people are being fed.

Comments on Equity and Justice

In general, this chapter does a good job applying an equity and justice lens with respect to Alaska Native people. Although the authors mention the other kinds of racial/ethnic diversity in the state and the data are limited, there is not much discussion on how climate change will affect people overburdened due to other races or other factors. This discussion could be expanded on. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

Additional references are needed throughout this chapter any time a claim is made. There are especially limited references with respect to some descriptions of climate impacts, cryosphere processes and change and as a physical driver for many impacts on society. For example, on page 29-4, lines 26-29, and page 29-5, lines 10-14, a series of trends in climate impacts is mentioned but not referenced. Key Message 29.1 should reference Dannenberg et al. (2019).

Other Recommended Changes

Adaptation and mitigation seem to be interchangeable in some instances. Mitigation is generally underappreciated throughout the draft NCA5 report, as discussed in Chapter 2 of this report. In addition, the implications of a changing climate on the fossil fuel industry and economy of Alaska are not addressed. Authors should consider addressing what is known about trends in fossil fuel development as it may be impacted by changes in policy and regulation intended to limit GHG emissions, and subsequent ripple effects or instabilities on the state's economy.

In addition, this chapter would benefit from more precise language when describing climate change, natural variability, and the impact of other drivers. Similarly, the chapter authors should be precise when talking about Alaska Native communities versus the use of communities as an encompassing term. Chapter authors should also be mindful that there is an overall balance between discussions about marine and terrestrial ecosystems. As written, marine ecosystems are well described and referenced with concrete examples, whereas terrestrial ecosystems could be emphasized more.

CHAPTER 30: HAWAI‘I AND US-AFFILIATED PACIFIC ISLANDS

Summary

The Hawai‘i and US-Affiliated Pacific Islands (USAPI) chapter satisfies Section 106 of the GCRA and provides effective key messages that are relevant for the target audiences with a particular emphasis on the power and success of adaptation strategies rooted in traditional and Indigenous knowledges. The chapter also emphasizes equity and justice throughout by highlighting groups that are disproportionately affected by climate change, particularly as it pertains to mental and physical health. The supporting content for the key messages is well written and contains references to a substantial body of recent literature. Areas for improvement include the lack of connection to the physical-science basis both within the chapter and across the draft NCA5 report; inaccurate links between SLR scenarios and IPCC emissions scenarios; and unclear or insufficient descriptions of confidence likelihood in the traceable accounts.

The Committee notes that Chapter 1 (Overview) mentions Hawai‘i only a handful of times and the USAPI only once in a table. Chapter 1 (Overview) (as well as other physical-science basis and national chapters) should be more inclusive of Hawai‘i, and especially the USAPI.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The first section of the introduction provides a brief yet adequate and well-written overview of the chapter.

The second section of the introduction provides the physical-science context for the chapter, which could be improved in a variety of ways. First, there is no connection to Chapters 2 (Climate Trends) or 3 (Earth System Processes), which provide the physical-science basis for the draft NCA5 report. Better utilization of these chapters would add additional context for this chapter by examining a wider range of climate trends and systems beyond precipitation and sea-level. The Committee notes, however, that these chapters do not adequately provide information for Hawai‘i and USAPI in many cases. The Committee outlines a recommendation in Chapter 2 of this report for those chapters and the draft NCA5 report overall to provide climate information equitably across all regions and territories, including for Hawai‘i and USAPI. The Committee encourages the chapter authors to incorporate this recommendation by leveraging and referencing the recommended additions to the physical-science basis chapters that will cover Hawai‘i and USAPI.

Second, there are few mentions of natural climate variability (e.g., Pacific Decadal Oscillation [PDO], El Niño–Southern Oscillation [ENSO]) and other non-climatic physical processes (e.g., changes in tides, vertical land motion) and their interactions with climate trends. ENSO is mentioned in the last sentence of the first section of the introduction, which elevates its importance and gives the expectation that this feature of climate variability—which is indeed critical for Hawai‘i and US-Affiliated Pacific Islands—will be robustly discussed throughout the chapter. However, ENSO is not mentioned again until the traceable accounts section of Key Message 30.1 (page 30-36, lines 8-11), and this is the only other place it is discussed. It is

recommended that the content related to ENSO be moved to the introduction due to its importance and then referenced throughout the chapter. Another relevant example of the importance of natural variability is the high rates of SLR in the western Pacific, which are not due to climate change alone, but rather a combination of climate change and natural fluctuations in the PDO. The authors cite Merrifeld and Maltrud (2011) regarding western Pacific sea-level trends, but there are more recent papers that highlight the relationship between these trends and the PDO (e.g., Merrifield and Thompson, 2018; Merrifield et al., 2012). This is essential context because scientists do not expect the trends in the western Pacific to continue unabated but rather to wax and wane over time with the PDO. Beyond climate variability, there is also subsidence in American Samoa (Han et al., 2019) that greatly exacerbates climate-related sea-level trends and is currently contributing to severe impacts on water resources and flooding in the territory. There is also no mention of the interaction of sea-level and variation in tides on decadal timescales that can alternately suppress or amplify the impacts of climate-driven SLR on the frequency of tidal flooding (Thompson et al., 2019, 2021). This is particularly important in Hawai‘i, where the interaction between tides and sea-level is expected to produce a rapid increase in the frequency of tidal flooding during the mid-2030s. There are likely other examples as well regarding variables other than sea-level, but in summary, it is essential that the target audiences of NCA5 (i.e., decision makers) understand that (a) not all trends are solely due to climate change, and (b) non-climatic trends and variability can both mitigate and exacerbate the impacts of climate change—sometimes alternating from one decade to the next—and these effects are important to consider in planning efforts.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages of this chapter are generally well written and useful for the target audiences, and they are organized into logical and distinct sectors. The supporting text and traceable accounts for the key messages contain many relevant and recent citations, demonstrating a thorough review of the recent literature on climate-driven impacts to the region. There are, however, general and specific ways in which the key messages can be improved. The discussion below addresses issues that span multiple key messages, followed by comments specific to existing content in individual key messages.

The titles of all key messages should be formulated as brief, informative statements rather than categories of information. For example, the current title for Key Message 30.1 is “Water and Food,” which should be recast as a statement such as “Climate change impairs access to water and food.” The title for Key Message 30.2 could be recast as “Climate change undermines human health; community strength boosts resilience” (or perhaps a version of that with fewer words).

There is little connection to the physical-science basis provided in the introduction throughout the key messages and their supporting text. Figures 30.2 and 30.3 describe trends in precipitation and sea-level but are never referenced outside the introduction. In general, the context provided by the introduction regarding the physical climate system needs to be woven throughout the key messages and connected to the statements and conclusions made.

Similarly, the Hawai‘i and US-Affiliated Pacific Islands chapter is largely siloed within the draft NCA5 report overall. The only other chapter cited within the Hawai‘i and US-Affiliated Pacific Islands chapter is Chapter 15 (Human Health). Otherwise, there is no attempt to connect with the wealth of material outside this chapter. The Committee suggests the chapter authors

identify ways to leverage the physical-science basis and information on human systems detailed elsewhere in the draft NCA5 report, including Chapter 16 (Tribes and Indigenous Peoples), which connects with the focus in this chapter on traditional and Indigenous ways of knowing and the role this knowledge plays in adaptation efforts.

Comments on Specific Key Message Language

> **Key Message 30.3. Built Environment, Livelihoods, and Economy**
> Climate change, particularly sea level rise, is damaging and will increasingly negatively impact buildings, infrastructure, and other elements of the built environment (*very likely*, *high confidence*) and will harm numerous sectors of the islands' economies (*very likely*, *high confidence*). Climate-driven changes will exacerbate existing social challenges—disrupting livelihoods (*likely*, *medium confidence*), reshaping existing human migration patterns (*likely*, *medium confidence*), and intensifying displacement (*very likely*, *high confidence*). Government and community groups have developed innovative ways to mitigate emissions and improve resilience by moving toward green infrastructure, nature-based urban planning, forward-looking building codes, and sustainable and equitable economic growth, ideally all guided by the best available science and traditional knowledge.

The chapter authors should be careful about using the word "will" when the likelihood is not *virtually certain*, because "will" implies certainty. Instead, the authors could use the NCA5 confidence/likelihood language within the sentence instead of in a parenthetical at the end of the sentence. For example, the first sentence could state, "Climate change, particularly sea-level rise, is *very likely* to increasingly negatively impact buildings…."

The phrase "increasingly negatively impact" is awkward. Perhaps the authors could shorten the phrase to just "increasingly impact" as the context implies the impacts will be negative, or "increasingly harm" which avoids any ambiguity about the valence of the impact.

> **Key Message 30.4. Ecosystems and Biodiversity**
> The structure and composition of Pacific Island coastal and marine ecological communities are directly threatened by rising ocean temperatures, ocean acidification, and sea level rise (*highly likely*, *high confidence*). Increasingly severe droughts and warming are increasing fire risk (*high confidence*) and will have broad negative impacts on native plants and wildlife, including an increased risk of forest bird extinctions (*very likely*, *high confidence*). Strategies to improve the resilience of Pacific Island ecosystems to climate change include ecological restoration and invasive species control (*medium confidence*), investments in fire prevention (*high confidence*), better stewardship of freshwater resources (*high confidence*), and avian malaria control (*high confidence*).

This key message uses the term *highly likely*, which is not part of the NCA5 confidence/likelihood language. The specific attributes, trends, and threats to US Pacific ecosystems, including the potential for effective adaptation through partnership with Indigenous knowledge holders, has strong parallels with Chapter 23 (US Caribbean), and the chapters could benefit from cross-referencing each other. Also, the interaction between climate change and other stressors (e.g., invasive species, novel fire regimes, land-use change) is the basis of Chapter

8 (Ecosystems, Ecosystem Services, and Biodiversity), and this key message should reference that chapter and perhaps seek to use similar terminology where relevant.

Comments on Text Supporting the Key Messages

Regarding the text supporting Key Message 30.3, as mentioned above, authors should provide likelihood rankings for the statements regarding SLR occurring as early as 2075. The Intermediate High scenario from the US Interagency Task Force (ITF) report (i.e., Sweet et al., 2022) does indeed correspond to the amounts of SLR by 2075 stated in the chapter. However, this scenario has a low probability of occurring within the IPCC emissions-based framework used throughout the draft NCA5 report. A helpful table in the ITF report is Table 2.4, which relates (albeit in an indirect way) the IPCC emissions scenarios and the ITF SLR scenarios. The second-to-last row shows the probability of the Intermediate High scenario given various levels of warming and the closest IPCC emissions scenarios in the top two rows, respectively. For the ITF Intermediate High scenario, there are very low probabilities of this scenario occurring for even high-end warming outcomes (i.e., 2% for 5ºC of global warming by 2100). Only in the very last column corresponding to Very High emissions (SSP5-8.5) and including low-confidence processes such as marine ice-cliff instability is there a substantial probability of the ITF Intermediate High scenario occurring—and even then, the probability is only 20 percent. To be clear, the use of the ITF Intermediate High scenario itself is not being criticized—the ITF scenarios are useful tools—but it is essential to provide proper context for the ITF scenarios in terms of the emissions scenarios and processes they represent. For example, the parenthetical on page 30-20, line 35, currently says, "under an intermediate–high SLR scenario; Sweet et al. 2022." This should be revised to reflect NCA5 language for likelihood (Front Matter, Table 2), noting that the probability of the ITF Intermediate High scenario is near the upper bound of the *likely* range for Very High emissions (Front Matter, Table 3) when including the possibility for marine ice cliffs to become unstable due to processes for which there is low confidence in projections One possibility is to change the parenthetical referenced above to be "under an intermediate–high SLR scenario that is physically plausible but *unlikely* under Very High emissions when including low-confidence processes; Sweet et al. 2022." Alternatively, the authors could use a lower scenario such as Intermediate, which is *as likely as not* to occur under Very High emissions when including low-confidence ice-sheet processes, but then the statements regarding amounts of SLR by 2075 should be altered. These issues also apply for other statements in this key message regarding SLR.

The Committee has no major concerns regarding Key Message 30.5, but the supporting text would benefit from cross-referencing other NCA5 chapters such as Chapters 16 (Tribes and Indigenous Peoples), 19 (Economics), and 23 (US Caribbean).

Comments on Traceable Accounts

The purpose of the traceable accounts is to directly support the key messages. Thus, the "Descriptions of Confidence and Likelihood" should support and provide the rationale behind the specific statements of confidence and likelihood made in the key messages. However, there is a general disconnect across all key messages in the Hawai‘i and US-Affiliated Pacific Islands chapter between the statements made in the key messages and the "Descriptions of Confidence and Likelihood" in the traceable accounts sections. For example, Key Message 30.3 attributes

both confidence likelihood levels to five statements. In the "Descriptions of Confidence and Likelihood" for Key Message 30.3, there is discussion of only one confidence statement and one likelihood statement, and the rationale provided for these statements is inadequate. The chapter authors should provide one-to-one descriptions for *how* they assess confidence and likelihood for each statement made in each key message, particularly when making likelihood statements for which the NCA5 language corresponds to specific probability ranges. The authors should describe how the probability assessments were made and under what conditions they are applicable. For example, when a predictive statement is *virtually certain*, the chapter authors should state whether this applies across all possible futures for society in terms of emissions or if it is only *virtually certain* under higher emissions scenarios (i.e., SSP3-7.0 and SSP5-8.5).

Along similar lines, the application of confidence versus likelihood statements throughout the key messages is inconsistent with the intended usage outlined in the Front Matter on page 0-9. Confidence is intended to be a *qualitative* statement based on the amount and consistency of information available. Likelihood is intended to be a *quantitative* statement based on observations and model projections or an assessment of such *quantitative* information across sources. It is often unclear whether the authors distinguish between the qualitative versus quantitative natures of the two types of assessments. For example, Key Message 30.3 states that it is *likely* that climate-driven changes will disrupt livelihoods, which, according to NCA5 confidence/likelihood language, corresponds to probability greater than 66 percent. The traceable account needs to explain how this probability is assessed. whether there are specific models that predict livelihood disruption based on climate trends, and how the likelihood of greater or lesser climate trends gets folded into the likelihood of livelihood disruption. These are the types of details necessary to support likelihood statements in the traceable accounts. Otherwise, the authors can use confidence statements to make statements that are generally agreed upon but not quantitative in nature.

Key Message 30.1. Water and Food. The purpose of the traceable accounts section is not to introduce new concepts and topics, but rather to provide supporting documentation for content already discussed in the key message and its supporting text. The content in the traceable account for Key Message 30.1 focused on ENSO (page 30-36, lines 8-11) does not conform to this guideline, as it introduces a new topic not discussed in detail elsewhere. In addition, the content related to ENSO is highly important for the region and should be elevated to the main text where it can be read by broad audiences. The Committee suggests that this content be moved to the introduction section with other aspects of the physical-science basis for the chapter and then referenced throughout the key messages.

The "Major Uncertainties and Gaps" section for this traceable account should include the lack of island-specific groundwater models throughout the Pacific region.

Key Message 30.3. Built Environment, Livelihoods, and Economy. The "Major Uncertainties and Gaps" section should include that the lack of high-resolution topobathymetric information for many Pacific Islands is an important barrier to generating accurate wave run-up models for the region. There is also a lot of uncertainty in the amount of SLR that will be experienced across the region due to the potential for instabilities in marine ice cliffs for which scientists have low confidence in their ability to represent these processes accurately in models (see Chapter 3 [Earth System Processes], page 3-26, for more information).

Comments on Graphics and Boxes

Eight of the chapter's 15 figures contain only photographs, which can be helpful in providing context and sense of place, but photographs do not help the target audiences understand and synthesize the wealth of information provided in the text. A few photographs are welcome, but the Committee suggests the chapter authors work to replace purely visual graphics where possible with graphics focused on synthesizing concepts and information. Chapter 23 (US Caribbean), for example, is similarly focused on island communities and contains a variety of useful infographics and flow charts that help the reader efficiently digest the chapter's content (e.g., Figures 23.4, 23.6, 23.9, 23.12, 23.13). Chapter 29 (Alaska) has many good examples as well. Similar graphics would improve the Hawai‘i and US-Affiliated Pacific Islands chapter significantly. Perhaps the photographs used currently could be integrated into new conceptual and information-focused graphics.

Relatedly, it is mentioned in the text that it is difficult to document the wide variety of island-specific changes and impacts, but it is also difficult for the reader to keep track of where and when issues are currently or expected to become problematic across the region. A table or region-wide figure showing the dominant climate-related concerns or events for specific islands in Hawai‘i and US-Affiliated Pacific Islands (now and in the future) would be highly valuable in obtaining broad understanding of the issues facing the region. Figures 29.1 and 29.11 in Chapter 29 (Alaska) and Figure 8.2 in Chapter 8 (Ecosystems, Ecosystem Services, and Biodiversity) are good examples of providing broad geographical context for climate-driven impacts.

As mentioned above, the ITF SLR scenarios depicted in Figure 30.3 are not properly linked to IPCC emissions-scenarios in the caption. In general, the individual SLR scenarios from the ITF report cannot be attributed to individual emissions scenarios, as the methodology for producing the SLR scenarios mixes model runs across emissions scenarios. See the ITF report for more details. More specifically, the ITF Intermediate High scenario depicted on the right side of Figure 30.3 is not representative of the SSP3-7.0 emissions scenario as suggested in the Figure 30.3 caption. If one looks at Figure 9.28 in the IPCC AR6 report directly, there is a panel that shows a map of the median SLR expected for SSP3-7.0. The values in the Pacific region are mostly in the 70-80 cm range, roughly half of what is shown in Figure 30.3 for the same emissions scenario. The discrepancy is also apparent from the text on page 21 of the ITF report stating that the Intermediate High scenario is near the upper bound of the *likely* range (i.e., modestly below the 83rd percentile per the report) of the very high emissions (SSP5-8.5), low-confidence projection. In other words, SLR associated with the Intermediate High ITF scenario is much higher than one would expect for the *likely* range from SSP3-7.0, which does not include low-confidence projections The authors should be careful in how they navigate the NCA5 descriptive terms for emissions scenarios (Front Matter, Table 3) and the names for the ITF SLR scenarios to be sure that what is shown is properly labeled and attributed. It is also unclear in what way this figure is adapted from Sweet et al. (2022) as stated in the caption, because there is no analogous figure in that report. If the figure is showing the gridded fields from the Sweet et al. report and this is what is meant by "adapted from," then this should be stated more directly.

There are a few additional minor issues with Figure 30.3. First, the units in the figure are in centimeters, but the text uses feet. There needs to be consistency between the units in the figure and text. Second, the figure needs markers for locations of Hawai‘i and USAPI within the Pacific. Third, it is confusing that the colors stay the same, but the magnitude of the scale is different between the two rows.

There are a couple of minor issues with Figure 30.4. First, "Ocean heat content rising" is an unnecessarily technical term—perhaps just say "Ocean warming." Second, "Habitats and species distributions changing" in the upper panel should be in the Climate Impacts panel, not the Climate Indicators panel. Habitats and species distributions are not "climate" per se but respond to climate variation.

Figure 30.10 is important but almost impossible to read in the current side-by-side format because of the small scale of the maps. The authors should consider remaking this figure with subplots stacked top to bottom while maintaining the figure width so that the small differences along the coastline can be readily seen.

In Box 30.1, the authors should be more specific about what is meant by "strong progress toward meeting" the metrics on page 30-7, lines 17-18. On the Hawai'i scorecard,[17] there are 36 listed indicators (not 35 as on line 18). Only 6 of these are "on track" or "near target," while 17 are "measuring," and 13 are "needs improvement." It seems that the "measuring" category has been included as strong progress, but this paints an overly optimistic picture. Gathering the relevant data and being able to track progress is certainly an achievement, but this is not strong progress toward meeting these goals. These lines should be rephrased to emphasize that much progress has been made in being able to measure progress, but there is much work to be done to get the remaining 30 of the 36 metrics into the "on track" category.

Lastly, regarding Box 30.4, the draft NCA5 report contains a dedicated Focus Feature on blue carbon that should—at minimum—be referenced within this box, and it should be evaluated to what degree this box is necessary or repetitive given that existing focus feature.

Comments on Equity and Justice

This chapter effectively integrates elements of equity and justice throughout, including environmental justice. There is a clear emphasis on traditional and Indigenous practice and ways of knowing, as well as a focus on how overburdened groups are disproportionately affected by climate change, particularly as it pertains to mental and physical health. The chapter could cross-reference Chapter 23 (US Caribbean) and Chapter 16 (Tribes and Indigenous Peoples) in this regard. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

In general, the literature review was impressively comprehensive and up to date.

CHAPTER 31: ADAPTATION

Summary

While the Committee appreciates the effort that went into this chapter, the Committee finds this chapter could more clearly address the requirements of Section 106 of the GCRA. Many decision makers do not adequately recognize the need for adaptation. Residents of the United States may not fully appreciate how they have already been affected by climate change

[17] See https://alohachallenge.Hawai'i.gov.

even after the United States has had more than 100 billion-dollar disasters in less than a decade. This chapter is an opportunity to lay out the current state of adaptation research and the need for additional research to fill critical gaps. As written, Key Message 31.4 on "climate services" reads as a prescription for services that only well-resourced communities can afford. The Committee does not intend to minimize the effort on this chapter to date but encourages the authors to reevaluate the focus of this chapter to ensure that it is written for broad audiences, communicates the opportunity and urgency of adaptation, and clearly identifies successes and gaps.

The Committee suggests reordering the key messages, described below, for a more compelling chapter. The key messages are generally well stated, are supported by each key message section, and each key finding generally ties back to the key messages concisely. The findings are consistent and supported by timely and transparent research. Many sources are used and referenced, and the chapter is written at an appropriate technical level. The Committee provides specific suggestions to make sections more digestible and of interest to broad audiences.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction for this chapter could begin by introducing and defining adaptation and why it is needed, rather than starting with mitigation. Additionally, NCA5 authors should clearly differentiate between "adaptation" and "equitable adaptation." The third paragraph clearly introduces all the key messages in the following sections, which is appreciated.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The Committee suggests carefully considering the ordering of key messages in this chapter to help reach the broadest possible audiences. For example, authors may reorder key messages by priority to create a more compelling narrative: Key Messages 31.2 (Adaptation and Equity), Key Message 31.3 (Adaptation Governance), Key Message 31.1 (Transformative Adaptation), and Key Message 31.5 (Economics of Adaptation and Adaptation Finance). Another sequencing possibility may be to fold Box 31.1 into the initial key message. For example, Key Message 31.1 might begin with a statement along the lines of "Assessment, planning, and implementation of adaptation has progressed since the Fourth National Climate Assessment, yet most adaptation actions have been small in scale and incremental in approach (*medium to high confidence*)." Alternatively, a new Key Message 31.1 about the current state of adaptation could synthesize some of the examples of adaptation discussed in the regional chapters. Additionally, the Committee suggests authors consider removing Key Message 31.4 (Science and Services in Support of Adaptation) or revising it, as suggested below. As written, the Committee is not convinced that climate services should be elevated to the importance of its own key message compared to other important adaptation topics that do not receive similar treatment. Removing this key message would allow space for a new key message such as one focused on measuring adaptation success, which is currently addressed within Key Messages 31.1 and 31.5.

The key messages are generally well stated, though likelihood statements are not included in any of the key messages. The key message titles are topics rather than messages or statements, and should be restated (e.g., "Adaptation and Equity" could be "Adaptation Actions Can Exacerbate Social Inequities Unless Applied Through an Equity Lens."). In general, the text supporting key messages is communicated effectively, with minor comments included in Appendix A.

Comments on Key Message Language and Supporting Text

> **Key Message 31.1. Transformative Adaptation**
> Climate adaptation actions undertaken in the United States to date have generally been small in scale and incremental in approach, involving minor changes to business as usual (*medium* to *high confidence*). Transformative adaptation, which involves more fundamental shifts in systems, values, and practices, will be necessary in many cases to adequately address the risks of current and future climate change (*high confidence*). New monitoring and evaluation methods will also be needed to assess the effectiveness and sufficiency of adaptation and to address equity (*high confidence*).

This section appropriately identifies challenges, opportunities, and success stories with a range of broad to very specific examples. The key message claims are assigned high confidence, but lack specific likelihood language, which may be appropriate here since there is quantitative evidence available to support these statements. This is not a strong key finding to open this chapter with. The Committee suggests changing the language and/or clarifying the confidence level.

> **Key Message 31.2. Adaptation and Equity**
> People and communities are affected by climate change in different ways (*high confidence*). The way they adapt depends on social factors, including individual and community preferences, capacity, and access to resources (*high confidence*). Unless adaptation actions explicitly address the uneven distribution of climate harms, and the historical processes and injustices involved, adaptation can exacerbate social inequities and increase exposure to harm (*high confidence*).

The Committee appreciates placing the key message section on equity early in the chapter. This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, but lacks specific examples. The key message claims are assigned high confidence but lack specific likelihood language. Additionally, the third sentence in this key message borders on being policy prescriptive but could easily be rephrased to be policy informative. For example, the sentence could state: "Adaptations that do not address inequities can increase such inequities."

> **Key Message 31.3. Adaptation Governance**
> Adaptation involves actors from government, private sector, and civil society organizations, who often have different priorities and approaches (*high confidence*). Adaptation decision-makers must balance competing goals while also addressing uncertainties regarding future climate change and the ways that political, social, and

technological systems will be transformed (*high confidence*). To minimize the potential for adaptation actions to benefit some at the expense of others, adaptation processes must emphasize collaboration, centralize equity and justice, and incorporate a wide range of values and knowledge sources (*medium* to *high confidence*).

This section appropriately identifies the challenges, opportunities, and success stories with a range of broad examples, and has a few specific examples. The key message claims lack likelihood language. The medium to high confidence level is related to minimizing the potential for adaptation actions to benefit some at the expense of others related to equity and justice. The Committee suggests clarifying this claim.

Key Message 31.4. Science and Services in Support of Adaptation
Adapting to a changing climate requires both decision-relevant climate information and evidence-based decision-making approaches (collectively referred to as "climate services") in the face of rapid societal change and historical injustice (*high confidence*). Climate services can support equity in adaptation by intentionally addressing contextual factors, such as values, culture, risk perception, and historic injustices (*medium confidence*). Significant climate service gaps remain due to accessibility, discontinuities in sectoral and geographic coverage, and a scarcity of organizational capacity to support collaboration between communities, decision-makers, and scientists (*medium confidence*).

This section is focused on decision-relevant climate information and evidence-based decision-making approaches, which are collectively referred to as "climate services." The Committee suggests expanding the examples in New York City, California, New Mexico, and South Dakota to include more of the "how" in order to provide references for other communities. In exchange, some of the language for how these tools could be applied theoretically could be streamlined.

Key Message 31.5. Economics of Adaptation and Adaptation Finance
Improvements have been made in estimating the costs and benefits of adaptation, although many factors influence the decision to invest (*medium confidence*). Identifying, quantifying, and tracking adaptation investments made to date in the United States is challenging (*high confidence*). Future adaptation investment needs will be significant, although projected amounts vary due to uncertainty in future emissions trajectories, associated impacts, and the timing of implementation (*high confidence*). Barriers to adaptation investment and financing remain and need to be overcome through collaboration (*high confidence*).

This section appropriately identifies the challenges, opportunities, and success stories with a range of broad to very specific examples. The key message lacks specific likelihood language. However, the Committee questions why this key message is framed using a benefit-cost framework rather than a risk management framework.

The medium confidence ranking is related to improvements in estimating the costs and benefits of adaptation. It may be more helpful to modify the statement so that the authors have a higher confidence level. This section has an opportunity to discuss co-benefits and stacking of

funds based on the "color of money" to improve "status quo" projects with funding to achieve multiple adaptation benefits.

Comments on Traceable Accounts

The traceable accounts section is clearly written but could expand on the description of confidence and likelihood intervals and bolster the discussion on research gaps. The numbering of the key messages is also incorrect in the traceable accounts section and, thus, one is missing. In general, the traceable accounts are uneven—some key messages have very short traceable accounts while others are very thorough. Additionally, the use of citations is inconsistent, and in some cases new citations are introduced in the traceable accounts that do not appear in the text supporting the key messages. The Committee suggests referring to Chapter 2 of this report for more guidance on traceable accounts.

Comments on Graphics and Boxes

Some of the images and graphics for this section are missing, which makes them difficult to evaluate. The captions are clear and robust and the figures and maps available are clear.

Figure 31.1 is an important figure, but it should define what constitutes an adaptation activity.

Figure 31.2 is missing information and visual interest could be added.

Figure 31.3 is not particularly informative and could be modified to be more specific or removed.

Figure 31.4 lacks clarity, but that may be the point that is trying to be made with the graphic.

In Table 31.1, the Committee appreciates the permanent migration or planned retreat language. The Committee suggests this language be adopted across the draft NCA5 report in place of managed retreat.

Comments on Equity and Justice

Equity and justice principles are adequately incorporated into this chapter. The Committee appreciates the key message on equity being early in the chapter and that equity and justice principles are discussed in other sections as well. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters when possible.

Comments on Literature Cited

This chapter reflects the peer-reviewed scientific literature and other sources of information cited and incorporates ample recent literature appropriate for the draft NCA5 report. However, there is a reference to foundational work related to climate services on page 31-44, line 2 that references material from 2003. More recent literature should be cited instead. This reference causes the narrative about climate services throughout this section to appear dated.

CHAPTER 32: MITIGATION

Summary

Overall, this chapter is very broad and inclusive in its coverage of mitigation and the Committee commends the chapter authors for covering mitigation so comprehensively. The chapter is very close to satisfying the requirements of Section 106 of the GCRA, and, with additions and revisions specified here, the Committee believes it will meet those requirements. The key messages are clear; however, they are sometimes overly simplified and need additional detail provided in the supporting text and traceable accounts sections. While the chapter is mostly written at a technical level appropriate for the audiences, in some places, the language includes jargon. Specific places where the language is too technical are called out in Appendix A. This chapter would benefit from adding context and in-text definitions to ensure comprehension by broad audiences with varied exposure to climate change science. For example, the introduction could do a better job describing mitigation and how it differs from adaptation, and the chapter tends to omit timescale discussions that provide context for the timeline to decarbonize, and what a decarbonized world might look like past 2030 or 2050. Some omissions are noted in the text below, but chapter authors should be able to address these concerns with limited additions to the text. Additionally, the traceable accounts need more work to describe which references support the confidence ratings and how the authors determined confidence and likelihood to be fully consistent, transparent, and credible.

Review Comments Related to the Statement of Task

Comments on Chapter Introduction

The introduction to Chapter 32 (Mitigation) is very short and could provide more context for readers new to the topic of climate change and mitigation. The Committee suggests opening the introduction with the definition of mitigation (presently paragraph two of the introduction) and then discussing the goal to stabilize the Earth's climate (i.e., shift the order of the first two paragraphs). Additionally, while the introduction does have a definition of mitigation, the Committee suggests adding some more context—for example, adding a description about how mitigation differs from adaptation, and what time frames matter for mitigation efforts and why.

Comments on Key Messages, Supporting Information, and Traceable Accounts

The key messages in this chapter reflect the current understanding of observed and projected impacts to the United States. The key messages are written in a consistent and appropriate manner that build on one another, and they reflect supporting evidence. Additionally, the titles are statements, rather than headers, which is a great way to highlight the content of the chapter and introduce each key message. The key messages appropriately include assessments of confidence likelihood and, for the most part, communicate effectively. Specific suggestions for the key message text are included below.

Comments on Specific Key Message Language

> **Key Message 32.1. Successful Mitigation Means Reaching Net-Zero Emissions**
> Greenhouse gas emissions in the United States decreased by 12% between 2007 and 2019, mostly due to decreases in coal-fired electricity generation and carbon uptake on lands abandoned by agriculture (*high confidence*). Yet US net greenhouse gas emissions remain substantial and would have to decline by more than 6% per year on average, reaching net-zero around midcentury, to meet current national and international mitigation goals (*high confidence*).

Suggested title: "Successful Mitigation Means Reaching Net-Zero Emissions by Midcentury or Sooner to Meet Current National and International Mitigation Goals."

The Committee suggests adding a time scale to the title to be more specific and to answer the question: how soon must we reach net-zero emissions?

Regarding the key message text, the Committee suggests the following modifications:

> "Net greenhouse gas emissions in the United States decreased by 13 percent between 2005 and 2019, mostly due to decreases in the energy sector related to coal-fired electricity generation (*add confidence rating here*). The United States maintains a large carbon sink that offsets 12 percent of gross emissions, primarily in forests and settlements, with less in agriculture including soil management and land-use change (*high confidence*). Presuming the US carbon sink remains relatively constant, net US greenhouse gas emissions would need to decline by more than 6 percent per year on average, reaching net-zero around midcentury and stabilizing to meet current national and international mitigation goals (*high confidence*)."

The Committee has four key concerns related to this key message and its supporting text: the data used, the benchmark years used, the discussion about offsets to emissions from abandonment of agricultural land, and the inclusion of timescales and nuance.

Data: In the supporting text and the supporting images in this chapter, the Committee suggests the adoption of a report-wide standard dataset. There is variation across chapters regarding the data sources for inventory data, which may contribute to confusion across the draft NCA5 report. The Committee suggests the NCA5 authors use EPA (2022) for discussions of net US emissions.

Benchmark Years: Additionally, the Committee is concerned about the comparison benchmark of 2007, since it does not appear in EPA (2022) (which uses 2005 as a benchmark). The authors also use 2019 reporting (EPA, 2021) rather than the most recent reporting for 2020 (EPA, 2022). This may be due to concerns about pandemic-related anomalies in the data. For instance, 2020 alone was approximately 9 percent lower net emissions as compared to 2019. Thus, using 2020 data would suggest an approximate 21 percent decline in net emissions since 2005. In summary, the Committee suggests the authors either use the latest data from EPA (2022) or explain why 2019 and 2007 are used rather than 2020 and 2005.

Offsets to Emissions from Abandonment of Agriculture Land: The Committee is concerned about the reference to offsets to emissions from abandonment of agricultural land. Primarily, there is not strong support for this in the reports cited or in the literature. The EPA report and a USDA report by Walters et al. (2021) note the increased urban tree cover that

follows forest land as the major US sinks that offset emissions in this transition. Agriculture soil management and perhaps cropland abandonment contribute less. Land-based carbon sinks are unlikely to continue increasing for a long period of time at current rates and may even decline over time as forest growth on previously abandoned cropland reaches an equilibrium. Thus, an adjustment in the expectation of land-based sinks into the future may be necessary and any "new" mitigation opportunity will necessitate a change in land management or land-use.

Equally important is the fact that EPA (2022), which is based on IPCC methodology, does not have a category dedicated to cropland abandonment. The IPCC approach accounts for GHG sources and sinks by categorizing them by the land-use category *to which the land is transitioning* (not the land-use category previously employed). For instance, sources and sinks that fall within the land-use change category (i.e., land-use, land-use change, and forestry) describe these sinks as "Forests Remaining Forests," "Cropland Remaining Cropland," and "Land Converted to Forest," among others. Thus, to describe the offsets due to land that was abandoned is not consistent with the way EPA (2022) categorizes offset categories. Furthermore, the category of sinks and their numbers for 2019 are: Forest Remaining Forest = 676, Cropland Remaining Cropland = 15, and Land Converted to Forest = 100. Thus, the offsets due to abandoned agricultural land are overstated in this key message, and the supporting text.

Timescales and Nuances: The effectiveness of achieving net-zero emissions will be related to timing and duration, which the authors should mention and consider in more detail. This is perhaps one of the more significant aspects of mitigation efforts and will be related to the size of the sink necessary to offset emissions, the magnitude of overshoot, and the duration of sink activities. The Committee suggests mentioning this discussion here and discussing it in more detail under Key Message 32.3.

The Committee also suggests adding known nuances to the key message to reflect the literature base and remain consistent with other chapters in the report discussing carbon emissions and sinks. For example, the overall declines in the US forest-based carbon sink are not well-represented in this message nor is the premise that there is increased carbon uptake on lands due to abandonment of agriculture (as compared to Chapter 7 [Forests]). The Committee suggests the chapter authors work with other chapters to ensure consistency and cross-reference relevant chapters where appropriate.

> **Key Message 32.2. We Know How to Drastically Reduce Emissions**
> A US energy system with net-zero emissions would rely on widespread electrification of transportation, electrification of heating in buildings and industry, decarbonized electricity systems, and substantial electricity generation from solar and wind (*high confidence*). Low-carbon fuels would still be needed for some transport and industry applications (*high confidence*). Land-related emissions in the US could be reduced by increasing the efficiency of food systems and improving agricultural practices and by protecting or restoring natural lands (*high confidence*). Across all sectors, many of these options are economically feasible now (*high confidence*).

This key message title and message are satisfactory. The Committee appreciates the comprehensive nature of this message and the fact that it is positive.

Key Message 32.3. Additional Options Need to Be Explored
Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). The ideal approaches to carbon management—including both carbon capture and storage and carbon dioxide removal—are similarly uncertain (*high confidence*), as is the potential to reduce land-related methane and nitrous oxide emissions through technical interventions (*medium confidence*).

The title of this key message clearly reflects the content of the message and supporting text, though the title could be expanded to provide more clarity. The Committee suggests at least adding "to achieve net zero emissions" at the end of the title. The message discusses existing uncertainty, and the need for further research to understand the optimal mix of energy sources and the ideal approaches to carbon management. The Committee also suggests the following restated title: "Additional Research Is Needed to Better Understand the Optimal Mix of Energy Sources and Technologies to Reach Net-Zero Emissions for a Decarbonized Future."

The confidence rankings—high and medium confidence, assigned to the uncertainty regarding the ideal approaches to carbon management and the potential to reduce land-related methane and nitrous oxide emissions—are unclear. Is it that there is high confidence about uncertainty? The use of passive voice is unclear. The Committee suggests two separate sentences here to accurately convey what the confidence statement applies to and the following language modifications:

> Although many mitigation options are currently available and cost-effective, the optimal mix of energy sources and technologies in net-zero emissions energy systems depends on still-uncertain technological progress, public acceptance, and future developments in institutions, markets, and policies (*high confidence*). There is considerable uncertainty surrounding the appropriate tools for, and level of, emissions management needed (*high confidence*), including methods to reduce land-related methane (*add confidence rating here*), tools to capture and store carbon dioxide (*add confidence rating here*), and methods to reduce nitrous oxide emissions using technical interventions (*add confidence rating here*).

Similar to Key Message 32.2, this message is an accurate representation of the state of knowledge. The Committee appreciates the clear description of uncertainties that remain surrounding the future successful mix of energy sources.

Key Message 32.4. Mitigation Can Be Sustainable, Healthy, and Fair
Large reductions in US greenhouse gas emissions could have substantial benefits for human health and well-being (*high confidence*). Mitigation is expected to affect pollution, the use of land and water resources, the labor force, and the affordability, reliability, and security of energy and food (*high confidence*). An equitable and sustainable transition to net-zero emissions energy and food systems in the United States would redress legacies of inequity, racism, and injustice while maximizing overall benefits to our economy and environment (*high confidence*).

The Committee appreciates that this key message integrates equity and justice components as well as its call-out to the many sectors affected by mitigation.

> **Key Message 32.5. Governments, Organizations, and Individuals Can Act to Reduce Emissions**
> Mitigation efforts can be supported by a range of actors and actions, from choices made by individuals to decisions made by businesses and local, tribal, state, and national governments (*high confidence*). Actions with significant near-term potential include sector-based policies accelerating deployment of low-carbon technologies, city-level efforts to promote public transportation and improve building efficiency, and individual behavioral changes to reduce energy demand and meat consumption (*high confidence*). This key message has an adequate title, and its message content is satisfactory.

Comments on Text Supporting the Key Messages

Key Message 32.1. Successful Mitigation Means Reaching Net-Zero Emissions. This key message focuses on observed rather than projected trends in emissions. The Committee appreciates the context that the focus on observed trends provides toward the discussion of mitigation; however, there is broad literature modeling energy systems into the future that should also be represented here. The chapter does cover the overall changes that must occur to meet emissions reductions goals, which is great; however, the reader is left wondering what the United States might look like under various mitigation pathways at different benchmark years into the future— for instance 2030 versus 2050 or 2120. Also, the supporting text (page 3, lines 19-24) omits literature that notes that the lowest cost emissions scenarios involve the United States reaching net zero before 2050 (Schaeffer et al., 2020).

This key message and supporting text frame the changes to the "US sink" as due to agriculture abandonment, but it is actually due to "agriculture, forestry, and other land-uses (AFOLU)" more generally, with most of the changes occurring in forests. As written, the supporting text for this key message does not support the discussion about carbon uptake on lands abandoned by agriculture. More supporting text and references are needed on this topic. The Committee encourages the authors to bolster the review of the mitigation measures related to agriculture by noting that systematic changes that target mitigation can also provide adaptation benefits, such as diversification of cropping systems. Furthermore, the message, supporting text, and Figure 32.7 do not align with Chapter 7 (Forests). The Committee suggests collaboration across the two chapters to ensure the chapters are consistent regarding assertions made about net sinks and carbon uptake. If the chapters opt to rely on different literature or data, the chapter authors should explain the differences, the implications in the text, or at very least the traceable accounts.

Also omitted is a discussion of an important nuance regarding the US sink. AFOLU has potential to generate carbon sinks in the present day and into the future. The immediacy of this benefit is not overtly stated in this chapter, and it should be. The implications of this nuance are significant—existing net sinks (largely forestry based) can contribute to a false sense of security. US emissions are less than they otherwise would be due to our large net sink (forests). However, the forestry-based sink is shrinking and is at risk due in part to climate change and in part to other human activities. This is a drawback that should be explicitly stated in the chapter.

Another nuance that the Committee suggests adding to the supporting text for this key message is the important role of timing and accounting (i.e., what happens with mitigation efforts if and after we meet the net-zero goals around mid-century). It is important to emphasize when talking about mitigation, that it is not sufficient to simply reduce emissions; emissions must be *contained*, or held below a maximum level, *into the future*. Holding emissions at a certain level into the future is difficult when the "maximum level" is the total emissions that the climate system can absorb, which is an imprecise estimate, at best, and heavily vulnerable to human activity across the world.

If the chapter authors are concerned about word and page count constraints, these nuances are worthwhile to mention in the supporting text but can be discussed in greater detail in the traceable accounts section.

Key Message 32.2. We Know How to Drastically Reduce Emissions. This key message is inclusive and effective in addressing uncertainty, while also stating what is known about generation profiles and land management techniques necessary for a net-zero emissions future. Adding discussion, supporting literature, and figures that forecast the potential different energy generation profiles, land-use practices, and carbon management techniques into the future (past 2030 and past 2050) may provide context that meets the charge of Section 106 of the GCRA to project up to 100 years into the future (e.g., Schaeffer et al., 2020; Van Soest et al., 2021).

Key Message 32.3. Additional Options Need to Be Explored. This key message is inclusive; its focus is on both technical developments and deployments as well as land interventions and modifications.

Key Message 32.4. Mitigation Can Be Sustainable, Healthy, and Fair. This key message should have a more complete discussion of water use needs for many newly considered energy technologies discussed earlier in the chapter under Key Message 32.3. This discussion does not require much more space, but the text as written does not acknowledge that there are sometimes drastic increases in water use with low and zero carbon technologies (e.g., CCUS, nuclear, and hydrogen all require drastic increases in water use for operations). Citations to support a more comprehensive discussion here include Dindi et al. (2022). The supporting text for this key message also only briefly mentions critical minerals and supply chain limitations. It says merely that the supply chain is vulnerable to disruptions (page 32, lines 12-13), which is an understatement. The Committee suggests broadening this discussion to highlight the recent executive orders issued by both President Trump and President Biden, such as Proclamation No. 13817 (*Federal Register*, 2017), Proclamation No. 13953 (*Federal Register*, 2020), Proclamation No. 14017 (*Federal Register*, 2021a) and the Consolidated Appropriations Act (2021), and the inherent link between critical minerals, supply chain constraints, and our ability as a nation to build the technology and infrastructure necessary to mitigate emissions. Additionally, a brief discussion on supply chains should reference the Focus on Risks to Supply Chains, which may limit additional text needed.

Key Message 32.5. Governments, Organizations, and Individuals Can Act to Reduce Emissions. The Committee suggests the chapter authors define the Paris Agreement early in the chapter, preferably the first time it is mentioned. The chapter should help educate audiences and the discussion about the Paris Agreement could be surprising. The Committee also suggests discussion of the Inflation Reduction Act (IRA) in the supporting text for this key message, particularly at page 32-36, lines 3-4. The IRA created an entirely new tax credit scheme that not

only increases available tax credits but also leverages protections for workers and populations of concern. This discussion might fit nicely right before Box 32.3.

Comments on Traceable Accounts

The traceable accounts for this chapter are short, do not have citations, and do not describe the analytic process used to develop the confidence and likelihood ratings included in each key message. It is worth the considerable effort required to produce meaningful traceable accounts, especially for a chapter on mitigation, which will be read carefully by most readers of NCA5.

Because the Chapter 32 (Mitigation) traceable accounts section is lacking citations and explanation, the chapter does not identify and provide sufficient context for embedded content and does not yet reflect current scientific understanding. The traceable accounts should be revised to demonstrate *which* references support *each* confidence and likelihood statement under each key message, consistent with the more detailed recommendation provided in Chapter 2 of this report.

In addition to the broad guidance in Chapter 2 of this report, the Committee provides specific examples and questions below to help chapter authors revise this section to ultimately ensure it provides sufficient context for embedded content and reflects current scientific understanding.

In the traceable account for Key Message 32.1, chapter authors should clarify where audiences can find some of the literature discussed (e.g., "a database of 95 of the most recent and detailed energy system scenarios of net-zero US emissions produced by X independent models"—this should be clearly cited so that audiences can find that information). Additionally, the sentence, "a large body of literature also supports the opportunities…" needs clarification and references.

In the traceable account for Key Message 32.3, there should be a discussion about how the lack of literature informs the confidence rankings. Additionally, the explanation for how the authors reached their confidence ranking is not clear, nor is it clear what the medium confidence is assigned to. Is it that the authors have medium confidence that the options to reduce land-based emissions can be reduced using available practices or is it that there is medium confidence that the best methods to do so are not yet known? The Committee suggests that the chapter authors resolve this lack of clarity both in the key message itself and in the traceable accounts section.

Comments on Graphics and Boxes

The graphics require some attention to improve their ability to convey information to broad audience bases. A few comments are offered below to improve the utility and clarity of graphics and their captions. The figures should be self-contained, which means they should have instructive captions that help audiences understand the content of the figures and how to read them. For some readers, the graphics will be their point of entry to the chapter as they decide whether they want to read the chapter (or parts thereof). Specific suggestions to improve the utility of the figures and captions are provided below.

In Figure 32.1, "US territories" should be defined in the caption.

Figure 32.2 should include a statement clarifying what (1900 = 100) means and adding labels to the x and y axes.

In Figure 32.4, it is hard to see the motorcycle line in image (a) and it is, likewise, hard to see LPG, electricity, and aviation gasoline in image (b). The Committee suggests a different order or colors for the lines.

The Committee suggests using a different color in Figure 32.5 for the fossil fuel combustion line in image (a) because it is currently hard to see.

Chapter authors should consider integrating the supporting text with Figure 32.7 and caption text discussing land-use emissions to improve the clarity of the supporting text. The caption is much clearer than the supporting text. Additionally, Figure 32.7(b) is confusing. The two blue lines are so close they are hard to distinguish. The Committee suggests using a different color for one of them. The caption should also call out lines for land-use emissions and emissions intensity of land-use in the explanatory caption.

In Figure 32.9(a), the Committee suggests gas and hydrogen use different colors because it is difficult to differentiate between the two blue shades. Additionally, it might be helpful to add a sentence comparing the Figure 32.9(a) and (b) depictions of GW generated per year to draw attention to the stark increase needed.

The caption for Figure 32.12 should include more text—it is hard to tell without the image here to evaluate, but there does not appear to be enough descriptive text in the caption.

The caption of Figure 32.15 says "Not surprisingly, …" which seems a bit opinionated or borderline prescriptive. Chapter authors should consider omitting the "Not surprisingly" to be more neutral.

The caption of Figure 32.18 could use additional detail to facilitate understanding by general audiences, including: how the maps were drawn; defining what red, green, blue, and yellow indicate on the map, and explaining a box plot.

Figure 32.19 should define what commodities are represented in the figure by each category of NIR percent.

Figure 32.20 should explain how "mitigation activities" are defined. Many states have taken actions to reduce emissions or reach net zero even if they have not passed legislation mandating a clean energy standard, renewable energy standard, emissions reduction goal, or the governor has not issued an executive order requiring mitigation. Some cities and universities have acted in absence of their state leading the charge. The Committee suggests clarifying what was included and what was omitted.

In Figure 32.22, it is unclear if the abatement estimates are correct, and specifically if the image considers the new IRA tax credits when calculating the costs; the caption should detail this information. The structure of the figure is adapted from Figure SPM.7 in IPCC (2022b), but the cost option for which implementation is cheaper than the conventional alternative shown in Figure SPM.7 are not shown in Figure 32.22. The figure caption should describe why this data was not included.

Comments on Equity and Justice

The Committee suggests adding some framing of equity- and justice-related issues in the introduction. equity and justice principles are well incorporated into a focused section of the chapter; however, the Committee suggests more integration throughout the chapter where

possible. The chapter, as well as the cohesiveness of the report, will benefit from cross-referencing related equity and justice issues from other chapters as appropriate.

Comments on Data and Analyses

Some of the images and discussion points about carbon sinks and agriculture and forests do not align with Chapter 7 (Forests), detailed above. This discussion should be consistent across chapters, or the discrepancy should be noted, particularly in each chapter's traceable accounts sections.

Comments on Literature Cited

The chapter accurately reflects the peer-reviewed scientific literature, with a particular focus on literature since NCA4. Suggestions for additions to literature cited are provided above.

Other Recommended Changes

Geoengineering is not specifically called out by name, nor is it largely discussed (the Committee only sees discussion of geoengineering topics on page 32-22, lines 33-37, and this discussion focuses on ocean-based carbon dioxide removal methods). There is emerging literature on this topic (e.g., NASEM, 2021), which might be worth mentioning and discussing in the traceable accounts section in more detail.

The chapter could emphasize AFOLU methods to reach net zero more. Along these lines, mitigation using AFOLU methods is discussed conceptually as "interventions" rather than "management techniques." The Committee suggests the chapter authors review and edit the text of this chapter for precise terminology when referring to land-use change and land-use management. The term "land-use change" usually refers to converting lands (typically, from forest lands to agricultural lands), while the term "land-use management" usually refers to fertilizer applications, range management, and other practices. These are two separate management techniques and should be distinguished in the chapter.

Chapter authors may consider adding a discussion about the ongoing difficulties with SEC filings (Curtis et al., 2021). The Biden administration recently published new rules requiring corporate filings on climate risk and accountability. While the scientific base provides guidance on how to conduct land-based accounting, private industry has not yet developed common practices for reporting land-based emissions reductions. Some of these details are covered in other chapters (e.g., Chapter 19 [Economics] and the Focus on Risks to Supply Chains), and this chapter should at a minimum cross-reference those other chapters, include a brief discussion, and ensure language is consistent. Discussing the same issues in multiple chapters would serve readers who only read certain chapters.

FOCUS ON COMPOUND AND COMPLEX EVENTS

Summary

This Focus on Compound and Complex Events is well written at an appropriate technical level and includes useful examples of the compound events that are its focus. However, the text does not discuss the "complex events" as suggested by its title; the Committee suggests that a discussion of cascading hazards might be a better partner for the compound events that are the main focus. The key message in the Focus does not include confidence or likelihood statements, nor does the traceable account, which should be included for consistency with other key messages and Focus On… Features, as recommended in Chapter 2 of this report. Additionally, the text could integrate equity and justice issues into earlier sections to add more real-world context and motivation for both the compound events as well as the equity and justice issues discussed the final section on "Adaptation." Finally, the examples used are broad and the references provide a narrow perspective. The Committee suggests several citations describing hazards and events from a first responders and planners' perspective that would provide more immediacy for readers.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

> **Key Message:** Climate change is increasing the likelihood of compound events—simultaneous or multiple back-to-back climate hazards—across every US region. Compound events impose greater harm on society and natural systems than singular events and can reduce the ability of overburdened communities to effectively respond and recover. Building climate resilience requires preparing for increasing compound event risks through new infrastructure design, planning, and disaster preparedness.

They key message is written clearly and concisely at the appropriate technical level; however, it may be useful to acknowledge the difficulty of conceptualizing or incorporating the actual range of possibilities presented by the broad class "compound events" in almost any locale.

Overall, this Focus is well integrated with the other chapters with about 20 different references to other chapters and their key messages. Other chapters should similarly cite this Focus where they currently do not (e.g., Chapter 12 [Built Environment, Urban Systems, and Cities]).

The Focus is titled "Compound and Complex Events" but (1) the key message does not mention "complex events" at all and (2) the supporting discussion only defines "complex events" at the bottom of the long list of forms that compound events can take and never returns to the subject. The Committee suggests dropping "Complex Events" from the title, or perhaps instead including "Cascading Events" in its place (see the other Recommended Changes section below).

Lastly, the key message does not include confidence or likelihood statements at all; these should be added for consistency (see Chapter 2 of this report).

Comments on Text Supporting the Key Message

A more explicit example of what "strained disaster response resources" refers to in the third bullet under "What are Compound/Complex Events" would be useful. Simultaneous megafires (even without the hurricanes) strain response resources but also regularly disrupt provision of living needs—for example, food, water, power, motor fuel, and communications supply lines—far and wide; referencing only "strained response resources" makes the problems seem more localized than they are. If a reference is needed, consider Albano et al. (2016) for an example of the ripple of disruptions a flood can engender. This is also a suitable place to better integrate Figure F1.1 into the Focus.

Under the "Climate Change" section, there is no mention of the modeling work done by Swain et al. (2018) on increasing odds of climatic "whiplashes" under climate change. This widely reported work offers an opportunity to make some of this discussion more quantitative and concrete and provide examples that readers will have encountered in the media in recent years.

As another example, it may be worth considering that in large areas of the west, wet years projected in the region cause floods, but also drive increased vegetation growth that, in many grass- and shrublands, result in significant increases in wildfire activity in the following summer(s) (e.g., Westerling et al. [2003], or subsequent studies).

Comments on the Traceable Account

The traceable account is well written, albeit too short, and with insufficient information. It fails to bring the discussion back to the specific issues of confidence and likelihood and includes only two citations to supporting literature. Thus, it does little to technically support of the body of the Focus. Additionally, there is no process description including how authors for this Focus were chosen from the NCA5 author team or what perspectives they provide. The traceable account should follow the recommended framework provided in Chapter 2 of this report.

Comments on Graphics and Boxes

There is one graphic (Figure F1.1), which illustrates west coast/east coast sequencing of disasters during fall 2020 through the end of 2021, with the COVID-19 pandemic ongoing, and the September 15, 2020, national-scale compound simultaneous wildfires and storms events. This graphic certainly shows how events can compound either at a single time or over months. The figure is well done, but has many "moving parts," making it difficult to interpret overall, including six different "layers" (from a timeline on top to a separate one-day snapshot on the bottom, with three geographic levels and COVID-19 in between). As such, despite the many ways the figure illustrates concepts in this Focus for readers who can follow it, it may be helpful to separate it into two figures (at least)—specifically, everything above the bottom (September 15) panel versus that panel, and then decide whether both figures are necessary. The figure caption describes the intent of the figure but not what it shows or how to interpret it; the caption

should be a stand-alone explanation of the figure, targeted at the intended audiences. Finally, the figure is used as a graphic for the "Recent Examples" section, but it could be better integrated into the discussion.

Comments on Equity and Justice

Equity and justice finally appear in the "Adaptation" section, although it could also have been incorporated into the "Recent Examples" section to illustrate disproportionate impacts of compound events. Examples could include disproportionate impacts from COVID-19 or the lack of drought-response resources and monitoring on tribal lands (e.g., Hiza-Redsteer and Wessells, 2017).

The statement on page F-4, lines 7-9, about investments in improving infrastructures, community-level resources and governance are reasonable (if vague) recommendations, but verge on being policy prescriptive. It can be difficult for planners and policymakers to predict what accommodations are needed to avoid or respond to compound, complex, and cascading events given the uncertainties involved in designing useful scenarios for planning purposes. It would be appropriate to acknowledge challenges communities face in making investments and infrastructure improvements, especially communities with limited adaptation resources and capacity.

Comments on Literature Cited

This Focus provides, given length restrictions, a reasonable introduction to the state of knowledge on these topics, with some exceptions mentioned above. Some additional concrete examples of compound and, especially, cascading events and risks from the responders' point of view would be helpful (e.g., Albano et al., 2016; Gerlak et al., 2021; Green et al., 2017; Toland et al., 2022).

Other Recommended Changes

As suggested above, "cascading risks or events" might be a more useful replacement for "complex events," which is essentially missing from this Focus. "Cascading risks or events" are sequences of impacts and repercussions from some initial climate events that cascade down through (often unanticipated and generally difficult to anticipate) connections to ultimately be felt in ways that appear on the surface appear to be quite remote (geographically or sectorally) from the initial impact. For example, major flooding or transportation disruptions (e.g., from a snowstorm) can disrupt electrical supply that in turn disrupts delivery of gasoline and diesel at gas stations, further disrupting the ability of utilities and first responders to address the initial impacts and/or to safeguard vulnerable residents of hospitals and nursing homes (Albano et al., 2016). California wildfires in recent years have been extremely challenging, but a largely unexpected ramification has been water quality impacts in nearby communities and domestic water supplies even in areas not thoroughly burned or far downstream, resulting in economic disruptions and human health challenges long after the wildfire is quelled. Including examples of these types of cascading events would be highly relevant to this Focus.

FOCUS ON WESTERN WILDFIRES

Summary

The Focus On… Feature is generally well stated and supported by the text, with findings documented in a credible way, and written at an appropriate technical level. However, there are two major omissions. First, the Focus does not include projections of future wildfire regimes under climate change scenarios, even though there are models that exist (e.g., Littell et al., 2018; Westerling, 2018). Fire regimes are difficult to predict under novel, historically unprecedented "non-analog" conditions, owing to strong feedbacks and interactions with vegetation dynamics, ignitions, topography, and so forth. The predicted impacts of climate change on fire regimes, while dire in some western ecosystems, are very difficult to forecast, but the available projections and associated challenges should be included. Second, the Focus does not mention the effect of increased wildfire size and severity on the mitigation potential of western forests, for example, by carbon sequestration. These effects are uncertain, but should be listed as a knowledge gap, or at least, the Focus should refer to other chapters that cover this issue such as Chapter 7 (Forests). In general, though, the Focus does a good job of citing some other chapters (e.g., Chapters 14 [Air Quality], 15 [Human Health], 28 [Southwest]).

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

The Focus accurately communicates that wildfires are a critical issue related to global change, which has become more prevalent since NCA4. The Focus describes the increase in large, severe wildfires in the West that has degraded ecosystems and biodiversity, leading to flooding and reduced water quality, destroying infrastructure, and producing air pollutants including $PM_{2.5}$ that harm people close to and far from the fire.

Comments on the Key Message

> **Key Message:** Climate change is leading to larger and more severe wildfires, bringing acute and chronic impacts both near and far from the flames. Wildfires have significant public health, socioeconomic and ecological implications for the entire country.

The key message accurately represents the current understanding of the observed impacts of climate change as it relates to wildfires in the United States and the associated challenges.

Overall, the key message is written in a consistent and appropriate way and communicated effectively. There is no confidence/likelihood assigned to the message which should be added for consistency with other key messages (see Chapter 2 of this report). Additionally, the key message for this Focus is not specific to the western United States while the remainder of the text is. A key message more specific to the title of the Focus would insert "in the western United States" after wildfires in the first sentence.

Comments on the Text Supporting the Key Message

The text supporting the Focus explains (and represents current understanding) that vegetation management, development patterns, human caused ignitions, and warmer, drier conditions (climate change) have led to an increase in area burned and in burn severity in the western United States. To a lesser extent, the supporting text addresses projected impacts in the United States, and opportunities and success stories for addressing risk, but could enhance these areas by referencing other chapters.

To improve the clarity and communicate the message more effectively the Committee suggests using more explicit terms and a more precise chronology. Here is an example of alternative wording for page F2-4, lines 1-4:

> Nineteenth and early 20th century logging and grazing, followed by a policy of fire suppression (intended to end Indigenous as well as settler burning), led to fuel buildup in low-elevation fire-adapted western forests in the late 20th century. Urban, suburban and exurban development in the last 50 years has greatly expanded the wildland-urban interface bringing people and their infrastructure adjacent to fire-prone wildlands. In the 21st century, warmer drier conditions have led to widespread bark beetle infestations and tree death, adding more fuel.

The Focus correctly points out—representing current understanding—that non-forested regions behave differently than low-elevation fire-adapted forests, although more mesic (those with adequate moisture) and high elevation (cooler, wetter) subalpine forests are not really addressed in the Focus. However, it is an overgeneralization to say that (page F2-4, lines 10-11), "In nonforested regions, changes in the frequency and extent of wildfires are being driven primarily by invasive annual grasses that have benefited from climate change." This lumps together sagebrush steppe, desert scrub, oak savanna, and chaparral shrublands ecosystems where somewhat different global change drivers have altered (or introduced novel) fire regimes. The statement is most correct for sagebrush steppe and desert scrub, nonforested ecosystems naïve to fire. In savanna rangelands, non-native annual grasses have been established for 200 years (not primarily driven by climate change). The Committee suggests changing the sentence to "in *some* nonforested regions, *primarily the interior arid shrublands and steppe*, changes in the frequency and extent of *novel* wildfires are being driven primarily by invasive annual grasses that have benefited from climate change" (e.g., Bradley et al., 2018; Fusco et al., 2019; Nagy et al., 2021).

Fire-adapted chaparral shrubland ecosystems with wind-driven fire regimes are qualitatively different from forests (see Keeley and Syphard, 2019). This is important because southern California urban areas where 20 million people live are surrounded by these ecosystems. All of these "non-forest" ecosystems are suffering from too much or too frequent fire, with ecological consequences (Syphard et al., 2022) but this is not driven by climate change or by buildup of woody ("ladder") fuels and therefore [woody] "fuel treatments" and "vegetation management" are likely to be ineffective and to have negative ecological effects. A sentence could be added to this effect (following page F2-4, lines 10-11), for example:

> In other non-forested regions, including oak savanna and chaparral shrublands, fires are weather limited, not fuel limited, and historical increases in fire are

> linked to human ignitions and land-use, not climatic factors like high temperatures and drought; those increases are degrading shrubland ecosystems. (Keeley and Syphard, 2019; Syphard et al., 2022)

This Focus, importantly, addresses the knock-on effects of larger, more severe fires on plant and animal species, representing current understanding of the observed impacts and challenges. Major smoke events associated with recent western wildfires have had regional, national, and even global impacts on air quality and human health. Fire also affects water supply and water quality, and therefore critical infrastructure. The following could be reworded, however, to be more accurate (page F2-4, lines 29-30): "Although electricity grids do not cause a large number of fires, some fires they have caused were large and deadly." In fact, the vast majority of wildfires are small, but it is the large wildfires that are of concern, and power lines have caused many of them, at least in California. The sentence could be changed by adding at the end, "and large fires have the greatest impact on lives and property, as well as ecosystem." The next sentence (page F2-4, lines 31-33) correctly states that "[public safety power shutoffs] negatively affect local economies and key sectors." However, it should be emphasized even more that these negative impacts disproportionately affect the lives and livelihoods of rural and overburdened communities, not just "key sectors" in the abstract. The public safety power shutoffs are in fact very controversial—the for-profit utilities would rather turn off the power than upgrade their infrastructure—and this could also be noted. It could also be mentioned that urban emergency plans that limit escape routes from neighborhoods are upstream hazards as well. Finally, the Focus should include some mention of projected future trends in western wildfire under climate change scenarios, and their uncertainty. Projections for some regions are dire (e.g., Abatzoglou, 2021; Littell et al., 2018; Westerling, 2018) and are being used by regional and national land management agencies for planning.

Comments on the Traceable Account

The traceable accounts section effectively describes the evidence for the link between recent climate warming and wildfire, citing the literature that established a link between climate change, increased fuel flammability, and increased burned area.

Uncertainties in research and information gaps were not described but would enhance the traceable account and be more consistent with other chapters. For example, there is still uncertainty about the efficacy of fuel treatments in different forest types. The "strong evidence" (page F2-5, line 35) mentioned in this section and in the main text should be qualified to delimit that "reducing fuels and decreasing stand (tree) density may lessen the impact of climate-driven stress and disturbance" only pertains to forest, and only certain (low-elevation) forests at that and does not just refer to wildfire (the stresses that may be lessened include drought and insects outbreaks). Another information gap that could be noted is the projected effect of future climate change on western wildfires. There are projections, but they are highly uncertain, discussed above.

This traceable account section does not have citations. The section should follow recommendations in Chapter 2 of this report to remove broad statements about the literature and include citations already provided in the main text. Consistent with the suggestion to include confidence/likelihood statement(s) with the key message, the traceable account should also describe how confidence/likelihood were assigned and what evidence was used.

Comments on Graphics and Boxes

Figure F2.1 is helpful in illustrating the chain of events from wildfire drivers to impacts. It is explained that fire-exclusion and land-use practices in low-elevation fire-dependent forests have led to fuel accumulation, although "vegetation management," "land-use practices," and other concepts could be replaced with more explicit terms and a chronology of policy and land-use decisions should also be provided. Also, it is not immediately obvious to read the figure from the bottom up. The Committee suggests either reordering the images in the figure to read from top to bottom or providing clear directives, such as arrows and a description in the figure caption for how to read the figure. The figure caption is somewhat repetitive of the text in the figure and should instead guide the reader to understand its meaning.

Comments on Equity and Justice

The Focus addresses some of the equity and justice dimensions of increasing western wildfires, although its statement of the evidence for the broader disproportionate impacts on overburdened populations could be strengthened. The Focus correctly points out, for example, that wildfire smoke disproportionately harms poor people (note "socioeconomic status" or "vulnerable population" should be made consistent with terminology chosen for the report overall; see Chapter 2 of this report), but it could be emphasized even more strongly that all fallout from climate-driven disasters including large wildfires disproportionately harms people with low income and people who have historically been discriminated against because they have less access to health care, more comorbidities, and less resources (i.e., money, insurance).

The "farmworkers and other outdoor workers" at risk from wildfire smoke (page F2-5, line 10) are frequently low-income workers from immigrant and Indigenous communities so this human health impact is an environmental justice issue. The paragraph regarding wildfire smoke (page F2-5, lines 4-12) does reference Chapter 15 (Human Health), but Chapter 15 does not directly address the risk posed to farmworkers. Méndez et al. (2020) could be added to the citations. Page F2-4, line 35, mentions populations residing in the wildland-urban interface but does not mention who those populations are and the relevant stressors that have driven increased development there.

Comments on Data and Analyses

The Focus could briefly state the changing extent of large western wildfires in recent years. Chapter 7 (Forests) does so, for example, stating: "Area burned by high-severity wildfires (e.g., stand-replacing fires) has increased in the West by about eightfold since 1985 (Parks and Abatzoglou 2020)." Chapter 7 (Forests) could also be cited, but it seems worth reporting this basic fact in this Focus.

FOCUS ON COVID-19 AND CLIMATE CHANGE

Summary

Overall, this Focus Feature is well written, flows logically, and drives home the important points related to climate change and pandemics, using COVID-19 as an example. The key message provides a high-level overview before delving into the details and nuances in the supporting text, though the key message could be revised to better reflect the knowledge base. It is written at a suitable level for general audiences. The traceable accounts section requires additional citations to fully support the text and reasoning in the key message. Because Section 106 of the GCRA requires NCA5 to forecast 25 to 100 years into the future, it will be important to emphasize that there will be future pandemics, possibly during that time period.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

> **Key Message:** Climate change has exacerbated the devastating impacts of the COVID-19 pandemic. Climate-driven changes in ecosystems alter susceptibility and interactions among humans, pathogens, and animals, increasing risk of emerging infectious diseases. Climate change also amplifies the risk of infection among people at the frontlines of exposure, especially those with fewer resources. Addressing the challenges of climate change and the COVID-19 pandemic requires early, collective action and systemic change.

The first sentence in the key message makes the overarching statement that "climate change has exacerbated the devastating impacts of the COVID-19 pandemic;" however, there is only one reference in supporting text that could be directly attributed to this statement and that reference supports the statement that "over half of known human pathogens are exacerbated by climate change," not the premise that climate has exacerbated the COVID-19 pandemic. In addition, the supporting text goes on to undermine the first statement in the key message when it states that "our understanding of COVID-19 is evolving." The Committee is concerned by the lack of literature to support this strong of a statement, particularly regarding a topic that has been at the forefront of national and global attention. The Committee suggests the following modified key message to address its concerns:

> **Proposed Key Message: Climate change has potential to exacerbate pandemics.** Climate-driven changes in ecosystems alter susceptibility and interactions among humans, pathogens, and animals, increasing risk of emerging infectious diseases like COVID-19 (*add confidence and likelihood ratings*). Climate change also amplifies the risk of infection among people at the frontlines of exposure, especially those with fewer resources (*add confidence and likelihood ratings*). Addressing the challenges of climate

change and pandemics requires early, collective action and systemic change (*add confidence and likelihood ratings*).

Structurally, the key message is lacking a title and would benefit from using a similar format to the rest of the key messages in the report (i.e., using a title, a message, confidence ratings, and supporting text). The Committee is also concerned that there are no corresponding confidence and likelihood ratings for the first statement in the key message to help gauge the level of scientific understanding behind the assertion. Confidence and/or likelihood statements should be added to the key message for consistency with other key messages (see Chapter 2 of this report) and the traceable accounts section should likewise discuss analysis and supporting evidence for those statements.

Otherwise, the message itself is comprehensive and inclusive, integrates equity and justice—climate change can amplify risk of pathogenic infections for those on the front lines of exposure or with fewer resources—and notes the need for investments in health and medical infrastructure, improved surveillance, and dissemination of public health information. The Committee suggests adding text that recognizes that the next pandemic could arrive much sooner than a century, and that it may be the result of malign agents, described below.

Comments on Text Supporting the Key Message

The supporting text that discusses the "impact of climate on infectious disease" is well written and clear, and it cites excellent write-ups and graphics in Key Messages 8.2 and 15.1.

The supporting text that discusses how "interactions between COVID-19 and climate change can exacerbate existing inequities" is well written. In general, specific comments would be more effective than broad ones. For example, on page F3-2, line 23, rather than reflecting that Hurricane Laura increased COVID-19 cases "significantly," authors should report that the increase was 12 percent per week. The recent references for this section are strong. The discussion of how vulnerable communities face compounded risks from climate change that are further exacerbated by highly contagious and debilitating infectious pathogens like COVID is critical: it should be elevated beyond this Focus Feature to Chapter 1 (Overview) and Chapter 15 (Human Health).

The supporting text that discusses the "lessons learned from COVID-19 for managing climate change" is good, as is Figure F3.1. However, the figure caption is not self-contained and would be more helpful if it were to walk the reader through the infographic.

The supporting text on page F3-4, lines 1-4, would benefit from more specificity. "Acting now…" is a nod to the future but could make a stronger statement about proactive preparations for future pandemics. The Committee suggests adding a final section to the Focus Feature that would focus on the importance of nimble responses and the use of emerging technologies to respond to pandemics and climate change. The supporting text under this discussion could include suggested aspects of nimble pandemic responses including challenges of the current pandemic surveillance systems (e.g., fragmented, legally constrained, non-interoperative), opportunities for preparations before a crisis (e.g., pre-commissioned team drills to learn mutual strengths and limitations),[18] and the emergence of wastewater surveillance as an early warning system (NASEM, 2023).[19]

[18] See https://www.washingtonpost.com/health/2022/08/17/walensky-revamp-cdc-culture-covid.
[19] See https://www.cdc.gov/healthywater/surveillance/wastewater-surveillance/wastewater-surveillance.html.

Comments on the Traceable Account

The traceable accounts section is brief and clear; however, the authors only include one reference and do not describe the analytic process used to arrive at the key message. The traceable accounts should describe and support how the authors arrived at their key message and each statement describing a body of literature should have citations after it. The description of the gaps in understanding is great, however, and the rest of the traceable accounts section should model the discussion after that one. Consistent with the suggestion to include confidence/likelihood statement(s) with the key message, the traceable account should also describe how confidence/likelihood were assigned and what evidence was used.

Comments on Equity and Justice

This Focus makes it clear that economically disadvantaged and overburdened communities suffer greater harm when preexisting vulnerabilities—economic, racial, and economic—are compounded by pandemics.

Comments on Literature Cited

The Focus accurately reflects the knowledge base, particularly what has been learned from the COVID-19 pandemic since NCA4. The Fisher et al. (2021) citation (cited on page F3-3, line 12) should be added the reference list.

FOCUS ON RISKS TO SUPPLY CHAINS

Summary

The key message in the Focus On… Feature is clearly stated and thoroughly supported by the detail provided within the Feature. This Focus is appropriate for the intended audiences and does a commendable job of cross-referencing other chapters and Focus On… Features. There are no major concerns about this Focus, though the Committee notes a few omissions and provides suggestions for clarifications below. The only key concern is a lack of confidence/likelihood statements in the key message. Confidence and likelihood statements convey important context to key message readers about the scientific claim being made, and their inclusion would enhance the overall message and credibility of the Focus.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Overall, the key message and supporting text are clear, consistent, and written at the appropriate technical level for the intended audiences. The Focus prioritizes newer literature (since NCA4) and provides citations following each assertion or claim. The Committee

commends the authors for consistently cross-referencing other chapters in NCA5, thereby emphasizing the cross-cutting nature of the Focus.

Comments on the Key Message

> **Key Message:** Damage to supply chain networks caused by climate change reverberates through people's livelihoods and investments in ways that threaten quality of life and security, often in lasting and unequal ways. Coordinated efforts can mediate impacts and help communities and companies adapt to these large, interconnected, and recurring risks. However, the pace, scale, and scope of efforts needed to transform supply chains are not yet sufficient to meet either current or expected disruptions and costs.

The key message in this Focus reflects the current understanding of observed and projected impacts on the supply chain in the United States as well as the challenges, opportunities, and ways to address supply chain risks. The key message is written in a consistent and appropriate way and reflects supporting evidence well. The only major concern is a lack of confidence/likelihood statements of the projected outcomes and conclusions in the key message.

Comments on Text Supporting the Key Message

The text supporting the key message should include a discussion of seaports and their vulnerability to SLR (Izaguirre et al., 2021). There should also be a brief discussion about the impact of heat waves on global supply chain (Le Page, 2022). Both issues can be briefly mentioned in the second paragraph starting with "Climate-driven disruptions to supply chains…."

Additionally, the SEC has proposed new rules for reporting material risk up and down the supply chain from climate change.[20,21] This Focus should recognize the proposed structure in the last paragraph on page F4-3 and/or cross-reference Chapter 19 (Economics) if it is included there.

Comments on the Traceable Account

The traceable accounts section does not include any process description including comments on the authorship makeup and lacks sufficient details on the methods of how authors reached the conclusions, and citations. Broad statements such as "recent lived experience confirm how supply chains are a core factor…" do not provide sufficient support for the key message and should be referenced more explicitly. The traceable accounts section should be revised with the addition of confidence and likelihood statements to demonstrate which references support the statements and how the authors made their assessment.

Comments on Graphics and Boxes

There is one figure in this Focus on the vulnerability of livestock food supply chains to drought. The figure is mostly clear and effective. However, the caption should be a standalone

[20] See https://www.sec.gov/news/press-release/2022-46.
[21] See https://www.fdic.gov/news/speeches/2022/spmar3022.html.

explanation of the figure and the figure title and caption should match. There also should be an explanation about what the two different colors of arrows mean.

Comments on Equity and Justice

Equity and justice principles are adequately addressed. The Focus mentions that supply chain issues can deepen existing inequities in risk distribution and resource access for overburdened communities. The Committee notes the inconsistent use of terminology (i.e., "vulnerable," "marginalized," and "overburdened") and suggests that the terminology should be consistent throughout both the Focus and the draft NCA5 report. Additionally, as noted in Chapter 2 of this report, authors should make an effort to avoid harmful terms like "marginalized" when describing impacted communities.

Comments on Literature Cited

This Focus cites papers from well-respected journals and reports from major agencies such as the Electric Power Research Institute and the California Energy Commission, most of which were published since the last NCA. However, there is a lack of citations in the traceable accounts section, discussed above.

FOCUS ON BLUE CARBON

Summary

The Focus on Blue Carbon is well written and informative but could benefit from the addition of confidence statements and a discussion of the feedback on the climate system if conservation and restoration efforts are not undertaken.

Review Comments Related to the Statement of Task

Comments on the Key Message, Supporting Information, and the Traceable Account

Comments on the Key Message

> **Key Message:** Blue carbon refers to carbon captured by marine and coastal ecosystems, such as mangroves, coastal wetlands, and seagrasses. Coastal ecosystems sequester carbon at a much faster rate than terrestrial ecosystems, and the carbon stored belowground can remain in place for decades to millennia if undisturbed by humans or extreme events. Although carbon sequestration in coastal ecosystems is not a new phenomenon, use of the term blue carbon has increased because conservation and restoration of coastal ecosystems may play a role in mitigating global carbon dioxide emissions.

The key message is well written and mostly reflects current understanding, but it could be improved in the following ways. The Committee suggests that the authors include confidence statements for the second and third sentences in the key message, especially on the possibility that blue carbon may play a role in mitigating global CO_2 emissions. The Committee also suggests that the third sentence be shortened to focus less on usage of the term "blue carbon" itself (which can be moved to the supporting text) and more on the importance of conservation. The third sentence could simply state, "Conservation and restoration of coastal ecosystems may play a role in mitigating global carbon dioxide emissions by increasing sequestration of blue carbon" and provide a confidence statement.

Comments on Text Supporting the Key Message

In general, the supporting text is well written and targets an appropriate technical level, but the Committee suggests the following changes. First, it should be made clear for readers not familiar with the terminology that the term "marine" does not include freshwater ecosystems. Second, the chapter highlights that SLR and extreme events are the greatest threat to blue carbon ecosystems, but it would be helpful to know if other effects of climate change on marine environments (e.g., temperature, ocean acidification) have an impact. Third, much attention is paid to the potential for carbon sequestration in marine ecosystems to mitigate climate change, but there is no mention of the feedback on climate change if conservation and restoration efforts are not undertaken—for example, accelerating SLR degrades blue carbon ecosystems, reducing carbon sequestration, further accelerating warming and SLR, which further increases the rate of ecosystem degradation and so on. Finally, the content of this Focus does not specifically discuss the role of or impacts on blue carbon systems in the United States. The supporting text could be expanded to include information about specific US locations that are particularly important and/or threatened by SLR and extreme events. Along these lines, the Committee notes that this Focus is only referenced by three national-level chapters (Chapters 9 [Coastal Effects], 10 [Oceans and Marine Resources], and 32 [Mitigation]) and no regional chapters. The Committee suggests that the authors of this Focus work with authors of regional chapters to cross-reference between the relevant ecosystems discussed in the regional chapters and the importance of these ecosystems described in this feature.

Comments on the Traceable Account

Consistent with the suggestion above that confidence statements be added to the key message, the Committee suggests that the rationale for the confidence statements be added to the traceable account. The Committee also suggests adding a statement describing the process and rationale used to compose the author team for consistency with other chapters and recommendations in Chapter 2 of this report.

Comments on Equity and Justice

Equity and justice are not discussed in the Focus, but given the narrow focus, this is not a major concern.

Comments on Literature Cited

Few references are provided for statements regarding the effect of extreme events on blue carbon ecosystems. If this due to a lack of literature on the subject, this should be added as a research gap in the traceable account, and noted as an uncertainty in the main text, as appropriate. Otherwise, the literature review of this effect could be expanded.

Other Recommended Changes

The Committee notes there is a box in Chapter 30 (Hawai'i and US-Affiliated Pacific Islands) that also discusses blue carbon. The authors of this Focus and the authors of Chapter 30 (Hawai'i and US-Affiliated Pacific Islands) should coordinate to (1) decide whether both the box and the Focus are necessary and (2) cross-reference if both are deemed necessary.

APPENDIX 3: SCENARIOS AND DATASETS

Overall, this is a solid annex although, as discussed in the review of Chapter 3 (Earth System Processes), authors should make sure that the discussion of IPCC emission/concentration scenarios is consistent between the Front Matter, Chapter 3 (Earth System Processes) and Appendix 3 (Scenarios and Datasets) and consider whether Key Message 3.4 is necessary given the availability of this Appendix.

This Appendix is the only place in the report where the sea-level scenarios are introduced. This section should be expanded because the way that sea-level scenarios are generated is not entirely consistent with the IPCC scenarios as usually referenced, but this is not clear from the Appendix. The authors should add: (1) a discussion of overlapping names between SLR and emissions scenarios, (2) an overview of the method by which the SLR scenarios are derived from IPCC/CMIP6 projections, and (3) a discussion of how Table 2.4 in Sweet et al. (2022) and the likelihood language in the Front Matter of the draft NCA5 report can be combined to make likelihood statements for the SLR scenarios.

APPENDIX 4: INDICATORS

The topic of climate change indicators is of growing importance and the Committee commends the draft NCA5 report for including this appendix. EPA has for years published reports on indicators.[22] In general, the examples of indicators in the appendix are sound, other than the presentation of billion-dollar damages (described below). However, the Committee suggests better integrating this important appendix throughout the draft NCA5 report. Appendix 4 is only referenced in three chapters: Chapters), (Overview), 15 (Human Health) and 26 (Southern Great Plains). The NCA5 authors could also consider mentioning the following indicators in the following chapters:

- Greenhouse gases in Chapter 2 (Climate Trends)

[22] See https://www.epa.gov/climate-indicators.

- Temperature and extreme heat in national Chapters 2 (Climate Trends), 3 (Earth System Processes), 12 (Built Environment, Urban Systems, and Cities), and 14 (Air Quality) as well as all regional chapters
- Precipitation in Chapter 2 (Climate Trends)
- Extreme events in Chapters 2 (Climate Trends) and 3 (Earth System Processes) and other chapters, as appropriate
- Sea ice in Chapters 2 (Climate Trends), 10 (Oceans and Marine Resources), and 29 (Alaska)
- Snowpack and snow cover in Chapters 2 (Climate Trends), 4 (Water), 27 (Northwest), 28 (Southwest), and 29 (Alaska)
- Flooding in Chapter 4 (Water) and regional chapters, as appropriate
- Drought in Chapter 4 (Water) and regional chapters, as appropriate
- Sea-level rise and coastal flooding in Chapter 9 (Coastal Effects)
- Marine heat waves in Chapter 10 (Oceans and Marine Resources)
- Marine species in Chapters 8 (Ecosystems, Ecosystem Services, and Biodiversity) and 10 (Oceans and Marine Resources)
- Seasonal change in Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity)
- Wildland fire in Chapters 6 (Land Cover and Land-Use Change), 7 (Forests), and 8 (Ecosystems, Ecosystem Services, and Biodiversity)
- Agricultural productivity in Chapter 11 (Agriculture, Food Systems, and Rural Communities)
- Adaptation and mitigation in Chapters 31 (Adaptation) and 32 (Mitigation)

The appendix presents trends in type and number of billion-dollar disasters as an example of how extreme events have changed. While there may be a signal of change in extreme events that have caused billion-dollar disasters, the larger explanation of the increase is most likely due to exposure (see Smith and Katz, 2013), such as increase in population in hazardous areas and growth in the value of property in exceedance of the Consumer Price Index used to deflate the value of disasters. The Committee's comments on the billion-dollar disaster figure in Chapter 1 (Overview) and 2 (Climate Trends) also point out that the figure should explain that increase is mainly the result of socioeconomic factors.

References

Abatzoglou, J. T., D. S. Battisti, A. P. Williams, W. D. Hansen, B. J. Harvey, and C. A. Kolden. 2021. Projected increases in western US forest fire despite growing fuel constraints. *Communications Earth & Environment* 2(1):1-8. https://doi.org/10.1038/s43247-021-00299-0.

Aladangady, A., and A. Forde. 2021. Wealth inequality and the racial wealth gap. *FEDS Notes* October 22, 2021. https://www.federalreserve.gov/econres/notes/feds-notes/wealth-inequality-and-the-racial-wealth-gap-20211022.html.

Albano, C. M., M. D. Dettinger, M. I. McCarthy, T. L. Welborn, and D. A. Cox. 2016. Application of an extreme winter storm scenario to identify vulnerabilities, mitigation options, and science needs in the Sierra Nevada mountains. *USA: Natural Hazards* 80:879-900. https://doi.org/10.1007/s11069-015-2003-4.

Albano, C. M., M. D. Dettinger, and A. A. Harpold. 2020. Patterns and drivers of atmospheric river precipitation and hydrologic impacts across the western United States. *Journal of Hydrometeorology* 21:143-159. https://doi.org/10.1175/JHM-D-19-0119.1.

Albano, C. M., J. T. Abatzoglou, D. J. McEvoy, J. L. Huntington, C. G. Morton, M. D. Dettinger, and T. J. Ott. 2022. A multidataset assessment of climatic drivers and uncertainties of recent trends in evaporative demand across the continental United States. *Journal of Hydrometeorology* 23(4):505-519. https://doi.org/10.1175/jhm-d-21-0163.1.

Allen, J. G., P. MacNaughton, J. G. Cedeno-Laurent, X. Cao, S. Flanigan, J. Vallarino, F. Rueda, D. Donnelly-McLay, and J. D. Spengler. 2018. Airplane pilot flight performance on 21 maneuvers in a flight simulator under varying carbon dioxide concentrations. *Journal of Exposure Science & Environmental Epidemiology* 29(4):457-468. https://doi.org/10.1038/s41370-018-0055-8.

Amjad, S., D. Chojecki, A. Osornio-Vargas, and M. B. Ospina. 2021. Wildfire exposure during pregnancy and the risk of adverse birth outcomes: A systematic review. *Environment International* 156:106644. https://doi.org/10.1016/j.envint.2021.106644.

Amorim-Maia, A. T., I. Anguelovski, E. Chu, and J. Connolly. 2022. Intersectional climate justice: A conceptual pathway for bridging adaptation planning, transformative action, and social equity. *Urban Climate* 41:101053. https://doi.org/10.1016/j.uclim.2021.101053.

Andela, N., D. C. Morton, L. Giglio, Y. Chen, G. R. van der Werf, P. S. Kasibhatla, R. S. DeFries, G. J. Collatz, S. Hantson, S. Kloster, D. Bachelet, M. Forrest, G. Lasslop, F. Li, S. Mangeon, J. R. Melton, C. Yue, and J. T. Randerson. 2017. A human-driven decline in global burned area. *Science* 356(6345):1356-1362. https://doi.org/10.1126/science.aal4108.

Anguiano, D., and A. Gee. 2021. *Fire in Paradise: An American Tragedy*. New York: W.W. Norton & Company.

Armstrong, J. H. 2021. People and power: Expanding the role and scale of public engagement in energy transitions. *Energy Research & Social Science* 78:102136. https://doi.org/10.1016/j.erss.2021.102136.

Auch, R. F., D. F. Wellington, J. L. Taylor, S. V. Stehman, H. J. Tollerud, J. F. Brown, T. R. Loveland, B. W. Pengra, J. A. Horton, Z. Zhu, and A. A. Midekisa. 2022. Conterminous

United States land-cover change (1985-2016): New insights from annual time series. *Land* 11(2):298. https://doi.org/10.3390/land11020298.

Badarudeen, S., and S. Sabharwal. 2010. Assessing readability of patient education materials: Current role in orthopedics. *Clinical Orthopedics and Related Research* 468(10):2572-2580. https://doi.org/10.1007/s11999-010-1380-y.

Ballinger, B., M. Stringer, D. R. Schmeda-Lopez, B. Kefford, B. Parkinson, C. Greig, and S. Smart. 2019. The vulnerability of electric vehicle deployment to critical mineral supply. *Applied Energy* 255:113844. https://doi.org/10.1016/j.apenergy.2019.113844.

Ban, Z., and D. P. Lettenmaier. 2022. Asymmetry of western US river basin sensitivity to seasonally varying climate warming. *Water Resources Research* 58(2):e2021WR030367. https://doi.org/10.1029/2021WR030367.

Barnett, T. P., D. W. Pierce, H. G. Hidalgo, C. Bonfils, B. D. Santer, T. Das, G. Bala, A. W. Wood, T. Nozawa, A. A. Mirin, and D. R. Cayan. 2008. Human-induced changes in the hydrology of the western United States. *Science* 319(5866):1080-1083. https://doi.org/10.1126/science.1152538.

Barnhart, T. B., N. P. Molotch, B. Livneh, A. A. Harpold, J. F. Knowles, and D. Schneider. 2016. Snowmelt rate dictates streamflow. *Geophysical Research Letters* 43(15):8006-8016. http://dx.doi.org/10.1002/2016GL069690.

Basso, B. 2021. Precision conservation for a changing climate. *Nature Food* 2:322-323. https://doi.org/10.1038/s43016-021-00283-z.

Beard, C. B., R. J. Eisen, C. M. Barker, J. F. Garofalo, M. Hahn, M. Hayden, A. J. Monaghan, N. H. Ogden, and P. J. Schramm. 2016. Ch. 5: Vectorborne Diseases. Pp. 129-156 in *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, A. Crimmins, J. Balbus, J. L. Gamble, C. B. Beard, J. E. Bell, D. Dodgen, R. J. Eisen, N. Fann, M. D. Hawkins, S. C. Herring, L. Jantarasami, D. M. Mills, S. Saha, M. C. Sarofim, J. Trtanj, and L. Ziska, eds. Washington, DC: US Global Change Research Program. http://dx.doi.org/10.7930/J0765C7V.

Besley, J.C., and A. Dudo. 2022. *Strategic Science Communication: A Guide to Setting the Right Objectives for More Effective Public Engagement*. Baltimore, MD: Johns Hopkins University Press.

Bhattachan, A., M. Jurjonas, A. C. Moody, P. R. Morris, G. M. Sanchez, L. S. Smart, P. J. Taillie, R. Emanuel, and E. Seekamp. 2018. Sea level rise impacts on rural coastal social-ecological systems and the implications for decision making. *Environmental Science & Policy* 90:122-134. https://doi.org/10.1016/j.envsci.2018.10.006.

Billiot, S., R. Beltran, D. Brown, A. Fernandez, and F. Mitchell. 2019a. Indigenous perspectives for strengthening social responses to global environmental changes: A response to the social work grand challenge on environmental changes. *Journal of Community Practice*. https://doi.org/10.1080/10705422.2019.1658677.

Billiot, S., S. Kwon, and C. E. Burnette. 2019b. Repeated disasters and chronic environmental changes impede generational transmission of Indigenous knowledge. *Journal of Family Strengths* 19(1):11. https://digitalcommons.library.tmc.edu/jfs/vol19/iss1/11.

Bloomfield, J. P., B. P. Marchant, and A. A. McKenzie. 2019. Changes in groundwater drought associated with anthropogenic warming. *Hydrology and Earth System Sciences* 23(3):1393-1408. http://dx.doi.org/10.5194/hess-23-1393-2019.

Blunt, K. 2022. *California Burning: The Fall of Pacific Gas and Electric—and What It Means for America's Power Grid*. New York: Portfolio/Penguin.

Bonebrake, T. C., A. D. Syphard, J. Franklin, K. E. Anderson, H. R. Akçakaya, T. Mizerek, C. Winchell, and H. M. Regan. 2014. Fire management, managed relocation, and land conservation options for long-lived obligate seeding plants under global changes in climate, urbanization, and fire regime. *Conservation Biology* 28(4):1057-1067. https://doi.org/10.1111/cobi.12253.

Booth, J. F., V. Narinesingh, K. L. Towey, and J. Jeyaratnam. 2021. Storm surge, blocking, and cyclones: A compound hazards analysis for the northeast United States. *Journal of Applied Meteorology and Climatology* 60(11):1531-1544. https://doi.org/10.1175/JAMC-D-21-0062.1.

Bostrom, A., G. Böhm, and R. E. O'Connor. 2013. Targeting and tailoring climate change communications. *Wiley Interdisciplinary Reviews: Climate Change* 4(5):447-455. https://doi.org/10.1002/wcc.234.

Botzen, W. J. W., F. Estrada, and R. S. J. Tol. 2021. Methodological issues in natural disaster loss normalization 25 studies. *Environmental Hazards* 20(2):112-115. http://dx.doi.org/10.1080/17477891.2020.1830744.

Bradley, B. A., C. A. Curtis, E. J. Fusco, J. T. Abatzoglou, J. K. Balch, S. Dadashi, and M. N. Tuanmu. 2018. Cheatgrass (Bromus tectorum) distribution in the intermountain Western United States and its relationship to fire frequency, seasonality, and ignitions. *Biological Invasions* 20(6):1493-1506. https://doi.org/10.1007/s10530-017-1641-8.

Bromirski, P. D., A. J. Miller, R. E. Flick, and G. Auad. 2011. Dynamical suppression of sea level rise along the Pacific coast of North America: Indications for imminent acceleration. *Journal of Geophysical Research: Oceans* 116(C7). https://doi.org/10.1029/2010JC006759.

Bromirski, P. D., A. J. Miller, and R. E. Flick. 2012. Understanding North Pacific sea level trends. *Eos*, *Transactions of the American Geophysical Union* 93(27):249-251. https://doi.org/10.1029/2012eo270001.

Budescu, D. V., H. H. Por, S. B. Broomell, and M. Smithson. 2014. The interpretation of IPCC probabilistic statements around the world. *Nature Climate Change* 4(6):508-512. https://doi.org/10.1038/nclimate2194.

Burdon, J. J., and J. Zhan. 2020. Climate change and disease in plant communities. *PLoS Biology* 18(11):e3000949. https://doi.org/10.1371/journal.pbio.3000949.

Burke, M., F. González, P. Baylis, S. Heft-Neal, C. Baysan, S. Basu, and S. Hsiang. 2018. Higher temperatures increase suicide rates in the United States and Mexico. *Nature Climate Change* 8(8):723-729. https://doi.org/10.1038/s41558-018-0222-x.

Burns, J., A. C. Angelino, K. Lewis, M. E. Gotcsik, R. A. Bell, J. Bell, and A. Empey. 2021. Land rights and health outcomes in American Indian/Alaska Native children. *Pediatrics* 148(5). https://doi.org/10.1542/peds.2020-041350.

Carley, S., and D. M. Konisky. 2020. The justice and equity implications of the clean energy transition. *Nature Energy* 5(8):569-577. https://doi.org/10.1038/s41560-020-0641-6.

CEQ (Council on Environmental Quality). 2023. Climate and Economic Justice Screening Tool. https://toolkit.climate.gov/tool/climate-and-economic-justice-screening-tool.

Chan, N. W. and C. J. Wichman. 2020. Climate change and recreation: Evidence from North American cycling. *Environmental and Resource Economics* 76:119-151. https://doi.org/10.1007/s10640-020-00420-5.

Chan, N. W. and C. J. Wichman. 2022. Valuing nonmarket impacts of climate change on recreation: From reduced form to welfare. *Environment and Resource Economics* 81:179-213. https://doi.org/10.1007/s10640-021-00624-3.

Charnley, S., H. Gosnell, R. Davee, and J. Abrams. 2020. Ranchers and beavers: Understanding the human dimensions of beaver-related stream restoration on western rangelands. *Rangeland Ecology & Management* 73(5):712-723. https://doi.org10.1016/J.RAMA.2020.04.008.

Chen, G., W. Wang, L. Tao, H. Hsu, C. Tu, and C. Cheng. 2019. Extreme snow events along the coast of the northeast United States: Analysis of observations and HiRAM simulations. *Journal of Climate* 32(21):7561-7574. https://doi.org/10.1175/JCLI-D-18-0874.1.

Chen, G., W. C. Wang, C. T. Cheng, and H. H. Hsu. 2021a. Extreme snow events along the coast of the northeast United States: Potential changes due to global warming. *Journal of Climate* 34(6):2337-2353. https://doi.org/10.1175/JCLI-D-20-0197.1.

Chen, R., L. Fang, J. Liu, B. Herbig, V. Norrefeldt, F. Mayer, R. Fox, and P. Wargocki. 2021b. Cabin air quality on non-smoking commercial flights: A review of published data on airborne pollutants. *Indoor Air* 31(4):926-957. https://doi.org/10.1111/ina.12831.

Cheng, M., B. McCarl, and C. Fei. 2022. Climate change and livestock production: A literature review. *Atmosphere* 13(1):140. https://doi.org/10.3390/atmos13010140.

Chetty, R., M. Stepner, S. Abraham, S. Lin, B. Scuderi, N. Turner, A. Bergeron, and D. Cutler. 2016. The association between income and life expectancy in the United States, 2001-2014. *Journal of the American Medical Association* 315(16):1750-1766. https://doi.org/10.1001/jama.2016.4226.

Chowdhury, R., and B. L. Turner. 2019. The parallel trajectories and increasing integration of landscape ecology and land system science. *Journal of Land Use Science* 14(2):135-154. https://doi.org/10.1080/1747423X.2019.1597934.

Cole, H. V., M. G. Lamarca, J. J. Connolly, and I. Anguelovski. 2017. Are green cities healthy and equitable? Unpacking the relationship between health, green space and gentrification. *Journal of Epidemiol Community Health* 71:1118-1121. https://doi.org/10.1136/jech-2017-209201.

Cordeira, J. M., J. Stock, M. D. Dettinger, A. M. Young, J. F. Kalansky, and F. M. Ralph. 2019. A 142-year climatology of northern California landslides and atmospheric rivers. *Bulletin of the American Meteorological Society* 100(8):1499-1509. https://doi.org/10.1175/BAMS-D-18-0158.1.

Crimmins, A. 2022. Overview of the Fifth National Climate Assessment for the National Academies NCA5 Peer Review Committee. Presented to the Committee to Review the Draft Fifth National Climate Assessment, November 15, 2022, Washington, DC.

Curtis, Q., J. E. Fisch, and A. Robertson. 2021. Do ESG mutual funds deliver on their promises? *Michigan Law Review* 393. https://scholarship.law.upenn.edu/faculty_scholarship/2298.

Dannenberg, A. L., H. Frumkin, J. J. Hess, and K. L. Ebi. 2019. Managed retreat as a strategy for climate change adaptation in small communities: Public health implications. *Climatic Change* 153:1-14. https://doi.org/10.1007/s10584-019-02382-0.

de Koning, K., and T. Filatova. 2020. Repetitive floods intensify outmigration and climate gentrification in coastal cities. *Environmental Research Letters* 15(3):034008. https://doi.org/10.1088/1748-9326/ab6668.

Diaz, M., M. Cools, M. Trebilcock, B. Piderit-Moreno, and S. Attia. 2021. Effects of climatic conditions, season and environmental factors on CO_2 concentrations in naturally

ventilated primary schools in Chile. *Sustainability* 13:4139. https://doi.org/10.3390/su13084139.

Diffenbaugh, N. S. and M. Burke. 2019. Global warming has increased global economic inequality. *Proceedings of the National Academy of Sciences of the United States of America* 116(20):9808-9813. https://doi.org/10.1073/pnas.1816020116.

Dindi, A., K. Coddington, J. F. Garofalo, W. Wu, and H. Zhai. 2022. Policy-driven potential for deploying carbon capture and sequestration in a fossil-rich power sector. *Environmental Science & Technology* 56(14):9872-9881. https://doi.org/10.1021/acs.est.1c08837.

Domke, G. M., B. F. Walters, D. J. Nowak, J. Smith, M. C. Nichols, S. M. Ogle, J. W. Coulston, and T. C. Wirth. 2021. *Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2019.* Resource Update FS 307. Madison, WI: US Department of Agriculture, Forest Service, Northern Research Station.

Dougherty, E., and K. L. Rasmussen. 2019. Climatology of flood-producing storms and their associated rainfall characteristics in the United States. *Monthly Weather Review* 147(11):3861-3877. https://doi.org/10.1175/MWR-D-19-0020.1.

Du, B., M. C. Tandoc, M. L. Mack, and J. A. Siegel. 2020. Indoor CO_2 concentrations and cognitive function: a critical review. *Indoor Air* 30(6):1067-1082. https://doi.org/10.1111/ina.12706.

Ebi, K. L., J. Vanos, J. W. Baldwin, J. E. Bell, D. M. Hondula, N. A. Errett, K. Hayes, C. E. Reid, S. Saha, and J. Spector. 2021. Extreme weather and climate change: Population health and health system implications. *Annual Review of Public Health* 42:293. https://doi.org/10.1146/annurev-publhealth-012420-105026.

Eckelman, M. J., K. Huang, R. Lagasse, E. Senay, R. Dubrow, and J. D. Sherman. 2020. Health care pollution and public health damage in the United States: An update. *Health Affairs* 39(12):2071-2079. https://doi.org/10.1377/hlthaff.2020.01247.

Ellena, M., M. Breil, and S. Soriani. 2020. The heat-health nexus in the urban context: A systematic literature review exploring the socio-economic vulnerabilities and built environment characteristics. *Urban Climate* 34:100676. https://doi.org/10.1016/j.uclim.2020.100676.

EPA (US Environmental Protection Agency). 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. EPA 430-R-21-003. http://www.epa.gov/cira/social-vulnerability-report.

EPA. 2022. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020. EPA 430-R-22-003. https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2020.

Etterson, J. R., M. W. Cornett, M. A. White, and L. C. Kavajecz. 2020. Assisted migration across fixed seed zones detects adaptation lags in two major North American tree species. *Ecological Applications* 30(5). https://doi.org/10.1002/eap.2092.

Farr, E. R., M. R. Johnson, M. W. Nelson, J. A. Hare, W. E. Morrison, M. D. Lettrich, B. Vogt, C. Meaney, U. A. Howson, and P. J. Auster. 2021. An assessment of marine, estuarine, and riverine habitat vulnerability to climate change in the Northeast US. *PLoS One* 16(12):e0260654. https://doi.org/10.1371/journal.pone.0260654.

Farrell, A. E., and J. Jäger. 2006. *Assessments of Regional and Global Environmental Risks: Designing Processes for the Effective Use of Science in Decision Making*. Washington, DC: Resources for the Future.

FED (Federal Reserve Board). 2020. Financial Stability Report. https://www.federalreserve.gov/publications/2020-november-financial-stability-report-purpose.htm.

Federal Register. 2017. Proclamation No. 13817, 82 Fed. Reg. 60835 (December 26, 2017). Department of the Interior.

Federal Register. 2020. Proclamation No. 13953, 84 Fed. Reg. 62539, at 62539-62544 (Oct. 5, 2020). F. Register.

Federal Register. 2021a. Proclamation No. 14017, 86 Fed. Reg. 11849 (Feb. 24, 2021). Department of Agriculture.

Federal Register. 2021b. Proposed Rule, 86 Fed. Reg. 59309 (Oct. 27, 2021). Occupational Safety and Health Administration.

Field, J. L., T. L. Richard, E. A. H. Smithwick, H. Cai, M. S. Laser, D. S. LeBauer, S. P. Long, K. Pautisan, Z. Qin, J. J. Sheehan, P. Smith, M. Q. Wang, and L. R. Lynd. 2020. Robust paths to net greenhouse gas mitigation and negative emissions via advanced biofuels. *Proceedings of the National Academy of Sciences of the United States of America* 117:21968-21977. https://doi.org/10.1073/pnas.1920877117.

Fillmore, H., and L. Singletary. 2021. Climate data and information needs of Indigenous communities on reservation lands: Insights from stakeholders in the Southwestern United States. *Climatic Change* 169(3):37. http://dx.doi.org/10.1007/s10584-021-03285-9.

Findlater, K., S. Webber, M. Kandlikar, and S. Donner. 2021. Climate services promise better decisions but mainly focus on better data. *Nature Climate Change* 11:731-737. https://doi.org/10.1038/s41558-021-01125-3.

Fisher, A., A. Roberts, A. R. McKinlay, D. Fancourt, and A. Burton. 2021. The impact of the COVID-19 pandemic on mental health and well-being of people living with a long-term physical health condition: A qualitative study. *BMC Public Health* 21(1):1801. https://doi.org/10.1186/s12889-021-11751-3.

Fleischman, F., S. Basant, H. Fischer, D. Gupta, G. G. Lopez, P. Kashwan, J. S. Powers, V. Ramprasad, P. Rana, A. Rastogi, and C. R. Solorzano. 2021. How politics shapes the outcomes of forest carbon finance. *Current Opinion in Environmental Sustainability* 51:7-14. https://doi.org/10.1016/j.cosust.2021.01.007.

Ford, J. D., N. King, E. K. Galappaththi, T. Pearce, G. McDowell, and S. L. Harper. 2020. The resilience of Indigenous peoples to environmental change. *One Earth* 2:6. https://doi.org/10.1016/j.oneear.2020.05.014.

Foster, S., R. Leichenko, K. H. Nguyen, R. Blake, H. Kunreuther, M. Madajewicz, E. P. Petkova, R. Zimmerman, C. Corbin-Mark, and E. Yeampierre. 2019. New York City panel on climate change 2019 report chapter 6: Community-based assessments of adaptation and equity. *Annals of the New York Academy of Sciences* 1439(1):126-173. https://doi.org/10.1111/nyas.14009.

Friedland, K. D., E. T. Methratta, A. B. Gill, S. K. Gaichas, T. H. Curtis, E. M. Adams, J. L. Morano, D. P. Crear, M. C. McManus, and D. C. Brady. 2021. Resource occurrence and productivity in existing and proposed wind energy lease areas on the Northeast US Shelf. *Frontiers in Marine Science* 336. https://doi.org/10.3389/fmars.2021.629230.

Frumpkin, H., and R. J. Jackson. 2020. We Need a National Institute of Climate Change and Health. *Scientific American*, November 22, 2020. https://www.scientificamerican.com/article/we-need-a-national-institute-of-climate-change-and-health.

Fusco, E. J., J. T. Finn, J. K. Balch, R. C. Nagy, and B. A. Bradley. 2019. Invasive grasses increase fire occurrence and frequency across US ecoregions. *Proceedings of the National Academy of Sciences of the United States of America* 116(47):23594-23599. https://doi.org/10.1073/pnas.1908253116.

Gaffney J., J. Bing, P. F. Byrne, K. G. Cassman, I. Ciampitti, D. Delmer, J. Habben, H. R. Lafitte, U. E. Lidstrom, D. O. Porter, J. E. Sawyer, J. Schussler, T. Setter, R. E. Sharp, T. J. Vyn, and D. Warner. 2019. Science-based intensive agriculture: Sustainability, food security, and the role of technology. *Global Food Security* 23:236-244. https://doi.org/10.1016/j.gfs.2019.08.003.

Gaichas, S. K., G. S. DePiper, R. J. Seagraves, B. W. Muffley, M. G. Sabo, L. L. Colburn, and A. J. Loftus. 2018. Implementing ecosystem approaches to fishery management: Risk assessment in the US Mid-Atlantic. *Frontiers in Marine Science* 5:442. https://doi.org/10.3389/fmars.2018.00442.

Galway, L.P., T. Beery, K. Jones-Casey, K. Tasala. 2019. Mapping the Solastalgia Literature: A Scoping Review Study. *International Journal of Environmental Research and Public Health* 16(15):2662. https://doi.org/10.3390/ijerph16152662.

Gangopadhyay, S., C. A. Woodhouse, G. J. McCabe, C. C. Routson, and D. M. Meko. 2022. Tree rings reveal unmatched 2nd century drought in the Colorado River Basin. *Geophysical Research Letters* 49:e2022GL098781. https://doi.org/10.1029/2022GL098781.

Garofalo, J. F. 2019. Toward holism: Aligning the science and policy of recovery planning for the endemic fishes in the Upper Colorado River Basin. *Environs: Environmental Law and Policy Journal* 42(2). https://ssrn.com/abstract=3522681.

Garofalo, J. F., and M. Lewis. 2020. Sources to Sinks: Expanding a National CO_2 Pipeline Network. *Environmental Law Reporter*, 50 ELR 10057. https://www.elr.info/articles/elr-articles/sources-sinks-expanding-national-co2-pipeline-network.

Gee, A., and D. Anguiano. 2021. *Fire in Paradise: An American Tragedy.* New York: W.W. Norton & Company.

Gellman, J., M. Walls, and M. Wibbenmeyer. 2022. Wildfire, smoke, and outdoor recreation in the western United States. *Forest Policy and Economics* 134:102619. https://doi.org/10.1016/j.forpol.2021.102619.

Gerlak, A. K., K. L. Jacobs, A. L. McCoy, S. Martin, M. Rivera-Torres, A. M. Murveit, A. J. Leinberger, and T. Thomure. 2021. Scenario planning—Embracing the potential for extreme events in the Colorado River Basin. *Climatic Change* 165:28. https://doi.org/10.1007/s10584-021-03013-3.

Gerst, M. D., M. A. Kenney, and I. Feygina. 2021. Improving the usability of climate indicator visualizations through diagnostic design principles. *Climatic Change* 166:33. https://doi.org/10.1007/s10584-021-03109-w.

Goldsmith, L., and M. L. Bell. 2022. Queering environmental justice: Unequal environmental health burden on the LGBTQ+ community. *American Journal of Public Health* 112(1):79-87. https://doi.org/10.2105/ajph.2021.306406.

Goldsmith, L., V. Raditz, and M. Méndez. 2022. Queer and present danger: Understanding the disparate impacts of disasters on LGBTQ+ communities. *Disasters* 46(4):946-973. https://doi.org/10.1111/disa.12509.

Gordon, B. L., P. D. Brooks, S. A. Krogh, G. F. S. Boisrame, R. W. H. Carroll, J. P. McNamara, and A. A. Harpold. 2022. Why does snowmelt-driven streamflow response to warming

vary? A data-driven review and predictive framework. *Environmental Research Letters* 17(5):053004. https://doi.org/10.1088/1748-9326/ac64b4.

Grant, A., A. A. Millward, S. Edge, L. A. Roman, and C. Teelucksingh. 2022. Where is environmental justice? A review of US urban forest management plans. *Urban Forestry & Urban Greening* 77:127737. https://doi.org/10.1016/j.ufug.2022.127737.

Green, D., D. Yu, I. Pattison, R. Wilby, L. Bosther, R. Patel, P. Thompson, K. Trowell, J. Draycon, M. Halse, L. Yang, and T. Ryley. 2017. City-scale accessibility of emergency responders operating during flood events. *Natural Hazards Earth System Science* 17:1-16. https://doi.org/10.5194/nhess-17-1-2017.

Griscom, B. W., J. Adams, P. W. Ellis, R. A. Houghton, G. Lomax, D. A. Miteva, W. H. Schlesinger, D. Shoch, J. V. Siikamäki, P. Smith, P. Woodbury, C. Zganjar, A. Blackman, J. Campari, R. T. Conant, C. Delgado, P. Elias, T. Gopalakrishna, M. R. Hamsik, M. Herrero, J. Kiesecker, E. Landis, L. Laestadius, S. M. Leavitt, S. Minnemeyer, S. Polasky, P. Potapov, F. E. Putz, J. Sanderman, M. Silvius, E. Wollenberg, and J. Fargione. 2017. Natural climate solutions. *Proceedings of the National Academy of Sciences of the United States of America* 114(44):11645-11650. https://doi.org/10.1073/pnas.1710465114.

Gurgel, A. C., J. Reilly, and E. Blanc. 2021. Agriculture and forest land use change in the continental United States: Are there tipping points? *IScience* 24(7):102772. https://doi.org/10.1016/j.isci.2021.102772.

Gutman, G., A. C. Janetos, C. O. Justice, E. F. Moran, J. F. Mustard, R. R. Rindfuss, D. Skole, B. L. Turner II, and M. A. Cochrane, eds. 2004. *Land Change Science: Observing, Monitoring and Understanding Trajectories of Change on the Earth's Surface.* Remote Sensing and Digital Image Processing, vol. 6. Dordrecht, Netherlands: Springer Science & Business Media.

Gutmann, E. D., R. M. Rasmussen, C. Liu, K. Ikeda, C. L. Bruyere, J. M. Done, L. Garrè, P. Friis-Hansen, and V. Veldore. 2018. Changes in hurricanes from a 13-yr convection-permitting pseudo–global warming simulation. *Journal of Climate* 31(9):3643-3657. https://doi.org/10.1175/jcli-d-17-0391.1.

Han, S. C., J. Sauber, F. Pollitz, and R. Ray. 2019. Sea level rise in the Samoan Islands escalated by viscoelastic relaxation after the 2009 Samoa-Tonga earthquake. *Journal of Geophysical Research: Solid Earth* 124(4):4142-4156. https://doi.org/10.1029/2018jb017110.

Hanson, R. T., L. E. Flint, A. L. Flint, M. D. Dettinger, C. C. Faunt, D. Cayan, and W. Schmid. 2012. A method for physically based model analysis of conjunctive use in response to potential climate changes. *Water Resources Research* 48(6). http://dx.doi.org/10.1029/2011WR010774.

Harold, J., I. Lorenzoni, T. F. Shipley, and K. R. Coventry. 2016. Cognitive and psychological science insights to improve climate change data visualization. *Nature Climate Change* 6(12):1080-1089. https://doi.org/10.1038/nclimate3162.

Harpold, A. A., and P. D. Brooks. 2018. Humidity determines snowpack ablation under a warming climate. *Proceedings of the National Academy of Sciences of the United States of America* 115(6):1215-1220. https://doi.org/10.1073/pnas.1716789115.

Harpold, A. A., M. D. Dettinger, and S. Rajagopal. 2017. Defining snow drought and why it matters. *Earth and Space Science* 98. https://doi.org/10.1029/2017EO068775.

Hatala, A. R., C. Njeze, D. Morton, T. Pearl, and K. Bird-Naytowhow. 2020. Land and nature as sources of health and resilience among Indigenous youth in an urban Canadian context: A photovoice exploration. *BMC Public Health* 20:538. https://doi.org/10.1186/s12889-020-08647-z.

Hatfield, J. L., L. Wright-Morton, and B. Hall. 2018. Vulnerability of grain crops and croplands in the Midwest to climatic variability and adaptation strategies. *Climatic Change* 146:263-275. https://doi.org/10.1007/s10584-017-1997-x.

Hiza-Redsteer, M. M. and S. M. Wessells, 2017. A record of change—Science and elder observations on the Navajo Nation. General Information Product 181. Washington, DC: US Geological Survey. https://pubs.er.usgs.gov/publication/gip181.

Holmquist, J. R., L. N. Brown, and G. M. MacDonald. 2021. Localized scenarios and latitudinal patterns of vertical and lateral resilience of tidal marshes to sea-level rise in the contiguous United States. *Earth's Future* 9(6):e2020EF001804. https://doi.org/10.1029/2020EF001804.

Houghton, A., and C. Castillo-Salgado. 2019. Associations between green building design strategies and community health resilience to extreme heat events: A systematic review of the evidence. *International Journal of Environmental Research and Public Health* 16(4):663. https://doi.org/10.3390/ijerph16040663.

Huang, H., J. M. Winter, and E. C. Osterberg. 2018. Mechanisms of abrupt extreme precipitation change over the northeastern United States. *Journal of Geophysical Research: Atmospheres* 123(14):7179-7192. https://doi.org/10.1029/2017JD028136.

Huang, H., C. M. Patricola, J. M. Winter, E. C. Osterberg, and J. S. Mankin. 2021. Rise in Northeast US extreme precipitation caused by Atlantic variability and climate change. *Weather and Climate Extremes* 33:100351. https://doi.org/10.1016/j.wace.2021.100351.

Huang, X., and D. L. Swain. 2022. Climate change is increasing the risk of a California megaflood. *Science Advances* 8(31). https://doi.org/10.1126/sciadv.abq0995.

Ibanez, T., W. J. Platt, P. J. Bellingham, G. Vieilledent, J. Franklin, P. H. Martin, C. Menkes, D. R. Pérez-Salicrup, J. Russell-Smith, and G. Keppel. 2022. Altered cyclone–fire interactions are changing ecosystems. *Trends in Plant Science* 27(12):1218-1230. https://doi.org/10.1016/j.tplants.2022.08.005.

Iglesias, V., A. E. Braswell, M. W. Rossi, M. B. Joseph, C. McShane, M. Cattau, M. J. Koontz, J. McGlinchy, R. C. Nagy, J. Balch, S. Leyk, and W. R. Travis. 2021. Risky development: Increasing exposure to natural hazards in the United States. *Earth's Future* 9(7). https://doi.org/10.1029/2020ef001795.

IOM (Institute of Medicine). 1988. *The Future of Public Health*. Washington, DC: National Academy Press. https://doi.org/10.17226/1091.

IPCC (Intergovernmental Panel on Climate Change). 2021a. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. V. Masson-Delmotte, P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou, eds. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009157896.

IPCC. 2021b. Annex VII: Glossary. J. B. R. Matthews, V. Möller, R. van Diemen, J. S. Fuglestvedt, V. Masson Delmotte, C. Méndez, S. Semenov, and A. Reisinger. Pp. 2215-2256 in *Climate Change 2021: The Physical Science Basis*. Contribution of Working

Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change edited by Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou, eds. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009157896.022.

IPCC. 2022a. *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. H. O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama, eds. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009325844.

IPCC. 2022b. Summary for Policymakers. In *Climate Change 2022: Mitigation of Climate Change.* Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. P. R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, and J. Malley, eds. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009157926.001

Izaguirre, C., I. J. Losada, P. Camus, J. L. Vigh, and V. Stenek. 2021. Climate change risk to global port operations. *Nature Climate Change* 11(1):14-20. https://doi.org/10.1038/s41558-020-00937-z.

Jeanson, A. L., A. Lynch, J. Thiem, W. Potts, T. Haapasalo, A. Danylchuk, T. Beard, R. Arlinghaus, L. Hunt, and N. Young. 2021. A bright spot analysis of inland recreational fisheries in the face of climate change: learning about adaptation from small successes. *Reviews in Fish Biology and Fisheries* 31(2):181-200. https://doi.org/10.1007/s11160-021-09638-y.

Johnson, D. E., M. Parsons, and K. Fisher. 2022. Indigenous climate change adaptation: New directions for emerging scholarship. *Environment and Planning E. Nature and Space* 5(3):1541-1578. https://doi.org/10.1177/25148486211022450.

Johnson-Jennings, M., S. Billiot, and K. Walters. 2020. Returning to our roots: Tribal health and wellness through land-based healing. *Genealogy* 4(3):91. https://doi.org/10.3390/genealogy4030091.

Johnston, C. M. T., and V. C. Radeloff. 2019. Global mitigation potential of carbon stored in harvested wood products. *Proceedings of the National Academy of Sciences of the United States of America* 116(29):14526-14531. http://dx.doi.org/10.1073/pnas.1904231116.

Juroszek, P., P. Racca, S. Link, J. Farhumand, and B. Kleinhenz. 2020. Overview on the review articles published during the past 30 years relating to the potential climate change effects on plant pathogens and crop disease risks. *Plant Pathology* 69(2):179-193. https://doi.org/10.1111/ppa.13119.

Karimi, P. 2023. Arid lands, imperial ambitions. *Science* 379(6631):445. http://dx.doi.org/10.1126/science.adf4887.

Karl, T. R., J. M. Melillo., and T. C. Peterson. 2009. *Global Climate Change Impacts in the United States.* Cambridge, UK: Cambridge University Press. https://doi.org/10.5860/choice.47-4432.

Karnauskas, K. B., S. L. Miller, and A. C. Schapiro. 2020. Fossil fuel combustion is driving indoor CO_2 toward levels harmful to human cognition. *GeoHealth* 4(5). https://doi.org/10.1029/2019gh000237.

Kause, A., W. Bruine De Bruin, J. Persson, H. Thorén, L. Olsson, A. Wallin, S. Dessai, and N. Vareman. 2022. Confidence levels and likelihood terms in IPCC reports: A survey of experts from different scientific disciplines. *Climatic Change* 173. https://doi.org/10.1007/s10584-022-03382-3.

Keeley, J. E., and A. D. Syphard. 2019. Twenty-first century California, USA, wildfires: Fuel-dominated vs. wind-dominated fires. *Fire Ecology* 15(1):1-15. https://doi.org/10.1186/s42408-019-0041-0.

Keith, D. A., J. P. Rodríguez, T. M. Brooks, M. A. Burgman, E. G. Barrow, L. Bland, P. J. Comer, J. Franklin, J. Link, M. A. McCarthy, R. M. Miller, N. J. Murray, J. Nel, E. Nicholson, M. A. Oliveira-Miranda, T. J. Regan, K. M. Rodríguez-Clark, M. Rouget, and M. D. Spalding. 2015. The IUCN Red List of Ecosystems: Motivations, challenges, and applications. *Conservation Letters* 8(3):214-226. https://doi.org/10.1111/conl.12167.

Keith, D. A., J. R. Ferrer-Paris, E. Nicholson, M. J. Bishop, B. A. Polidoro, E. Ramirez-Llodra, M. G. Tozer, J. L. Nel, R. Mac Nally, E. J. Gregr, K. E. Watermeyer, F. Essl, D. Faber-Langendoen, J. Franklin, C. E. R. Lehmann, A. Etter, D. J. Roux, J. S. Stark, J. A. Rowland, N. A. Brummitt, U. C. Fernandez-Arcaya, I. M. Suthers, S. K. Wiser, I. Donohue, L. J. Jackson, R. T. Pennington, T. M. Iliffe, V. Gerovasileiou, P. Giller, B. J. Robson, N. Pettorelli, A. Andrade, A. Lindgaard, T. Tahvanainen, A. Terauds, M. A. Chadwick, N. J. Murray, J. Moat, P. Pliscoff, I. Zager, and R. T. Kingsford. 2022. A function-based typology for Earth's ecosystems. *Nature* 610(7932):513-518. https://doi.org/10.1038/s41586-022-05318-4.

Khanna, M., L. Chen, B. Basso, X. Cai, J. L. Field, K. Guan, C. Jiang, T. J. Lark, T. L. Richard, S. A. Spawn-Lee, P. Yang, and K. Y. Zipp. 2021. Redefining marginal land for bioenergy crop production. *GCB Bioenergy* 13:1590-1609. https://doi.org/10.1111/gcbb.12877.

Kjesbu, O. S., S. Sundby, A. B. Sandø, M. Alix, S. S. Hjøllo, M. Tiedemann, M. Skern-Mauritzen, C. Junge, M. Fossheim, and C. Thorsen Broms. 2022. Highly mixed impacts of near-future climate change on stock productivity proxies in the North East Atlantic. *Fish and Fisheries* 23(3):601-615. https://doi.org/10.1111/faf.12635.

Knighton, J., J. Conneely, and M. T. Walter. 2019. Possible increases in flood frequency due to the loss of Eastern Hemlock in the Northeastern United States: Observational insights and predicted impacts. *Water Resources Research* 55(7):5342-5359. https://doi.org/10.1029/2018WR024395.

Kossin, J. P. 2018. A global slowdown of tropical-cyclone translation speed. *Nature* 558(7708):104-107. https://doi.org/10.1038/s41586-018-0158-3.

Kubiszewski, I., R. Costanza, S. Anderson, and P. Sutton. 2020. The future value of ecosystem services: Global scenarios and national implications. *Environmental Assessments* 26:289-301. https://doi.org/10.1016/j.ecoser.2017.05.004.

Lake, F. K. 2021. Indigenous fire stewardship: Federal/tribal partnerships for wildland fire research and management. *Fire Management Today* 79(1):30-39. https://www.fs.usda.gov/treesearch/pubs/62060.

Lamjiri, M. A., M. D. Dettinger, F. M. Ralph, and B. Guan. 2017. Hourly storm characteristics along the U.S. West Coast: Role of atmospheric rivers in extreme precipitation. *Geophysical Research Letters* 44(13):7020-7028. https://doi.org/10.1002/2017gl074193.

Lark, T. J., N. P. Hendricks, A. Smith, N. Pates, S. A. Spawn-Lee, M. Bougie, E. G. Booth, C. J. Kucharik, and H. K. Gibbs. 2022. Environmental outcomes of the US Renewable Fuel Standard. *Proceedings of the National Academy of Sciences of the United States of America* 119. https://doi.org/10.1073/pnas.2101084119.

Lavers, D. A., F. M. Ralph, D. E. Waliser, A. Gershunov, and M. D. Dettinger. 2015. Climate change intensification of horizontal water vapor transport in CMIP5. *Geophysical Research Letters* 42(13):5617-5625. https://doi.org/10.1002/2015GL064672.

Law, B. E., L. T. Berner, P. C. Buotte, D. J. Mildrexler, and W. J. Ripple. 2021. Strategic Forest Reserves can protect biodiversity in the western United States and mitigate climate change. *Communications Earth & Environment* 2(1):1-13. https://doi.org/10.1038/s43247-021-00326-0.

Law, B. E., W. R. Moomaw, T. W. Hudiburg, W. H. Schlesinger, J. D. Sterman, and G. M. Woodwell. 2022. Creating strategic reserves to protect forest carbon and reduce biodiversity losses in the United States. *Land* 11(5):721. https://doi.org/10.3390/land11050721.

Le Page, M. 2022. China's worst heatwave. *New Scientist* 255(3401):7. https://doi.org/10.1016/S0262-4079(22)01506-8.

Leonard, K. 2021. WAMPUM Adaptation framework: Eastern coastal tribal nations and sea level rise impacts on water security. *Climate and Development* 13(9):842-851. https://doi.org/10.1080/17565529.2020.1862739.

Letson, F. W., R. J. Barthelmie, K. I. Hodges, and S. C. Pryor. 2021. Intense windstorms in the northeastern United States. *Natural Hazards and Earth System Sciences* 21(7):2001-2020. https://doi.org/10.5194/nhess-21-2001-2021.

Li, J., K. Peng, P. Wang, N. Zhang, K. Feng, D. Guan, J. Meng, W. Wei, and Q. Yang. 2020. Critical rare-earth elements mismatch global wind-power ambitions. *One Earth* 3(1):116-125. https://doi.org/10.1016/j.oneear.2020.06.009.

Liddle, B. 2014. Impact of population, age structure, and urbanization on carbon emissions/energy consumption: Evidence from macro-level, cross-country analyses. *Population and Environment* 35:286-304. https://doi.org/10.1007/s11111-013-0198-4.

Lines, L., and C. G. Jardine. 2019. Connection to the land as a youth-identified social determinant of Indigenous Peoples' health. *BMC Public Health* 19:176. https://doi.org/10.1186/s12889-018-6383-8.

Lipton, R. B., S. Munjal, A. Alam, D. C. Buse, K. M. Fanning, M. L. Reed, T. J. Schwedt, and D. W. Dodick. 2018. Migraine in America Symptoms and Treatment (MAST) Study: Baseline study methods, treatment patterns, and gender differences. *Headache: The Journal of Head and Face Pain* 58(9):1408-1426. https://doi.org/10.1111/head.13407.

Littell, J. S., D. McKenzie, H. Y. Wan, and S. A. Cushman. 2018. Climate change and future wildfire in the western United States: An ecological approach to nonstationarity. *Earth's Future* 6(8):1097-1111. https://doi.org/10.1029/2018EF000878.

Liu, L. 2012. Association between residential proximity to fuel-fired power plants and hospitalization rate for respiratory diseases. *Environmental Health Perspectives* 120:807-810. http://dx.doi.org/10.1289/ehp.1104146.

Liu, L., and B. Basso. 2020. Impacts of climate variability and adaptation strategies on crop yields and soil organic carbon in the US Midwest. *PLoS One* 15(1). https://doi.org/10.1371/journal.pone.0225433.

Long, J. W., R. W. Goode, and F. K. Lake. 2020. Recentering ecological restoration with tribal perspectives. *Fremontia* 48(1):14-19. https://www.fs.usda.gov/treesearch/pubs/61600.

Lotze, H. K., S. Mellon, J. Coyne, M. Betts, M. Burchell, K. Fennel, M. A. Dusseault, S. D. Fuller, E. Galbraith, and L. G. Suarez. 2022. Long-term ocean and resource dynamics in a hotspot of climate change. *FACETS* 7:1142-1184. https://doi.org/10.1139/facets-2021-0197.

Madison, J. 1788. Federalist Papers No. 51.

Manning, B. R. M. and K. Reed. 2019. Returning the Yurok Forest to the Yurok Tribe: California's first tribal carbon credit project. *Stanford Environmental Law Journal* 39:71. https://heinonline.org/HOL/P?h=hein.journals/staev39&i=79.

Marks-Block, T., F. K. Lake, and L. M. Curran, 2019. Effects of understory fire management treatments on California Hazelnut, an ecocultural resource of the Karuk and Yurok Indians in the Pacific Northwest. *Forest Ecology and Management* 450:117517. http://dx.doi.org/10.1016/j.foreco.2019.117517.

Martinez-Feria, R. A., and B. Basso. 2020. Unstable crop yields reveal opportunities for site-specific adaptations to climate variability. *Scientific Reports* 10:2885. https://doi.org/10.1038/s41598-020-59494-2.

Martinez-Feria, R. A., B. Basso, and S. Kim 2022. Boosting climate change mitigation potential of perennial lignocellulosic crops grown on marginal lands. *Environmental Research Letters* 17:044004. https://doi.org/10.1088/1748-9326/ac541b.

Mastrandrea, M. D., C. B. Field, T. F. Stocker, O. Edenhofer, K. L. Ebi, D. J. Frame, H. Held, E. Kriegler, K. J. Mach, P. R. Matschoss, G. K. Plattner, G. W. Yohe, and F. W. Zwiers. 2010. Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties. Intergovernmental Panel on Climate Change (IPCC). https://www.ipcc.ch/site/assets/uploads/2017/08/AR5_Uncertainty_Guidance_Note.pdf.

Mayrhuber, E. A. S., M. L. Dückers, P. Wallner, A. Arnberger, B. Allex, L. Wiesböck, A. Wanka, F. Kolland, R. Eder, and H.-P. Hutter. 2018. Vulnerability to heatwaves and implications for public health interventions A scoping review. *Environmental Research* 166:42-54. https://doi.org/10.1016/j.envres.2018.05.021.

McEvoy, D. J., D. W. Pierce, J. F. Kalansky, D. R. Cayan, and J. T. Abatzoglou. 2020. Projected changes in reference evapotranspiration in California and Nevada: Implications for drought and wildland fire danger. *Earth's Future* 8(11). https://doi.org/10.1029/2020EF001736.

McMichael, C. 2020. Human mobility, climate change, and health: Unpacking the connections. *The Lancet Planetary Health* 4(6):e217-e218. https://doi.org/10.1016/S2542-5196(20)30125-X.

McMullin, R. T., Y. F. Wiersma, S. G. Newmaster, and J. C. Lendemer. 2019. Risk assessment and conservation strategies for rare lichen species and communities threatened by sea-level rise in the Mid-Atlantic Coastal Plain. *Biological Conservation* 239:108281. https://doi.org/10.1016/j.biocon.2019.108281.

Medellín-Azuara, J., D. MacEwan, R. E. Howitt, D. A. Sumner, J. R. Lund, J. Scheer, R. Gailey, Q. Hart, N. D. Alexander, and B. Arnold. 2016. Economic analysis of the 2016 California drought on agriculture. Center for Watershed Sciences, University of California, Davis. https://watershed.ucdavis.edu/news/2016/08/15/economic-analysis-2016-california-drought-agriculture-report.

Melillo, J. M., T. C. Richmond, and G. W. Yohe. 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* Washington, DC: US Global Change Research Program. https://doi/10.7930/J0Z31WJ2.

Méndez, M., G. Flores-Haro, and L. Zucker. 2020. The (in) visible victims of disaster: Understanding the vulnerability of undocumented Latino/a and Indigenous immigrants. *Geoforum* 116:50-62. https://doi.org/10.1016/j.geoforum.2020.07.007.

Merrifield, M. A., and M. E. Maltrud. 2011. Regional sea level trends due to a Pacific trade wind intensification. *Geophysical Research Letters* 38. https://doi.org/10.1029/2011GL049576.

Merrifield, M. A., P. R. Thompson, and M. A. Lander. 2012. Multidecadal sea level anomalies and trends in the western tropical Pacific. *Geophysical Research Letters* 39:L13602. https://doi.org/10.1029/2012GL052032.

Merrifield, M. A., and P. R. Thompson. 2018. Interdecadal sea level variations in the Pacific: Distinctions between the tropics and extratropics. *Geophysical Research Letters* 45(13):6604-6610. https://doi.org/10.1029/2018gl077666.

Michaelis, A. C., A. Gershunov, A. Weyant, M. A. Fish, T. Shulgina, and F. M. Ralph. 2022. Atmospheric river precipitation enhanced by climate change: A case study of the storm that contributed to California's Oroville Dam crisis. *Earth's Future* 10(3). https://doi.org/10.1029/2021EF002537.

Mohai, P., and R. Saha. 2015. Which came first, people or pollution? Assessing the disparate siting and post-siting demographic change hypotheses of environmental injustice. *Environmental Research Letters* 10(11):115008. https://doi.org/ 10.1088/1748-9326/10/11/115008.

Molino, G. D., M. A. Kenney, and A. E. Sutton-Grier. 2020. Stakeholder-defined scientific needs for coastal resilience decisions in the Northeast US. *Marine Policy* 118:103987. http://dx.doi.org/10.1016/j.marpol.2020.103987.

Moon, J.-H., Y. T. Song, P. D. Bromirski, and A. J. Miller. 2013. Multidecadal regional sea level shifts in the Pacific over 1958-2008. *Journal of Geophysical Research: Oceans* 118(12):7024-7035. https://doi.org/https://doi.org/10.1002/2013JC009297.

Mora, C., D. Spirandelli, E. C. Franklin, J. Lynham, M. B. Kantar, W. Miles, C. Z. Smith, K. Freel, J. Moy, L. V. Louis, E. W. Barba, K. Bettinger, A. G. Frazier, J. F. Colburn Ix, N. Hanasaki, E. Hawkins, Y. Hirabayashi, W. Knorr, C. M. Little, K. Emanuel, J. Sheffield, J. A. Patz, and C. L. Hunter. 2018. Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. *Nature Climate Change* 8(12):1062-1071. http://dx.doi.org/10.1038/s41558-018-0315-6.

Mora, C., T. McKenzie, I. M. Gaw, J. M. Dean, H. von Hammerstein, T. A. Knudson, R. O. Setter, C. Z. Smith, K. M. Webster, J. A. Patz, and E. C. Franklin. 2022. Over half of known human pathogenic diseases can be aggravated by climate change. *Nature Climate Change* 12(9):869-875. https://doi.org/10.1038/s41558-022-01426-1.

Morris, M. R., S. K., Nutley, C. W. Striley, and A. J. Pumariega. 2021a. Psychiatric medications prescribed on-campus and off-campus for university students: Differences in demographics, types of medication, and satisfaction with services. *Journal of American College Health.* https://doi.org/10.1080/07448481.2021.1942002.

Morris, M. R., C. C. Hoeflich, S. Nutley, V. L. Ellingrod, M. B. Riba, and C. W. Striley. 2021b. Use of psychiatric medication by college students: A decade of data. *Pharmacotherapy: The Journal of Human Pharmacology and Drug Therapy* 41(4):350-358. https://doi.org/10.1002/phar.2513.

Murray, A. T., L. Carvalho, R. L. Church, C. Jones, D. Roberts, J. Xu, K. Zigner, and D. Nash. 2021. Coastal vulnerability under extreme weather. *Applied Spatial Analysis and Policy* 14(3):497-523. https://doi.org/10.1007/s12061-020-09357-0.

Nagy, R. C., E. J. Fusco, J. K. Balch, J. T. Finn, A. Mahood, J. M. Allen, and B. A. Bradley. 2021. A synthesis of the effects of cheatgrass invasion on US Great Basin carbon storage. *Journal of Applied Ecology* 58(2):327-337. https://doi.org/10.1111/1365-2664.13770.

NASEM (National Academies of Sciences, Engineering, and Medicine). 2015. *Review of the Draft Interagency Report on the Impacts of Climate Change on Human Health in the United States.* Washington, DC: The National Academies Press. https://doi.org/10.17226/21787.

NASEM. 2016. *Attribution of Extreme Weather Events in the Context of Climate Change.* Washington, DC: The National Academies Press. https://doi.org/10.17226/21852.

NASEM. 2017a. *Accomplishments of the U.S. Global Change Research Program.* Washington, DC: The National Academies Press. https://doi.org/10.17226/24670.

NASEM. 2017b. *Review of the Draft Climate Science Special Report.* Washington, DC: The National Academies Press. https://doi.org/10.17226/24712.

NASEM. 2018a. *Review of the Draft Fourth National Climate Assessment.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25013.

NASEM. 2018b. *Review of the Draft Second State of the Carbon Cycle Report (SOCCR2).* Washington, DC: The National Academies Press. https://doi.org/10.17226/25045.

NASEM. 2019. *Negative Emissions Technologies and Reliable Sequestration: A Research Agenda.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25259.

NASEM. 2021. *Reflecting Sunlight: Recommendations for Solar Geoengineering Research and Research Governance.* Washington, DC: The National Academies Press. https://doi.org/10.17226/25762.

NASEM. 2022a. *A Research Strategy for Ocean-based Carbon Dioxide Removal and Sequestration.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26278.

NASEM. 2022b. *Greenhouse Gas Emissions Information for Decision Making: A Framework Going Forward.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26641.

NASEM. 2023. *Wastewater-based Disease Surveillance for Public Health Action.* Washington, DC: The National Academies Press. https://doi.org/10.17226/26767.

National Assessment Synthesis Team. 2001. Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Report for the US Global Change Research Program, Cambridge, UK: Cambridge University Press. 620. https://doi.org/10.1002/joc.749.

Nazarian, N., E. Krayenhoff, B. Bechtel, D. Hondula, R. Paolini, J. Vanos, T. Cheung, W. Chow, R. de Dear, and O. Jay. 2022. Integrated assessment of urban overheating impacts on human life. *Earth's Future* 10(8). https://doi.org/10.1029/2022EF002682.

Neelin, J. D., B. Langenbrunner, J. E. Meyerson, A. Hall, and N. Berg. 2013. California winter precipitation change under global warming in the Coupled Model Intercomparison Project phase 5 ensemble. *Journal of Climate* 26(17):6238-6256. https://doi.org/10.1175/JCLI-D-12-00514.1.

Nerbass, F. B., R. Pecoits-Filho, W. F. Clark, J. M. Sontrop, C. W. McIntyre, and L. Moist. 2017. Occupational heat stress and kidney health: From farms to factories. *Kidney International Reports* 2(6):998-1008. https://doi.org/10.1016/j.ekir.2017.08.012.

Niraula, R., T. Meixner, F. Dominguez, N. Bhattarai, M. Rodell, H. Ajami, D. Gochis, and C. Castro. 2017. How might recharge change under projected climate change in the western U.S.? *Geophysical Research Letters* 44(20):10407-10418. http://dx.doi.org/10.1002/2017GL075421.

Northrup, D. L., B. Basso, M. O. Wang, C. L. S. Morgan, and P. N. Befry. 2021. Novel technologies for emission reduction complement conservation agriculture to achieve negative emissions from row-crop production. *Proceedings of the National Academy of Sciences of the United States of America* 118(28):e2022666118. https://doi.org/10.1073/pnas.2022666118.

Novick, K., C. Williams, B. Runkle, W. R. L. Anderegg, D. Hollinger, M. Litvak, C. Normile, G. Shrestha, M. Almaraz, C. Anderson, M. Barnes, D. Baldocchi, L. Colburn, D. Cullenward, M. Evans, K. Guan, T. Keenan, R. Lamb, E. Larson, E. Oldfield, B. Poulter, J. Reyes, J. Sanderman, P. Selmants, E. Sepulveda Carlo, M. S. Torn, A. Trugman, and C. Woodall. 2022. The science needed for robust, scalable, and credible nature-based climate solutions in the United States: Full Report. https://doi.org/10.5967/n7r9-7j83.

NRC (National Research Council). 2003. *Planning Climate and Global Change Research: A Review of the Draft U.S. Climate Change Science Program Strategic Plan.* Washington, DC: The National Academies Press. https://doi.org/10.17226/11565.

NRC. 2004. *Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan.* Washington, DC: The National Academies Press. https://doi.org/10.17226/10635.

NRC. 2013. *A Review of the Draft 2013 National Climate Assessment.* Washington, DC: The National Academies Press. https://doi.org/10.17226/18322.

Nunfam, V. F., K. Adusei-Asante, E. J. Van Etten, J. Oosthuizen, and K. Frimpong. 2018. Social impacts of occupational heat stress and adaptation strategies of workers: A narrative synthesis of the literature. *Science of the Total Environment* 643:1542-1552. https://doi.org/10.1016/j.scitotenv.2018.06.255.

Nyelele, C. and C. N. Kroll, 2020. The equity of urban forest ecosystem services and benefits in the Bronx, NY. *Urban Forestry & Urban Greening* 53:126723. https://doi.org/10.1016/j.ufug.2020.126723.

ODNI (Office of the Director of National Intelligence). 2022. 2022 Annual Threat Assessment of the U.S. Intelligence Community. https://www.dni.gov/index.php/newsroom/reports-publications/reports-publications-2022/item/2279-2022annual-threat-assessment-of-the-u-s-intelligence-community.

Olafsdottir, H. K., H. Rootzén, and D. Bolin. 2021. Extreme rainfall events in the northeastern United States become more frequent with rising temperatures, but their intensity distribution remains stable. *Journal of Climate* 34(22):8863-8877. https://doi.org/10.1175/JCLI-D-20-0938.1.

Oreskes, N., 2021. *Science on a Mission: How Military Funding Shaped What We Do and Don't Know About the Ocean.* Chicago: University of Chicago Press.

Ortiz-Bobea, A., H. Wang, C. M. Carrillo, and T. R. Ault. 2019. Unpacking the climatic drivers of US agricultural yields. *Environmental Research Letters* 14(6):064003. https://doi.org/10.1088/1748-9326/ab1e75.

Oscilowicz, E., I. Anguelovski, M. Triguero-Mas, M. García-Lamarca, F. Baró, and H. V. Cole. 2022. Green justice through policy and practice: A call for further research into tools that foster healthy green cities for all. *Cities & Health* 6(5):878-893. https://doi.org/10.1080/23748834.2022.2072057.

Overland, J. E., T. J. Ballinger, J. Cohen, J. A. Francis, E. Hanna, R. Jaiser, B.-M. Kim, S. J. Kim, J. Ukita, and T. Vihma. 2021. How do intermittency and simultaneous processes obfuscate the Arctic influence on midlatitude winter extreme weather events? *Environmental Research Letters* 16(4):043002. https://doi.org/10.1088/1748-9326/abdb5d.

Papaioannou, E. A., R. L. Selden, J. Olson, B. J. McCay, M. L. Pinsky, and K. St. Martin. 2021. Not all those who wander are lost—responses of fishers' communities to shifts in the distribution and abundance of fish. *Frontiers in Marine Science* 8:669094. https://doi.org/10.3389/fmars.2021.669094.

Parks, S. A. and J. T. Abatzoglou. 2020. Warmer and drier fire seasons contribute to increases in area burned at high severity in western US forests from 1985 to 2017. *Geophysical Research Letters* 47(22):e2020GL089858. https://doi.org/10.1029/2020GL089858.

Penney, S., J. Bell, and J. Balbus. 2009. Estimating the health impacts of coal-fired power plants receiving public international financing. Environmental Defense Fund. https://www.edf.org/sites/default/files/9553_coal-plants-health-impacts.pdf.

Permentier, K., S. Vercammen, S. Soetaert, and C. Schellemans. 2017. Carbon dioxide poisoning: A literature review of an often forgotten cause of intoxication in the emergency department. *International Journal of Emergency Medicine* 10(1):14. https://doi.org/10.1186/s12245-017-0142-y.

Perra, M., and T. Brinkman. 2021. Seeing science: Using graphics to communicate research. *Ecosphere* 12(10):e03786. https://doi.org/10.1002/ecs2.3786.

Pershing, A. J., M. A. Alexander, D. C. Brady, D. Brickman, E. N. Curchitser, A. W. Diamond, L. McClenachan, K. E. Mills, O. C. Nichols, and D. E. Pendleton. 2021. Climate impacts on the Gulf of Maine ecosystem: A review of observed and expected changes in 2050 from rising temperatures. *Elementa: Science of the Anthropocene* 9(1):00076. https://doi.org/10.1525/elementa.2020.00076.

Piecuch, C. G., K. Bittermann, A. C. Kemp, R. M. Ponte, C. M. Little, S. E. Engelhart, and S. J. Lentz. 2018. River discharge effects on United States Atlantic and Gulf coast sea-level changes. *Proceedings of the National Academy of Sciences of the United States of America* 115(30):7729-7734. https://doi.org/10.1073/pnas.1805428115.

Pielke, R. 2021. Economic "normalization" of disaster losses 1998-2020: A literature review and assessment. *Environmental Hazards* 20(2):93-111. https://doi.org/10.1080/17477891.2020.1800440.

Polade, S. D., A. Gershunov, D. R. Cayan, M. D. Dettinger, and D. W. Pierce. 2017. Precipitation in a warming world: Assessing projected hydro climate changes in California and other Mediterranean climate regions. *Scientific Reports* 7:10783. https://doi.org/10.1038/s41598-017-11285-y.

Powell, E. J., M. C. Tyrrell, A. Milliken, J. M. Tirpak, and M. D. Staudinger. 2019. A review of coastal management approaches to support the integration of ecological and human community planning for climate change. *Journal of Coastal Conservation* 23(1):1-18. https://doi.org/10.1007/s11852-018-0632-y.

Pugh, T. A. M., M. Lindeskog, B. Smith, B. Poulter, A. Arneth, V. Haverd, and L. Calle. 2019. Role of forest regrowth in global carbon sink dynamics. *Proceedings of the National Academy of Sciences of the United States of America* 116(10):4382-4387. https://doi.org/10.1073/pnas.1810512116.

Reckien, D., and E. P. Petkova. 2019. Who is responsible for climate change adaptation? *Environmental Research Letters* 14(1):014010. https://doi.org/10.1088/1748-9326/aaf07a.

Redvers, J. 2020. "The land is a healer": Perspectives on land-based healing from Indigenous practitioners in northern Canada. *International Journal of Indigenous Health* 15(1):90-107. http://dx.doi.org/10.32799/ijih.v15i1.34046.

Reed, P. M., A. Hadjimichael, R. H. Moss, E. Monier, S. Alba, C. Brelsford, C. Burleyson, S. Cohen, A. Dyreson, D. Gold, R. Gupta, K. Keller, M. Konar, J. Macknick, J. Morris, V. Srikrishnan, N. Voisin, and J. Yoon. 2022. MultiSector Dynamics: Scientific Challenges and a Research Vision for 2030, A Community of Practice Supported by the United States Department of Energy's Office of Science. *Zenodo*. http://dx.doi.org/10.5281/zenodo.6144309.

Reyes-García, V., Á. Fernández-Llamazares, P. McElwee, Z. Molnár, K. Öllerer, S. J. Wilson, and E. S. Brondizio. 2019. The contributions of Indigenous Peoples and local communities to ecological restoration. *Restoration Ecology* 27(1):3-8. https://doi.org/10.1111/rec.12894.

Righetti, T. K., T. Stoellinger, and R. Godby. 2021. Adapting to coal plant closures: A framework to understand state energy transition resistance. *Environmental Law* 51:957. https://ssrn.com/abstract=3781987.

Rindfuss, R.R., S. J. Walsh, B. L. Turner, J. Fox, and V. Mishra. 2004. Developing a science of land change: Challenges and methodological issues. *Proceedings of the National Academy of Sciences of the United States of America* 101(39):13976-13981. https://doi.org/10.1073/pnas.0401545101.

Robertson, G. P., S. K. Hamilton, K. Paustian, and P. Smith. 2022. Land-based climate solutions for the United States. *Global Change Biology* 28(16):4912-4919. https://doi.org/10.1111/gcb.16267.

Rogers, L. A., R. Griffin, T. Young, E. Fuller, K. St. Martin, and M. L. Pinsky. 2019. Shifting habitats expose fishing communities to risk under climate change. *Nature Climate Change* 9(7):512-516. https://doi.org/10.1038/s41558-019-0503-z.

Rosenau, N. A., H. Galavotti, K. K. Yates, C. C. Bohlen, C. W. Hunt, M. Liebman, C. A. Brown, S. R. Pacella, J. L. Largier, and K. J. Nielsen. 2021. Integrating high-resolution coastal acidification monitoring data across seven United States estuaries. *Frontiers in Marine Science* 8:1066. https://doi.org/10.3389/fmars.2021.679913.

Rosenzweig, C., and M. L. Parry. 1994. Potential impact of climate change on world food supply. *Nature* 367(6459):133-138. https://doi.org/10.1038/367133a0.

Rothstein, R. 2017. *The Color of Law: A Forgotten History of How Our Government Segregated America.* New York: Liveright Publishing Corp.

Rougier, N. P., M. Droettboom, and P. E. Bourne. 2014. Ten simple rules for better figures. *PLoS Computational Biology* 10:e1003833. https://doi.org/10.1371/journal.pcbi.1003833.

Runkle, B. R. 2022. Biological engineering for nature-based climate solutions. *Journal of Biological Engineering* 16(1):1-8. https://doi.org/10.1186/s13036-022-00287-8.

Sanders, B. F., J. E. Schubert, D. T. Kahl, K. J. Mach, D. Brady, A. AghaKouchak, F. Forman, R. A. Matthew, N. Ulibarri, and S. J. Davis. 2023. Large and inequitable flood risks in Los Angeles, California. *Nature Sustainability* 6:47-57. https://doi.org/10.1038/s41893-022-00977-7.

Sanson, A., K. Malca, J. Hoorn, and S. Burke. 2022. *Children and Climate Change*. Elements in Child Development, vol. 26. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/9781009118705.

Satish, U., M. J. Mendell, K. Shekhar, T. Hotchi, D. Sullivan, S. Streufert, and W. J. Fisk. 2012. Is CO_2 an indoor pollutant? Direct effects of low-to-moderate CO_2 concentrations on human decision-making performance. *Environmental Health Perspectives* 120:1671-1677. https://doi.org/10.1289/ehp.1104789.

Scanlon, B. R., C. C. Faunt, L. Longuevergne, R. C. Reedy, W. M. Alley, V. L. McGuire, and P. B. McMahon. 2012. Groundwater depletion and sustainability of irrigation in the US High Plains and Central Valley. *Proceedings of the National Academy of Sciences of the United States of America* 109(24):9320-9325. https://doi.org/10.1073/pnas.1200311109.

Schaeffer, R., A. Köberle, H. Van Soest, C. Bertram, G. Luderer, K. Riahi, V. Krey, D. van Vuuren, E. Kriegler, and S. Fujimori. 2020. Comparing transformation pathways across major economies. *Climatic Change* 162(4):1787-1803. https://doi.org/10.1007/s10584-020-02837-9.

Schattman, R. E., M. T. Niles, and H. M. Aitken. 2021. Water use governance in a temperate region: Implications for agricultural climate change adaptation in the Northeastern United States. *Ambio* 50(4):942-955. https://doi.org/10.1007/s13280-020-01417-6.

Schmidt. 2019. Brain fog: Does air pollution make us less productive? *Environmental Health Perspectives* 127:5. https://doi.org/10.1289/EHP4869.

Schulte, L. A., B. E. Dale, S. Bozzetto, M. Liebman, G. M. Souza, N. Haddad, T. L. Richard, B. Basso, R. C. Brown, J. A. Hilbert, and J. G. Arbuckle . 2022. Meeting global challenges with regenerative agriculture producing food and energy. *Nature Sustainability* (5):384-388. https://doi.org/10.1038/s41893-021-00827-y.

Scully, R. R., M. Basner, J. Nasrini, C. Lam, E. Hermosillo, R. C. Gur, T. Moore, D. J. Alexander, U. Satish, and V. E. Ryder. 2019. Effects of acute exposures to carbon dioxide on decision making and cognition in astronaut-like subjects. *Nature Partner Journals Microgravity* (5):17. https://doi.org/10.1038/s41526-019-0071-6.

Seddon, T. and J. Waterhouse. 2009. *Graphic Design for Non-designers: Essential Knowledge, Tips, and Tricks, Plus 20 Step-by-step Projects for the Design Novice*. San Francisco, CA: Chronicle Books.

Seddon, N., A. Smith, P. Smith, I. Key, A. Chausson, C. Girardin, J. House, S. Srivastava, and B. Turner. 2021. Getting the message right on nature-based solutions to climate change. *Global Change Biology* 27(8):1518-1546. https://doi.org/10.1111/gcb.15513.

Seppanen, O. A., W. J. Fisk, and M. J. Mendell. 1999. Association of ventilation rates and CO_2 concentrations with health and other responses in commercial and institutional buildings. *Indoor Air* (9):226-252. https://doi.org/10.1111/j.1600-0668.1999.00003.x.

Setzer, J., and L. C. Vanhala. 2019. Climate change litigation: A review of research on courts and litigants in climate governance. *Wiley Interdisciplinary Reviews: Climate Change* 10(3):e580. https://doi.org/10.1002/wcc.580.

Setzer, J., and C. Higham. 2021. *Global trends in climate change litigation: 2021 snapshot.* London: Grantham Research Institute on Climate Change and the Environment and

Centre for Climate Change Economics and Policy, London School of Economics and Political Science.

Sharma, S., R. Andrus, Y. Bergeron, M. Bogdziewicz, D. C. Bragg, D. Brockway, N. L. Cleavitt, B. Courbaud, A. J. Das, M. Dietze, T. J. Fahey, J. F. Franklin, G. S. Gilbert, C. H. Greenberg, Q. Guo, J. H. R. Lambers, I. Ibanez, J. F. Johnstone, C. L. Kilner, J. M. H. Knops, W. D. Koenig, G. Kunstler, J. M. LaMontagne, D. Macias, E. Moran, J. A. Myers, R. Parmenter, I. S. Pearse, R. Poulton-Kamakura, M. D. Redmond, C. D. Reid, K. C. Rodman, C. L. Scher, W. H. Schlesinger, M. A. Steele, N. L. Stephenson, J. J. Swenson, M. Swift, T. T. Veblen, A. V. Whipple, T. G. Whitham, A. P. Wion, C. W. Woodall, R. Zlotin, and J. S. Clark, 2022: North American tree migration paced by climate in the West, lagging in the East. *Proceedings of the National Academy of Sciences of the United States of America* 119(3):e2116691118. http://dx.doi.org/10.1073/pnas.2116691118.

Sharpton, T., T. Lawrence, and M. Hall. 2020. Drivers and barriers to public acceptance of future energy sources and grid expansion in the United States. *Renewable and Sustainable Energy Reviews* 126:109826. https://doi.org/10.1016/j.rser.2020.109826.

Shen, M., and T. F. M. Chui. 2021. Characterizing the responses of local floods to changing climate in three different hydroclimatic regions across the United States. *Advances in Water Resources* 150:103885. https://doi.org/10.1016/j.advwatres.2021.103885.

Shepherd, T. G., 2016. A common framework for approaches to extreme event attribution. *Current Climate Change Reports* 2(1):28-38. http://dx.doi.org/10.1007/s40641-016-0033-y.

Shi, L., and S. Moser. 2021. Transformative climate adaptation in the United States: Trends and prospects. *Science* 372(6549):eabc8054. https://doi.org/doi:10.1126/science.abc8054.

Sicard, P., E. Agathokleous, V. Araminiene, E. Carrari, Y. Hoshika, A. De Marco, and E. Paoletti. 2018. Should we see urban trees as effective solutions to reduce increasing ozone levels in cities? *Environmental Pollution* 243:163-176. https://doi.org/10.1126/science.add9734.

Siirila-Woodburn, E. R., A. M. Rhoades, B. J. Hatchett, L. S. Huning, J. Szinai, C. Tague, P. S. Nico, D. R. Feldman, A. D. Jones, and W. D. Collins. 2021. A low-to-no snow future and its impacts on water resources in the western United States. *Nature Reviews Earth & Environment* 2(11):800-819. https://doi.org/10.1038/s43017-021-00219-y.

Smith, A., and R. Katz. 2013. US billion-dollar weather and climate disasters: Data sources, trends, accuracy and biases. *Natural Hazards* 67(2):387-410. https://doi.org/10.1007/s11069-013-0566-5.

Snow, S., A. S. Boyson, K. H.W. Paas, H. Gough, M.-F. King, J. Barlow, C. J. Noakes, and M. C. Schraefel. 2019. Exploring the physiological, neurophysiological and cognitive performance effects of elevated carbon dioxide concentrations indoors. *Building and Environment* (156):243-252. https://doi.org/10.1016/j.buildenv.2019.04.010.

Somerville, R. C., and S. J. Hassol. 2011. Communicating the science of climate change. *Physics Today*, October 2011. https://climatecommunication.org/wp-content/uploads/2011/10/Somerville-Hassol-Physics-Today-2011.pdf.

Spiegel, S. J., S. Thomas, K. O'Neill, C. Brondgeest, J. Thomas, J. Beltran, and A. Yassi. 2020. Visual storytelling, intergenerational environmental justice and Indigenous sovereignty: Exploring images and stories amid a contested oil pipeline project. *International Journal*

of Environmental Research and Public Health 17(7):2362. https://doi.org/10.3390/ijerph17072362.

Stevens, A., and P. Lambermont. 2021. An overview of natural gas bans in the U.S. Institute for Energy Research. https://www.instituteforenergyresearch.org/wp-content/uploads/2021/08/Natural-GasBan-Report_Updated.pdf.

Swain, D. L., B. Langenbrunner, J. D. Neelin, and A. Hall. 2018. Increasing precipitation volatility in twenty-first century California. *Nature Climate Change* 8:427-433. https://doi.org/10.1038/s41558-018-0140-y.

Sweet, W. V., B. D. Hamlington, R. E. Kopp, C. P. Weaver, P. L. Barnard, D. Bekaert, W. Brooks, M. Craghan, G. Dusek, T. Frederikse, G. Garner, A. S. Genz, J. P. Krasting, E. Larour, D. Marcy, J. J. Marra, J. Obeysekera, M. Osler, M. Pendleton, D. Roman, L. Schmied, W. Veatch, K. D. White, and C. Zuzak. 2022. Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines. NOAA Technical Report NOS 01. Silver Spring, MD: National Ocean Service, National Oceanic and Atmospheric Administration. https://aambpublicoceanservice.blob.core.windows.net/oceanserviceprod/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf.

Swiss Re. 2021. Natural catastrophes in 2021: The floodgates are open. *Swiss Re Institute* 36. https://www.swissre.com/institute/research/sigma-research/sigma-2022-01.html.

Syphard, A. D., T. J. Brennan, H. Rustigian-Romsos, and J. E. Keeley. 2022. Fire-driven vegetation type conversion in southern California. *Ecological Applications* e2626. https://doi.org/10.1002/ecs2.2796.

Taddicken, M., A. Reif, and I. Hoppe. 2018. What do people know about climate change and how confident are they? On measurements and analysis of science related knowledge. *Journal of Science Communication* 17(3). https://doi.org/10.22323/2.17030201.

Taylor, K. Y. 2019. *Race for Profit: How Banks and the Real Estate Industry Undermined Black Homeownership.* Chapel Hill, NC: The University of North Carolina Press.

Thomas, K., R. D. Hardy, H. Lazrus, M. Mendez, B. Orlove, I. Rivera-Collazo, J. T. Roberts, M. Rockman, B. P. Warner, and R. Winthrop. 2019. Explaining differential vulnerability to climate change: A social science review. *Wiley Interdisciplinary Reviews: Climate Change* 10(2):e565. https://doi.org/10.1002/wcc.565.

Thompson, P. R., M. J. Widlansky, M. A. Merrifield, J. M. Becker, and J. J. Marra. 2019. A statistical model for frequency of coastal flooding in Honolulu, Hawaii, during the 21st century. *Journal of Geophysical Research*: *Oceans* 124(4):2787-2802. https://doi.org/10.1029/2018jc014741.

Thompson, P. R., M. J. Widlansky, B. D. Hamlington, M. A. Merrifield, J. J. Marra, G. T. Mitchum, and W. Sweet. 2021. Rapid increases and extreme months in projections of United States high-tide flooding. *Nature Climate Change* 11(7):584-590. https://doi.org/10.1038/s41558-021-01077-8.

Thorne, L. H., R. W. Baird, D. L. Webster, J. E. Stepanuk, and A. J. Read. 2019. Predicting fisheries bycatch: A case study and field test for pilot whales in a pelagic longline fishery. *Diversity and Distributions* 25(6):909-923. https://doi.org/10.1111/ddi.12912.

Tol, R. S. J. 2018. The economic impacts of climate change. *Review of Environmental Economics and Policy.* https://doi.org/10.1093/reep/rex027.

Toland, J. C., A. Wein, A. Wu, and L. A. Spearing. 2022. A conceptual framework for estimation of initial emergency food and water resource requirements in disasters. https://doi.org/10.5066/P9FIJCCF.

Turner, B. L., E. F. Lambin, and A. Reenberg. 2007. The emergence of land change science for global environmental change and sustainability. *Proceedings of the National Academy of Sciences of the United States of America* 104(52):20666-20671. https://doi.org/10.1073/pnas.0704119104.

Turner, B. L., P. Meyfroidt, T. Kuemmerle, D. Müller, and R. R. Chowdhury. 2020. Framing the search for a theory of land use. *Journal of Land Use Science* 15(4):489-508. https://doi.org/10.1080/1747423X.2020.1811792.

Ullrich, P. A., Z. Xu, A. M. Rhoades, M. D. Dettinger, J. F. Mount, A. D. Jones, and P. Vahmani. 2018. California's drought of the future: A midcentury recreation of the exceptional conditions of 2012-2017. *Earth's Future* 6(11):1568-1587. https://doi.org/10.1029/2018EF001007.

USGCRP (US Global Change Research Program). 2016. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment.* A. Crimmins, J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, eds. Washington, DC: US Global Change Research Program. http://dx.doi.org/10.7930/J0R49NQX.

USGCRP. 2017. *Climate Science Special Report: Fourth National Climate Assessment.* Vol. 1. D. J. Wuebbles, D. W. Fahey, K. A. Hibbard, D. J. Dokken, B. C. Stewart, and T. K. Maycock, eds. Washington, DC: US Global Change Research Program. https://doi.org/10.7930/J0J964J6.

USGCRP. 2018a. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment*. Vol. 2. D. R. Reidmiller, C. W. Avery, D. R. Easterling, K. E. Kunkel, K. L. M. Lewis, T. K. Maycock, and B. C. Stewart, eds. Washington, DC: US Global Change Research Program. https://doi.org/10.7930/NCA4.2018.

USGCRP. 2018b. *Second State of the Carbon Cycle Report (SOCCR2): A Sustained Assessment Report.* N. Cavallaro, G. Shrestha, R. Birdsey, M. A. Mayes, R. G. Najjar, S. C. Reed, P. Romero-Lankao, and Z. Zhu, eds. Washington, DC: US Global Change Research Program. https://doi.org/10.7930/SOCCR2.2018.

van der Linden, S., E. Maibach, and A. Leiserowitz. 2015. Improving public engagement with climate change: Five "best practice" insights from psychological science. *Perspectives on Psychological Science* 10(6):758-763. https://doi.org/10.1177/1745691615598516.

Van Oldenborgh, G. J., K. Van Der Wiel, A. Sebastian, R. Singh, J. Arrighi, F. Otto, K. Haustein, S. Li, G. Vecchi, and H. Cullen. 2018. Corrigendum: Attribution of extreme rainfall from Hurricane Harvey, *Environmental Research Letters* 13(1):019501. https://doi.org/10.1088/1748-9326/aaa343.

van Soest, H.L., M. G. J. den Elzen, and D. P. van Vuuren. 2021. Net-zero emission targets for major emitting countries consistent with the Paris Agreement. *Nature Communications* 12:2140. https://doi.org/10.1038/s420501467-021-22294-x.

Vinyeta, K., K. Whyte, and K. Lynn. 2016. *Climate Change Through an Intersectional Lens: Gendered Vulnerability and Resilience in Indigenous Communities in the United States.* Report No. PNW-GTR-923. Portland, OR: Pacific Northwest Research Station, US Forest Service, US Department of Agriculture. https://doi.org/10.2737/PNW-GTR-923.

Walters, B. F., G. M. Domke, D. J. Nowak, J. E. Smith, S. M. Ogle. 2021. *Greenhouse Gas Emissions and Removals from Forest Land, Woodlands, and Urban Trees in the United States, 1990-2019: Estimates and Quantitative Uncertainty for Individual States.* Fort Collins, CO: Forest Service Research Data Archive. https://doi.org/10.2737/RDS-2021-0035.

Walton, D. B., A. Hall., N. Berg, M. Schwartz, and F. Sun. 2017. Incorporating snow albedo feedback into downscaled temperature and snow cover projections for California's Sierra Nevada. *Journal of Climate* 30:1417-1438. https://doi.org/10.1175/jcli-d-16-0168.1.

Wang, R.-Q., M. T. Stacey, L. M. M. Herdman, P. L. Barnard, and L. Erikson. 2018. The influence of sea level rise on the regional interdependence of coastal infrastructure. *Earth's Future* 6(5):677-688. https://doi.org/10.1002/2017ef000742.

Wang, C., F. Zhang, J. Wang, J. K. Doyle, P. A. Hancock, C. M. Mak, and S. Liu. 2021. How indoor environmental quality affects occupants' cognitive functions: A systematic review. *Building and Environment* 193:107647. https://doi.org/10.1016/j.buildenv.2021.107647.

Warren, R., J. Price, E. Graham, N. Forstenhaeusler, and J. Vanderwal. 2018. The projected effect on insects, vertebrates, and plants of limiting global warming to 1.5°C rather than 2°C. *Science* 360(6390):791-795. https://doi.org/10.1126/science.aar3646.

Watkins, S. L. and E. Gerrish. 2018. The relationship between urban forests and race: A meta-analysis. *Journal of Environmental Management* 209:152-168. https://doi.org/10.1016/j.jenvman.2017.12.021.

Weiskopf, S. R., M. A. Rubenstein, L. G. Crozier, S. Gaichas, R. Griffis, J. E. Halofsky, K. J. Hyde, T. L. Morelli, J. T. Morisette, R. C. Muñoz, and A. J. Pershing. 2020. Climate change effects on biodiversity, ecosystems, ecosystem services, and natural resource management in the United States. *Science of the Total Environment* 733:137782. https://doi.org/10.1016/j.scitotenv.2020.137782.

Westerling, A. L., A. Gershunov, T. J. Brown, D. R. Cayan, and M. D. Dettinger. 2003. Climate and wildfire in the Western United States. *Bulletin of the American Meteorological Society* 84(5):595-604. https://doi.org/10.1175/bams-84-5-595.

Westerling, A. L. 2018. *Wildfire Simulations for California's Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate.* California's Fourth Climate Change Assessment. Sacramento, CA: California Energy Commission. Publication Number: CCCA4-CEC-2018-014.

Williams, A. P., E. R. Cook, J. E. Smerdon, B. I. Cook, J. T. Abatzoglou, K. Bolles, S. H. Baek, A. M. Badger, and B. Livneh. 2020. Large contribution from anthropogenic warming to an emerging North American megadrought. *Science* 368(6488):314-318. https://dx.doi.org/10.1126/science.aaz9600.

Williams, A. P., B. I. Cook, and J. E. Smerdon. 2022. Rapid intensification of the emerging southwestern North American megadrought in 2020-2021. *Nature Climate Change* 12:232-234. https://doi.org/10.1038/s41558-022-01290-z.

Wobus, C., E. E. Small, H. Hosterman, D. Mills, J. Stein, M. Rissing, R. Jones, M. Duckworth, R. Hall, M. Kolian, J. Creason, and J. Martinich. 2017. Projected climate change impacts on skiing and snowmobiling: A case study of the United States. *Global Environmental Change* 45:1-14. https://doi.org/10.1016/j.gloenvcha.2017.04.006.

Wrathall, D. J., V. Mueller, P. U. Clark, A. Bell, M. Oppenheimer, M. Hauer, S. Kulp, E. Gilmore, H. Adams, R. Kopp, K. Abel, M. Call, J. Chen, A. Desherbinin, E. Fussell, C.

Hay, B. Jones, N. Magliocca, E. Marino, A. Slangen, and K. Warner. 2019. Meeting the looming policy challenge of sea-level change and human migration. *Nature Climate Change* 9(12):898-901. https://doi.org/10.1038/s41558-019-0640-4.

WRI/WBCSD (World Resources Institute/World Business Council for Sustainable Development). 2011. *Corporate Value Chain (Scope 3) Accounting and Reporting Standard. Supplement to the GHG Protocol Corporate Accounting and Reporting Standard.* Geneva, Switzerland: Greenhouse Gas Protocol. https://www.wri.org/research/greenhouse-gas-protocol-corporate-value-chain-scope-3-accounting-and-reporting-standard.

Xu, X., A. Huang, E. Belle, P. Frenne, and G. Jia. 2022. Protected areas provide thermal buffer against climate change. *Science Advances* 8:119. https://doi.org/10.1126/sciadv.abo0119.

Yang, Y., L. Liu, W. Zhou, K. Guan, J. Tang, T. Kim, R. F. Grant, B. Peng, P. Zhu, Z. Li, T. J. Griffis, and Z. Jin. 2022. Distinct driving mechanisms of non-growing season N_2O emissions call for spatial-specific mitigation strategies in the US Midwest. *Agricultural and Forest Meteorology* 324:109108. https://doi.org/10.1016/j.agrformet.2022.109108.

Yazd, S. D., S. A. Wheeler, and Z. A. Key. 2019. Risk factors affecting farmers' mental health: A systematic review. *International Journal of Environmental Research and Public Health* 16(23):48-49. https://doi.org/10.3390/ijerph16234849.

Zhang, X., P. Wargocki, Z. Lian, and C. Thyregod. 2017. Effects of exposure to carbon dioxide and bioeffluents on perceived air quality, self-assessed acute health symptoms, and cognitive performance. *Indoor Air* (1)27:47-64. https://doi.org/10.1111/ina.12284.

Zhou, W., G. Huang, S. T. Pickett, J. Wang, M. L. Cadenasso, T. McPhearson, J. M. Grove, and J. Wang. 2021. Urban tree canopy has greater cooling effects in socially vulnerable communities in the US. *One Earth* 4(12):1764-1775. http://dx.doi.org/10.1016/j.oneear.2021.11.010.

Appendix A
Line-by-Line Comments

CHAPTER LINE-BY-LINE COMMENTS

CHAPTER 0: FRONT MATTER

#	Page/Line	Comment
1	P6/L2	Suggest citing United States Code since the Act is codified in non-scattered sections: (15 U.S.C. § 2921 et seq.).
2	P7/L10	Suggest adding "since the [Fourth National Climate Assessment (NCA4)]" to the text, "and how methods to understand changes in Earth systems have advanced *since NCA4*."
3	P7-8/L15-4	Suggest consistent reference to other chapters; sometimes just the chapter is in parentheticals, other times the name of the chapter and the chapter number are in parentheticals.
4	P8/L1-2	Suggest including Figure 1 or specific regional maps after the introduction in each regional chapter.
5	P9/L3	Suggest "these" instead of "covered."
6	P9/L14-18	Does "calibrated" mean calibrated with the Intergovernmental Panel on Climate Change (IPCC) terms? Suggest more precise language or defining "calibrated" or chose different phrasing: "Authors used the IPCC terms to describe confidence and likelihood in their key messages, where appropriate."
7	P9/L19-25	Suggest a hover function where readers online can see *both* the definition of confidence and likelihood *and* the adopted IPCC scale for each term when they hover their mouse cursor over a confidence and likelihood rating (included on page 0-10, lines 1-6) in the text.
8	P13/L8-15	This paragraph is not written for broad audiences with little exposure to climate change and should be revised for clarity: suggest adding an introductory sentence to introduce global warming levels and internal variability; suggest adding a "for reference" introduction to the last sentence in this paragraph; and avoid "in which" where possible because it is unclear. "Conversely" is confusing here because it is not quite conversely—it is more of an "actually"; and the sentence in lines 11-13 uses the word "level" multiple times, which muddles the message. Suggest reworking these sentences to clarify the language as follows (from line 8 on): "Global warming levels can be impacted by internal variability in the climate system. Internal variability in the climate system means that even as the world rapidly warms, some years will be hotter, and some years will be cooler than the multidecadal average. Annual variability, for example when the global annual

		average temperature is 1.5°C (2.7°F) hotter than it was from 1850 to 1900, does not mean the 1.5°C global warming level has been reached. However, annual variability like this can mean that climate impacts that were projected to occur at a given global warming level may occur even before projections indicated. In addition, temperatures in different parts of the world could be warmer than the global average. For reference, a global warming level of 2°C (3.6°F) would result in regional temperatures in parts of the United States that are more than 2°C above preindustrial levels (Figure 1.16)."
9	P13/L16-17	"Runaway impacts" is not clear; suggest revising to clarify what this phrase means.

CHAPTER 1: OVERVIEW

#	Page/Line	Comment
1	P4/L6-7	"Worst harms" is not defined in the report. Suggest instead, "faster and deeper cuts in [greenhouse gas (GHG)] emissions are achievable."
2	P4/L16	Should reference Chapter 3 (Earth System Processes) key message on extreme events.
3	P4/L20	Suggest citing all of Chapter 4 (Water) rather than just Key Message 4.2.
4	P4/L23	Does the evidence cited in the report demonstrate that every individual American will have less harm from reduced warming? The evidence shows some Americans having some benefits. The report does support a conclusion that a reduction in adverse impacts is correlated with less warming.
5	P4/L25	"Individuals" should be mentioned. Key Message 32.5 states that governments, organizations, and individuals can reduce emissions.
6	P4/L25-31	This paragraph should be more inclusive and discuss other low-carbon energy sources discussed at length in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation) (e.g., hydrogen, carbon capture, utilization, and storage [CCUS], nuclear). Discussing only renewables is not an accurate picture of the state of the science, the technology, or industry.
7	P4/L28	Sustainable land-use is credited with helping to reduce emissions, but it is not clear where this is mentioned in the chapters. The chapters cited are Chapters 5 (Energy Supply, Delivery, and Demand), 12 (Built Environment, Urban Systems, and Cities), and 32 (Mitigation). The section on land-use in the mitigation chapter states that net sequestration of carbon on US land has decreased from 1990 to 2020.
8	P4/L35-36	The statement implies that the decrease was due entirely to increased use of renewables. Chapter 32 (Mitigation) notes that increased use of natural gas and renewables offsets coal use. The role of natural gas should be acknowledged.

9	P5/L4	"Risks" rather than "harms" would be more appropriate because anticipatory adaptation can be taken to reduce risk of harm. In many cases, if the harm happens, it may not be made less severe.
10	P5/L1-16	Key Message 31.4 discusses some examples of where climate services are being applied to support decision making. This should be summarized in Section 1.3.
11	P5/L11	Cite Key Message 4.2 rather than 24.4. Also note that the Committee's comments on Chapter 24 point out such modifications are also being made to adapt to sea-level rise.
12	P6/L2-3	This is an example of a statement that is technically correct but is policy prescriptive because it implies a preference for a policy outcome. If examples of climate action that also address equity and justice can be given in the report, they can be summarized in this section of the Overview.
13	P6/L5	Suggest not using contractions in formal reports. Use "do not" rather than "don't."
14	P6/L7	The adverb "fairly" makes this statement policy prescriptive. The statement should be rewritten to be policy relevant without appearing to advocate a policy prescription.
15	P7/L4-6	Should add a sentence saying that studies suggest that both a more equitable and lower cost action on climate change would imply that the United States should cut emissions in advance of the global average (Key Message 32.1) (Schaeffer et al., 2020).
16	P7/L3-8	The paragraph is technically correct but leaves out a lot of important and policy relevant information. Carbon sequestration, which the literature suggests is needed to meet net zero by mid-century emissions levels, is not mentioned. In addition, the paragraph does not mention barriers to implementation of low-carbon emissions options. Also, Chapter 5 (Energy Supply, Delivery, and Demand) does not address how GHG emissions can be reduced from the energy sector but focuses on climate change impacts on that sector.
17	P7/L5	Delete "preferably" because it makes the clause policy prescriptive.
18	P7/Figure 1.1	The figure is good and informative. Is it possible to have the divergence of scenarios start around 2020? If that is not possible, the caption should explain why the scenarios diverge around 2015.
19	P7/L9	The figure depicts carbon dioxide (CO_2) emissions, which is closely correlated, but not exactly climate futures. The Committee suggests indicating that CO_2 is the largest driver of climate change.
20	P7/L12-14	Suggest adding a discussion of emissions and sinks in the United States and using the word "net" before "US GHG emissions." The second sentence in this paragraph should align with any changes made in Chapter 32 (Mitigation) based on the Committee's review (see Chapter 3).
21	P7/L13	The phrase "avoid the worst harm" is vague. The Committee suggests replacing that phrase with reference to the 1.5°C and/or 2.0°C targets in the Paris Accord.

22	P8-9/L35-1	Suggest offsetting "and are exacerbated by" with commas.
23	P9/L29-30	This sentence is unclear as written; suggest: "many communities are learning climate change response techniques from tribal and Indigenous leadership."
24	P10/L2	Are the words "first and worst" scientifically defensible? There is literature, (e.g., EPA, 2021) that finds that, as the report terms, "minority" communities face relatively higher and hence disproportionate risks to climate hazards. But do they face these risks before other communities do? The word "worst" also seems loaded. The statement will be effective without the words "first and worst."
25	P10/L12-13	The sentence is unclear and should be revised. Is the point that we have to adapt no matter how effective mitigation is?
26	P10/Figure 1.2	It is useful to display long term temperature trends in the United States The figure title should show the years in the data range used to create the figure (e.g., 1900-2020). The reader may notice areas that have been cooling. The caption should address explanations for observed cooling and, if appropriate, why the western half of the country appears to be warming more than the eastern half.
27	P11/L1-2	The word "worse" in the title has a vague meaning. It would be more precise to replace it with, for example, "more frequent and severe."
28	P11/L12	The sentence on heat and wildfire jeopardizing outdoor sports and recreation may be overstated and does not consider other benefits of higher temperatures for warm weather recreation. The verb "jeopardize" is vague and unclear as to what the effect of extreme weather on warm weather recreation is estimated to be. While there is a lot of literature on climate change impacts on cold weather recreation, particularly skiing (e.g., Wobus et al., 2017) there appears to less literature on effects on warm weather recreation, but new literature has been published in recent years (e.g., Chan and Wichman, 2020, 2022; Gellman and Wibbenmeyer, 2022). These studies find there could be net benefits to total recreation from increased temperature but may not fully consider impacts of high heat, increased precipitation, and fire. Gellman and Wibbenmeyer (2022) addresses fire. The phrasing in the draft does adequately describe the complexity of the relationship of climate change and US recreation. This can be better addressed in the Overview and in appropriate underlying chapters such as Chapter 19 (Economics) and some of the regional chapters.
29	P12/L4-5	It is not clear why the Focus on Complex and Compound Events is cited. Key Message 4.3 and Chapter 28 (Southwest) can also be cited.
30	P12/L6-17 including Figure 1.4	The presentation of the billion-dollar disaster figure does not appropriately put the change in billion-dollar disasters in context. The paragraph in lines 6-11 attributes increase in billion-dollar disasters to "worsening weather" and line 16 states that the increase is "in part because of human caused warming." A different figure on billion-dollar disasters is displayed in Chapter 2 (Climate Trends), but shows

		the disasters that occurred in 2021, not the long-term trends. Figure 1.4 is introducing new information not in the underlying report. Line 15 states correctly that the data on billion-dollar disasters are adjusted for inflation. The National Oceanic and Atmospheric Administration (NOAA) uses the Consumer Price Index (CPI) to adjust the size of the disasters.[1] However, the exposure to such disasters appears to be increasing. Three trends should be noted to appropriately put the "Billion-Dollar Disaster" data in context. First, changes in property values versus CPI should be noted.[2] Second, population increased from 226 million in 1980 to 331 million in 2020—a 46 percent increase.[3] Third, increased development in vulnerable areas (Iglesias et al., 2021).
31	P13/L11-12	What do the terms "significant" and "well-being" mean in this statement? The terms are vague and subject to misinterpretation.
32	P13/L30	As noted above, the phrase "first and worst" is used regarding inequitable impacts. Please use words that are supported by evidence on inequitable impacts.
33	P13/L35	Suggest defining redlining for broad audiences. The definition is included below in Section 3.3, page 1-20, lines 13-14. Suggest moving the definition up or referring readers to where it is defined.
34	P16/Table 1.2 Southwest row 2nd column	The statement about groundwater is an oversimplification. See comments on Chapter 28 (Southwest).
35	P17/L2	"The things Americans value most are at risk." Does the report examine what Americans value most? This is a quotable statement but is it supported by the evidence base?
36	P17/L6-9	The sentence beginning "The threats to the people and places we love…" is policy prescriptive. Also, the Committee suggests removing "to unavoidable change."
37	P17/L12-15	Not all impacts of flooding are negative. There can be some positive ecosystem benefits (see page 4-6, lines 3-10).
38	P17-18/L12-12	The section should also discuss impacts of climate change on water quality.
39	P17/L20-21	The statement about excessive rainfall is in Chapter 24 (Midwest).
40	P17/L34	The Committee agrees with the statement about vulnerability of small water systems but does not see supporting information in Chapters 4 (Water) or 28 (Southwest).
41	P17/L37	Chapter 4 (Water) does not discuss how nature-based solutions (NBSs) can improve water supplies. It does address the role of NBSs and flooding.

[1] See https://www.ncei.noaa.gov/access/billions.
[2] See https://anytimeestimate.com/research/housing-prices-vs-inflation.
[3] See https://www.census.gov/data/tables/time-series/dec/popchange-data-text.html.

42	P18/L14	The Committee suggests caution in using "will" in this key statement because it implies there is virtually no uncertainty about the outcome. While the report cites published literature projecting decreases in agriculture output, uncertainties about potential changes in baseline conditions and the effectiveness of adaptation should result in some reduction in likelihood or confidence in this statement. The heading that disruptions to the food system are "expected" to increase is appropriate. "Expected" is a useful way to summarize what is projected, whereas "will" conveys certainty about the projection. See the traceable accounts regarding Key Message 11.1.
43	P19/L1-5	The statement on the effect of carbon fertilization and changes in climate is confusing. It is not clear whether the first sentence means that CO_2, temperature, and precipitation acting together reduce yields or whether each factor alone reduces yields. The second sentence states that high CO_2 concentrations and longer growing seasons by themselves have beneficial effects. The Committee suggests clarifying the relationships among the driving variables and the combined effect.
44	P19/L13-17	The paragraph as written is fine. What is not addressed here or in Chapter 11 (Agriculture, Food Systems, and Rural Communities) is whether adaptation by the agriculture sector could offset the adverse impacts of climate change. Is it technologically possible or do we not know? Are there barriers to implementation of technological and managerial changes that would result in adaptation being less effective? Such informative could be very informative to the agriculture sector.
45	P20/L5-9	The sentences describing how low-income households are more vulnerable to higher energy costs are true. The Overview should note, however, that annual energy expenditures are projected to decrease because reduced heating costs are projected to offset increased cooling costs (see Chapter 19 [Economics]).
46	P20/L27-31	There is an implication here that these extreme events and other changes are directly due to climate change. However, authors should make it clear that these events may have become more likely because of climate change, not that they were directly caused by climate change. Consider adding a sentence at the beginning indicating that no single event can be directly attributed to climate but that the odds of some events has increased due to climate change.
47	P20/L31-33	The text states that millions of internal migrants are "expected," which we interpret to mean are projected. Chapter 19 (Economics) discusses migration but states that numbers cannot be projected. Chapters 28 (Southwest) and 26 (Southern Great Plains) raise the possibility of migration into the United States from Mexico but do not project numbers. The Committee cannot find discussion in the report on internal migration nor any projections of how many people would migrate. The Committee's understanding is that while

		migration is quite possible it is difficult to project how many migrants there can be, where they come from, and where they go. The Committee suggests carefully reviewing the relevant chapters and revising statements on migration to reflect what is in those chapters. The Committee cautions against reporting specific projections largely because the field of migration projections from climate change is in a nascent stage and specific projections should be treated with caution.
48	P21-22/L26-3	The science suggests that climate change will cause more intense, but fewer hurricanes. This statement should be consistent with this.
49	P22/L10-14	The paragraph on adaptation of infrastructure is sound but, as noted above, it does not address whether adaptation has the potential to offset adverse impacts of climate change, or how expensive or feasible such measures may be. Infrastructure adaptation is often incremental. Since the report discusses the need for transformation, is the effectiveness of incremental adaptation limited, particularly under higher emissions scenarios?
50	P22/L13-14	Suggest adding "among other actions" to the end of this sentence.
51	P22/L24	The word "devastating" may not be appropriate for a scientific report.
52	P22/L25	The term "well-being" is vague. Perhaps it would be more focused to address the extent of health impacts from climate change across the country (i.e., whether the health of Americans is being adversely affected by climate change).
53	P23/L1-2	"Of families and communities across the country, with more people exposed to a compounding mix of health hazards, including." Please add "increasing the odds of."
54	P23/L8	Does the report support the statement that climate change harms everyone's health?
55	P23/L14	Suggest "contexts" instead of "impacts."
56	P24/L12	Recommend starting this section with the point that climate is not the only stressor on ecosystems: land-use, air, and water pollution are also occurring at the same time and adding stressors (Chapters 6 [Land Cover and Land-Use Change] and 7 [Forests]).
57	P24/L19-21	The Committee suggests phrasing this as a risk management matter (i.e., the risks of passing ecological tipping points increases with higher emissions).
58	P24/L23-24	"Many climate impacts, particularly changes in ocean conditions and extreme events, already threaten coastal, and aquatic, and marine ecosystems (Figure 1.10)." Include "increase in the odds for some extreme events."
59	P25/L1-3	Is the projection about fish die-off tied to a particular scenario or scenarios? This is important to help readers understand how likely the outcome is and whether mitigation reduces the likelihood of the outcome.

60	P25/L21	The title of the section states "and abroad." The Fifth National Climate Assessment (NCA5) focuses on impacts on the United States. Chapter 17 (Climate Effects on US International Interests) focuses on international impacts on US international interests and does not summarize international impacts (page 17-18, lines 19-20). Thus, it is not appropriate to have "and abroad" because international impacts are not a subject of NCA5.
61	P25/L25-26	The finding on projected international economic impacts is based on one study (Swiss Re, 2021) which was not published in a peer-reviewed journal and appears to be an extreme estimate. Chapter 19 (Economics) (page 19-12) finds that for each 1°F increase in average temperature, US gross domestic product (GDP) is projected (not "will") be reduced by approximately 0.13 percent. Several citations are given. Since the latter comes from a chapter about economics rather than international impacts, the Committee suggests citing that projection instead of the international GDP projection.
62	P26/L9-15	Authors should mention justice concerns regarding mitigation and adaptation (i.e., that mitigation and adaptation are done in a way that does not adversely impact already overburdened communities).
63	P27/L1-2	A more accurate heading would be "Many regional economies and livelihoods…."
64	P27/L3-4	The sentence is technically correct (see comment above), but it does reflect the entire draft NCA5 report, which identifies some sectors and regions that are projected to have some benefits.
65	P27/L3-7	Please add a sentence or phrase here emphasizing that usually already overburdened communities suffer more.
66	P27/L18-22	The paragraph only mentions adverse impacts on Midwest agriculture and does not mention any positive impacts such as improved wheat yields (see Key Message 24.1, page 24-4, lines 10-11). The Committee recognizes that overall, US agriculture is projected to face losses. Chapter 1 (Overview) should reflect the breadth of findings on agriculture.
67	P27/L23-26	Suggest including a note about building out new energy technology. The Inflation Reduction Act (IRA) includes many changes in the tax credit system to build out a variety of energy sources and there are worker apprenticeship and vulnerable populations considerations built into the credits. This discussion is frequently omitted from the Chapter 1 (Overview) discussion of energy, and fossils fuels are compared repeatedly to renewables, which is not the full picture. Suggest: "…shift as the energy sector transforms toward more renewables and low carbon technologies, electrification of more sectors of the economy, and power infrastructure…."

68	P27/L27-29	The examples for outdoor industries are geographically limited and only focus on certain activities. Please refer to the Committee's comments on page 1-12, lines 1-2, on the broader recreation literature. Studies that have examined impacts on total recreation in the United States have estimated net increases in welfare and expenditures. This can be tempered by noting decreases in cold weather recreation and how sea-level rise, more intense storms, and fire can limit recreation gains and reduce it in some cases.
69	P28/L1-8	Figure 1.14: The Committee has comments on recreation in Chapters 1 (Overview) and 19 (Economics). Chapter 1 (Overview) points out limitations on recreation from extreme events and reduced cold weather activities such as skiing but does not address the effect of higher temperatures on warm weather recreation and whether a longer time period with warm weather will be offset by extreme events.
70	P28/L3-4	Figure 1.12: What is the citation for the statement that Colorado ski resorts have lost revenue of because of declining snowfall? Vail Resorts does not report declining revenues since 2019.[4] These years were affected by COVID-19, but revenues in 2022 were about 10 percent higher than 2019.
71	P28/L13-15	The Committee applauds the caution applied to projections of climate change on crime and domestic violence, mental health, and happiness. We also note that the literature on annual recreation impacts does not find there will be a reduction in overall recreational but most certainly a reduction in some aspects, such as skiing, and adverse impacts on many warm weather recreation activities from extreme events and fire.
72	P29/L13	The title should be "cultures, heritages, and traditions."
73	P29/L14-15	The language in the sentence is sweeping and the Committee questions whether it is fully supported by the draft NCA5 report. Is the language meant to imply that all community ties, pastimes, and landscapes are being threatened or some? Is the clause "Americans are losing the things that make them feel at home" appropriate for a scientific report?
74	P29/L24-26	The focus of the bullet is on cold weather recreation with no mention of how warm weather recreation can be affected. Even though the discussion is on what aspects of Americans' lives are being lost or threatened, by leaving out what could be benefits to warm weather recreation, the discussion is unbalanced.

[4] See https://www.macrotrends.net/stocks/charts/MTN/vail-resorts/revenue.

75	P30/L1-13	The discussion on outdoor activities and particularly the analysis of implications for outdoor industry does not reflect the literature on climate change impacts on recreation. The discussion ignores that higher temperatures will lead to a longer season for outdoor recreation (see literature cited in comment on page 1-12, lines 1-2). The chapters cited do not address tourism across the country and Chapter 19 (Economics) does not cover tourism. The literature establishes that some aspects of tourism are projected to be adversely affected, but it does not find that all recreation or tourism will be reduced.
76	P31/L3-5	In the sentence beginning, "The extent of…" what is meant by "today?" Does this imply that decisions made "tomorrow" are ineffective or less effective? It is not clear that the draft NCA5 report has addressed effectiveness of timing of mitigation measures.
77	P31/L7-22	The Committee agrees that the more GHG emissions are reduced the more risks are reduced, but the statement is incomplete in that it does not address sequestration or removal and options to reduce radiative forcing. The Committee suggests using the term "net emissions" to include sequestration. Authors should cite Chapters 7 (Forests), 11 (Agriculture, Food Systems, and Rural Communities), and 32 (Mitigation).
78	P31/L24-28	Chapter 3 (Earth System Processes) discusses use of climate scenarios, and Chapter 1 (Overview) should cite the chapter.
79	P31/L29	Insert "emissions" before "scenarios" to clarify these are emissions scenarios.
80	P31/L29-31	The sentence beginning "This is due to…" is confusing. Chapter 32 (Mitigation) should also be listed as a source backing up the statements because it addresses infrastructure, economics, and policy.
81	P35/Figure 1.17	Suggest including the y-axis labels on the right graphs as well as the left.
82	P36-41/Section 5	Note that the general comments on Chapter 1 (Overview) in Chapter 3 of this report raise concerns about this section having many policy prescriptive statements. The content of many of these statements can be revised to be policy informative without appearing to be policy prescriptive.
83	P36/L2-7	The entire paragraph is policy prescriptive. The term "worst consequences" is unclear particularly regarding how much of a change in climate is associated with them. Does "avoided" mean they will not happen, they will be less severe, or the risks are reduced? Did the draft NCA5 report find that anything less than "large-scale" and "drastic" decarbonization of the economy will be ineffective? What about carbon sequestration or other options to reduce radiative forcing? The sentence on transformative mitigation and adaptation is policy prescriptive.
84	P36/L5	Would "near term" be more accurate than "immediate?"

85	P36/L9-10	The first sentence of the paragraph is policy prescriptive. Beyond that, does the draft NCA5 report analyze the timing of emissions reductions?
86	P36/L11	To be more accurate, the statement should say many options are "relatively cost effective." Neither the statement nor the analysis addresses whether the benefits of the options are greater than the costs.
87	P38/L8	Suggest changing the title of the section to "net emissions."
88	P38/L18-19	This statement does not reflect content in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation). Low-carbon, hydrogen, and nuclear should also be included.
89	P38/L29-34	These sentences omit the challenges of grid stress, the need to build out distributed energy resources, zero-and low-carbon electricity sources, and resources needed to build out infrastructure to support the energy transition (i.e., critical minerals) (cite Chapter 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]). Suggest updating the last sentence in the paragraph to read "recent legislation (IRA) has incentivized the deployment of low carbon, zero carbon, and renewable energy generation."
90	P39/L1	While transformative adaptation can reduce unequal vulnerabilities it is not evident that it will automatically do so. As noted elsewhere, it is not difficult to think of transformative adaptations that could continue or even exacerbate unequal vulnerabilities. Such potential outcomes are discussed briefly on page 31-10, lines 24-26.
91	P39/L9-11	Is the issue that all transformative adaptation should meet these criteria to be considered or is it that to be just, transformative adaptation should meet these criteria? This could be considered policy prescriptive.
92	P39/L9-16	This is a very important paragraph that should be rewritten in language that broad audiences can understand.
93	P39/L18-24	It is not clear how the restoration of the watershed was transformative. Was it a result of the governance process that was used?
94	P40/L2-18	This section seems repetitive; if needed, these points could be made in other sections or shortened. The next section and other justice concerns could be expanded instead.
95	P40/L19	The section title is policy prescriptive because it implies a preference for a particular policy approach.

CHAPTER 2: CLIMATE TRENDS

#	Page/Line	Comment
1	P2-13/L20-24	Citations are missing for statements in this section.
2	P3/L15	Suggest not beginning a paragraph with a nebulous subject like "this." What, specifically, has consequences for the United States?

3	P3/L16	Suggest replacing “this changing climate” with “climate change.”
4	P4/L12-13	The last sentence could be construed as policy prescriptive. The penultimate sentence is excellent, however, and would be a perfectly fine way to end the paragraph. Suggest removing the last sentence altogether.
5	P4/L17	Suggest replacing “even more warming” with “higher than average warming.”
6	P7/L5-9	Definition of aerosol optical depth (AOD) in the figure caption is welcome but suggest adding some context for the units. Is this a trend in AOD per year? Overall change in AOD during the period in question? How does the magnitude of the trend compare to the mean? Without the latter, it is not possible to know if the trend is impactful (i.e., is it 0.1% change or a 50% change?). It is not clear from the figure caption.
7	P11/L4-5	More support is needed for the statement that US sea-level is accelerating. Figure 2.5 shows trends, not acceleration. Appendix 4 shows a single sea-level curve for the United States—assuming the authors are referencing Figure A4.10—but it may be difficult for the general reader to ascertain acceleration in the curve. Suggest adding either a quadratic or trend lines pre- and post-1990 to Figure A4.10. Also suggest removing the reference to Figure 2.5 here, because it does not relate to acceleration.
8	P11/L9-12	Suggest adding the role of Pacific Ocean-atmosphere variability (i.e., Pacific Decadal Oscillation [PDO]) in suppressing rates of sea-level rise (SLR) along the west coast of North America (e.g., Bromirski et al., 2011; Moon et al., 2013).
9	P12/L25-37	Suggest connecting the statements in this paragraph to specific US regions and territories (e.g., changing Pacific cyclone tracks and El Niño-Southern Oscillation [ENSO] for US-Affiliated Pacific Islands [USAPI] and changes to hurricane frequency for the Southeast).
10	P13/L13-17	The last sentence in this section is out of place as this section is not about flooding and would be more relevant as the last sentence in the section of text on page 2-11.
11	P15/L27	Paleoclimate research has been very helpful in understanding the western US climate changes. It will be helpful to add some discussion with references on paleoclimate here.
12	P16/L14	It will be helpful to add a reference like Albano et al. (2022) that provides a more complete and newer assessment than Williams et al. (2020), including being continental US scale rather than Southwest limited and being based on multiple different data sources.
13	P17/L1-2	Is this Sweet et al. citation correct? The referenced report is about SLR scenarios.
14	P18/L31-35	The mixing of degrees Celsius and Fahrenheit in this paragraph is confusing. Suggest choosing one or providing both in all cases not just some cases.

15	P21/L17	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.
16	P22/L5	Please add the data source: CMIP5 or CMIP6? It is not clear what LOCA2 means.
17	P22/L7-10	It should be noted and referenced that the recent multidecadal drought in the Southwest United States is at least partially due to natural variability and not entirely due to human-driven climate change.
18	P25/L13	Missing the upper bound on the range "3 to ? billion."
19	P27/L17-20	The word "likely" has a specific meaning in NCA5 in terms of probability (>66%). The values presented here appear to correspond to the entire range of scenarios from Low to High, which does not correspond to the likely range as it is defined for NCA5.
20	P27/L26	The tone of the sentence sounds too strong. Consider rephrasing.
21	P29/L2	"Nonlinearly" is likely not an accessible word for broad audiences.
22	P34/L1	The key message title here differs from the title elsewhere.

CHAPTER 3: EARTH SYSTEMS

#	Page/Line	Comment
1	P4/L2-3	This is the first line on land-use effects on climate: much of the land-use effects will be direct albedo modification, but this is not mentioned.
2	P5/L29-30	Please add caveats: this statement is only true in a few places (i.e., North America and Europe) where they analyzed data. There are no data in places we expect to see increases (e.g., Asia).
3	P10/L9-10	Is "sequencing" the wrong word? Longer than a decade? Projections longer than 2 days start getting quite uncertain.
4	P14/L3-4	Please try to indicate the proportion or be more specific.
5	P16/L1	The discussion of global warming levels warrants a new paragraph.
6	P17/L25	Perhaps use a more recent addition to the Shepherd (2016) "storyline" citation, which is all about how to construct/populate storyline scenarios (for attribution or otherwise), (e.g., Albano et al., 2022).
7	P18/L1	"Storms that might have been": perhaps it is worthwhile to mention "pseudo-warming experiments" here, as it seems that this is one of the recent approaches to disentangling natural from climate change contributions in some individual events (e.g., Gutmann et al., 2018; Michaelis et al., 2022; Ullrich et al., 2018).
8	P18/L14-15	In addition to increased frequency and magnitude, "increases in duration" of various extreme events (heat waves and many storms) should be included here. In many settings, the duration can be deadly (in case of heat waves) or results in largest precipitation totals (e.g., Kossin, 2018; van Oldenborgh et al., 2018).

9	P19/L31	California is a great example of the final statement in this paragraph (e.g., Polade et al., 2017).
10	P19/L31-32	Please remove the "thus" as separate points which do not necessarily occur at the same time.
11	P19/L36	This is an important paragraph, but does not talk about all the implications, including making it harder to do detection and attribution studies.
12	P20/L3	Total vapor transport is a natural combination of both changes in total vapor content and the circulation changes discussed here and goes a long way toward simplifying the statement of conclusions. Lavers et al. (2015) would simplify the discussion.
13	P22/L11	Atmospheric water demand can change as well and could be discussed here (e.g., Albano et al., 2022; McEvoy et al., 2020).
14	P28/L31	Perhaps including in this chapter some of the changes in storm tracks impacting the west coast storms could be helpful and using more recent papers instead of Neelin et al. (2013).
15	P34/L23-28	The authors should concentrate on citing the evidence base, not discussing the scientists themselves. Replace "Scientists have known" with "Scientific studies show."
16	P35/L1-6	This paragraph discusses topics that are not in this key message: should be moved or removed. Attribution is discussed later in the chapter.

CHAPTER 4: WATER

#	Page/Line	Comment
1	P3/L6-7	Suggest placing the first clause of this sentence at the end of the sentence for greater clarity. As written, it is unclear whether climate change is responsible for greater exposure and vulnerability, which is what the sentence is trying to convey. Suggested modification: "Climate change is increasing the frequency, of water-related disasters in the United States and causing greater exposure and vulnerability to these disasters."
2	P3/L13-15	The statement about water security seemingly has nothing to do with the next sentence about water quality. It leaves the audiences to deduce the relation between climate impacts to water quality and water security. Suggest improved clarity in language and adding in-line descriptive and transitionary language, for example: "Water security refers to the adequate supply of clean water, whereas water quality refers to the availability of clean water. Human-caused climate change is expected to directly impact the availability of clean water, which indirectly threatens the availability of that water for use by people and ecosystems."
3	P3/Figure 4.1	This is an effective representation of year-by-year changes in the occurrence and kinds of billion-dollar disasters since 1980. Can a

		brief listing of (or more specific term for) what kinds of storms constitute the "severe storms" category be included in the caption? The audiences will be broader than the meteorology community.
4	P5/L5-7	The words "regulations and standards" would be more accurate as "policies, regulations, and formal agreements."
5	P5/L14-16	This sentence is not accurate; it should mention climate change. It should read: "These and similar efforts are the first steps toward building resilient human and natural systems in the face of climate induced changes to the water cycle."
6	P5/L18	"Human-caused climate change," rather than just "climate change."
7	P5/L20	Declaring that "many regions … see more precipitation" seems problematic here, when even Figure 4.3 shows that fully a third of the country is projected to see less. A few words added could hand this pivotal projection (for this chapter) more informatively: "see more precipitation in the northern parts, and less precipitation in the southern parts."
8	P5/L21	More precipitation does not always yield more floods. Floods depend on a lot of additional factors, like antecedent soil moisture, precipitation form (rain versus snow), and vegetation/land cover. For example, as stated in the caption of Figure 4.12, well less than half of recent flood increases can be attributed to increasing precipitation.
9	P5/L27-29	Suggest describing the water cycle and any natural variability. Then discuss climate change impacts to the water cycle. These topics are sometimes lumped together in the chapter.
10	P5/L30	This section on precipitation has no citations; please add some.
11	P6/L11-17	This section on evapotranspiration (ET) changes assumes audiences understand the how ET relates to climate change, but it likely will not. Suggest brief descriptions: How does ET relate to climate change? Explain to general audiences how climate change can influence ET. Explain in what regions will climate change cause ET to go up and in what regions will climate change cause ET to go down. When ET goes up/down is that good or bad? Why? This explanatory text could also be integrated into the caption text for Figure 4.4.
12	P7/L8-23	Some of the citations in this section detailing snow and glacier changes are quite old. Is there new literature looking at this?
13	P7/L11	These references regarding snow versus rain transitions are old. Several more recent studies have revisited and honed understanding of how this works (e.g., Harpold and Brooks, 2018; Harpold et al., 2017).
14	P8/L17	This projection of increasing soil moisture "in the northern US" is essentially diametrically at odds with Figure 4.6.
15	P9/L8-21	Are there regional differences in groundwater change expected due to climate change?
16	P9/L15	Are higher temperatures related to climate change? If so, make sure to say so.

17	P9/L15-20	The summary of projected western groundwater-recharge changes (i.e., "decreas[ing] natural recharge across much of the West," stated without confidence level) is a key example of this kind of overbroad depiction of change and is directly contradicted by a key figure (6) in their primary citation (Niraula et al., 2017), which shows very different outcomes in different regions, time frames, and from different climate models. This conclusion is based on one cited research paper and based on one model analysis untested by other groups, so that confidence should be relatively modest, at present. Furthermore, it would be a breakthrough if this NCA5 report acknowledged that groundwater recharge varies temporally with important lessons for climate-change assessment from understanding and quantifying these variations.
18	P9/Figure 4.6	The projections of increased summer soil moisture over much of the Southwest here are a puzzle that should be discussed. The pattern also needs to be communicated to, and coordinated with, the authors of Chapter 28 (Southwest), who draw a different conclusion (projecting soil moisture declines there, even though their own soil moisture Figure 28.2a shows this same increase in soil moisture).
19	P10/L18	Streams dependent on glacial melt are expected to have increased flows in coming decades (as the ice melts) followed by flow declines later after the ice is essentially gone.
20	P11/Figure 4.8	This is a useful infographic indicating both the complexity of projecting future flood changes and the mechanisms that will determine those changes. Maintain tense alignment in all three text boxes (e.g., "Decreased flood magnitude…" should be listed for each bullet under "Decreases In Flood Activity" box rather than "Decreased flood magnitude…" and then "Decrease in magnitude").
21	P14/Box 4.1	The material presented in this box very much follows the discussion (and even choice of figures) from Harpold et al. (2017). This article is also where the warm snow drought/dry snow drought nomenclature was formally developed and recommended. Thus, the citations included here should be adjusted accordingly.
22	P15/L4	It is not immediately clear what "the frontlines of climate change" are and this should be defined for broad audiences. This term is used throughout the report so this might be easily solved by adding the term to a glossary or index. Alternatively, a different term in the key message language could be used.
23	P15/Figure 4.12	Clarify whether precipitation change is due to climate change in the figure title and caption.
24	P15/Figure 4.12	This is an interesting and informative way to show recent trends in US flood damages. It would be useful to briefly list some of the "other" causes of flood damage (besides increased precipitation) in the caption, since this is not stated in the text (other than an allusion to increasing amount of impermeable surface, which is not the only other cause).

25	P16/L5	High precipitation routinely overwhelms many stormwater-sewer systems around the country, probably more than captured by "can."
26	P16/L3-10	No mention is made of positive effects of floods on farmlands and floodplains (such as soil renewal and dissipation of flood impacts downstream). Including this observation would also provide an opportunity to mention corresponding reforms in US Army Corps of Engineers policy.
27	P16/L11	This text does not mention climate change until the fourth paragraph and instead seems to expect the audiences to infer that the discussion pertains to climate change. Suggest improving clarity and focus of language to focus on specific climate change impacts to drought.
28	P16/L19	"Megadroughts" are (historically) natural events. The point that megadroughts have happened many times in the natural past is neglected throughout this chapter, which makes for a dangerously one-sided presentation of, for example, developing conditions in the Colorado River basin.
29	P16/Figure 4.13	The caption says higher temperatures and human use can exacerbate or even cause drought. Please clarify whether this means higher human use of what resources (e.g., water, land). Also, should the last sentence be an "and" or an "and/or" rather than an "or" when discussing that drought can develop in a matter of weeks and/or last for decades?
30	P17/L4	Drought-driven streamflow (and lake level) declines also threaten cooling-water supplies for thermoelectric (traditional and nuclear power plants) systems, impacting many non-hydropower systems. Also correct this at page 4-18, line 10.
31	P17/L5	Discussion lacks mention of transportation impacts of droughts and floods along major rivers.
32	P17/L10	Consider replacing "insects" with "pests" to be more comprehensive.
33	P17/L14	If increased groundwater pumping is region specific, authors should note that detail in the text. The literature cited does not represent the United States broadly. Bloomfield (2019) is looking at groundwater in the United Kingdom; Hanson et al. (2012) is using a case study of California not looking at the United States broadly and discusses a method to assess how climate change could affect surface water and groundwater rise in highly developed agro-urban watersheds; and Scanlon et al. (2012) looks at the high plains and central valley of California and does not represent a nation-wide trend. What about other types of watersheds? What about other regions? The literature cited does not represent the United States broadly nor does it represent the very broad statement in the supporting text.
34	P17/L17	Increased pumping *can* increase land subsidence, not "does." Land subsidence depends on a lot of factors that all have to be aligned for it to occur.
35	P17-18/L23-11	Consider mentioning tribal rights to water in the drought-stricken Colorado River basin that have yet to be quantified.

36	P18/L21	Duration of precipitation is also projected to increase (e.g., Gutmann et al., 2018; Kossin, 2018) in ways that will mimic or exacerbate the impacts of heavier precipitation.
37	P18/Figure 4.15	This is a graphically simple depiction of the disproportional distribution of flood damages projected over the next 30 years. It is an excellent addition to this key message and Box 4.2 that should be discussed in both.
38	P18-19/Box 4.2	This material dives relatedly into the topic of Key Message 4.2 by focusing on the specific case of Hurricane Katrina flooding and Houston. It should refer to Figure 4.15 where it notes "as with recent floods elsewhere" to drive home the representativeness of what this Katrina example indicates more broadly. It also needs to cite the corresponding regional chapter and should tie back to climate change at least briefly to be entirely clear that, whether or not Katrina was enhanced by climate change (and lots of attribution studies suggest it likely was), it is a good model of how disparities arise and play out.
39	P19/L11	What type of infrastructure is being discussed? Add text to improve clarity of language.
40	P19/L11-17	This is stated entirely in terms of impacts on tribes, which is accurate and well-motivated, but many of these impacts also apply to other disadvantaged, underserved communities elsewhere, which should be acknowledged.
41	P21/L10	Suggest explaining why uncertainty always factors into water planning.
42	P21/L20-21	Saying that water disputes are typically resolved using litigation is not quite accurate. It depends on the scope of the dispute and the disputing bodies. If two people, two states, two countries, or tribes versus other users there are actually a variety of ways disputes can be resolved. Additionally, the reference cited does not support this statement. Suggest deleting this sentence and adding the text suggested in the next comment.
43	P21/L21-23	This sentence is overly simplified, the references provided are not legal, and they do not discuss the entire body of law that applies to the Colorado River, which determines what allocation options are available for water rights holders. A more accurate sentence might say: "Climate change impacts to water supplies can result in competition, collaboration, or conflict. Tools may include litigation, administrative proceedings, treaty negotiations, compacts, and/ or cooperative agreements, among others. Under current severe drought conditions, water rights holders in the Colorado River basin, including Mexico, tribal nations, states, and other interested parties are struggling to adapt under the existing legal framework—one that was mistakenly based on the assumption of continued flows and on an above average historic estimate of total water available to apportion. While some of these efforts include tribes...." See suggested citation (Garofalo, 2019).

44	P21/L18-26	Suggest moving Figure 4.19 to under the discussion of the Colorado River here after line 26.
45	P21-22/Box 4.3	This material does a nice, brief job of illustrating how interjurisdictional cooperation can succeed, but a word or two more about how climate change will be addressed under the new management plan, or at least how the expected success of the plan will likely be impacted by climate change, would make it much more relevant to this chapter and report. The corresponding regional chapter should also be cited.
46	P22/Figure 4.18	The caption should address the level of scientific understanding arrow across the bottom of the image.
47	P23/L17	It is worth noting, here and elsewhere in this chapter, that natural variability of storms and droughts (and temperatures) are projected to increase in magnitude (e.g., IPCC, 2021a).
48	P24/Figure 4.19	The figure is important and yet left until the end of the chapter and then not fully discussed. This is where the issue of how much of the recent western megadrought is climate change and where the issue of how much normal climate variability can and will mask and/or interact with coming climate changes is finally given some illustration. Having this figure appear earlier in the chapter and having what it shows described there in detail would be a major improvement to the chapter as a whole.
49	P26/L26-36	This projection is largely missing from the key messages, replaced instead with descriptions of a recent paper. Albano et al. (2022) provides useful multi-dataset comparisons and analyses of evaporative demand trends over the contiguous United States and might be considered in this traceable account.
50	P26/L26	Consider mentioning the status of the long-standing discussions of measured pan evaporation trends (or lack thereof) in this context in this traceable account (given the strong assertion regarding future evaporative demands here).
51	P26/L31	Neither changes nor variability in recharge have been well quantified or projected.
52	P26/L33	The advancement of snowmelt timing is also projected to increase overall (annual) streamflow totals in many areas (e.g., Ban and Lettenmaier, 2022; Barnhart et al., 2016).
53	P27/L5	This section makes many strong and concise statements but needs citations to support those statements regarding uncertainties and gaps.
54	P27/L6	This chapter regarding water should be more careful about not ascribing most uncertainties to precipitation; rising temperatures (as has been acknowledged earlier in this chapter) are projected to have major impacts on future water. Better to drop the “especially precipitation” here. There will still be significant uncertainties about how much warming will occur and quantitatively how much that warming will impact water in which ways.

55	P27/L28	This is a good acknowledgment of real uncertainties as to how complicated the pathways to eventual streamflow outcomes will be. It might be worth also acknowledging that the more recent literature has been turning up "second-order influences" beyond just precipitation and temperature impacts, including factors like humidity (e.g., Harpold and Brooks, 2018; Harpold et al., 2017).
56	P27/L37-38	See Albano et al. (2022), which has resolved many disagreements through a multi-dataset comparison of the various trends and non-trends.
57	P28/L6	This discussion regarding groundwater pumpage impacts is focused entirely on irrigation pumping and ignores the equally impactful and widespread issue of urban pumpage.
58	P28/L17	Consider adding "outside of the most heavily groundwater-developed areas" to the end of this sentence. There are a lot of groundwater level data in places that are dealing with overdrafts; there is much less data collected where climate is a primary driver. There is also very little monitoring directed at tracking recharge variations.
59	P28/L22	This characterization of precipitation as only increasing is misleading and does not agree with the chapter's own maps. The traceable account for Key Message 4.1 does not touch on the water quality issues raised in Figure 4.2.
60	P28/L27	Some mention of confidence and likelihoods regarding water quality changes is needed.
61	P28/L33	Given that this sentence starts out talking about natural conditions (and presumably variability), this statement that extreme events will increase amounts to a non sequitur (not an incorrect statement, but it does not follow from the "evidence" of the first half of the sentence).
62	P29/L20	Add "water quality" to this list of research needs.
63	P29/L21	The "Major Uncertainties and Gaps" discussion neglects to mention the extreme limitations of our knowledge regarding water quality impacts of these extremes. It states, "There is uncertainty about…" and neglects to categorize how much uncertainty.
64	P29/L25	The "Description of Confidence and Likelihood" discussion on lines 27-28 makes a weak case for (and nearly contradicts) the Key Message 4.2 conclusion that these systems cannot adapt quickly. Mostly this paragraph is a restatement of the claims of Key Message 4.2 rather than a description of how confidence/likelihood were assigned.
65	P30/L23-24	This same assertion that a lack of downscaled projections is the limiting factor was made, with no more evidence here than in Key Message 4.3. Either here or there, more citations supporting this assertion are needed.
66	P30/L34	Some literature support for this assertion that adaptation efforts are proceeding slower than climate change would be extremely useful; not disputing it but would very much like to have that evidence at hand.

67	P31-42	None of the citations for the figures from University of Colorado are in the bibliography.

CHAPTER 5: ENERGY SUPPLY, DELIVERY, AND DEMAND

#	Page/Line	Comment
1	P3/L1-18	The introduction does a great job defining words in text, for instance adaptation and the changing risk profile.
2	P3/L23-25	The last sentence of the key message should be reorganized to have active voice and more clearly establish that the extreme precipitation, extreme temperatures, sea-level rise, and more intense storms, droughts, and wildfires are likely to damage energy infrastructure and disrupt energy system operations. Using active voice in sentences with confidence and likelihood ratings helps the rating make more sense.
3	P3/L29-30	Mention permafrost impacts on distribution and energy consumers. These are discussed on page 5-7, lines 3-7, in terms of production.
4	P5/L1-3	Add language to improve clarity to this sentence: “and are projected to be impacted by changes in solar irradiance.”
5	P5/L10-31	The discussion about electricity generation and water availability omits discussion of how some low- and zero-carbon technologies use more, in some cases much more water. Thus, the demand for water could increase with the deployment of some low- and zero-carbon electricity and energy generation processes. Citations are included in the chapter but CCUS, small modular nuclear reactors, and hydrogen can all increase water demands.
6	P5/L15-16	The connection of dam-removal-to-protect-vulnerable-species to climate change is not clearly articulated and should be clarified.
7	P5-6/L17-7	Suggest adding brief discussion in first paragraph of this section on oil and gas delivery that discusses what oil and gas are used for besides electricity so that even in a “transitioned” world, their development, use, and delivery is relevant.
8	P5/L21	Use of the term “risks” in this case does not seem to conform to recommendations of the IPCC on risk language.
9	P5/L27-29	For the sentence discussing operations relying on reservoir storage, clarify whether this is particularly difficult in some regions of the United States as compared to others.
10	P6/L1	Is this only true of aging assets?
11	P6/L9-10	Subsidence and landslides—specifically climate change driven?
12	P7/L12	Suggest using “as well as” instead of “and” in line 12 between consumption and peak demand patterns.
13	P7/Figure 5.2 and L8-13	Suggest integrating Figure 5.2 into text discussing electricity demand by discussing timelines depicted in the figure in the text.
14	P8/L1	Clarify that this is a projection.

15	P8/L7-24	Suggest offsetting the explanatory clause in the second sentence of the key message with commas: "Compounding and cascading hazards related to energy systems and additional stressors, such as cyberthreats and pandemics, create…."
16	P8/L33-34	Suggest cross-referencing the hydrogen box in Chapter 32 (Mitigation).
17	P9/L1-7 and 8-12	Suggest describing why some energy supply chains are more susceptible to supply chain disruptions. Suggest more clarity when discussing the critical mineral (CM) supply chain disruptions. Are the regions in the United States or other countries? What geopolitical and environmental factors influence how these materials are extracted, used, and recycled. This discussion omits the key points that the United States is reliant on processing facilities in other countries and at the same time is reliant on CMs to successfully transition to a net-zero economy. While the United States has lots of CM resources and can mine them, often the separations and processing facilities are not sited here due to environmental concerns, thus the United States is reliant on a more global supply chain to source the processed minerals, or the end-use products made with processed CMs. This might be a good place to mention both the Trump and Biden Executive Orders on critical minerals. This comment is also included in Key Message 32.4. So, if this ends up being covered there, suggest cross-referencing Chapter 32 (Mitigation) here.
18	P9/L20-30	Please clarify the connection to climate change.
19	P9/L31	It might be helpful to add to the discussion of vulnerable communities the impacts of transitioning to a different electricity profile and different energy generation sources to energy sector workers who will not be trained to work in different technologies and may resist the movement to low- and zero-carbon renewable energy.
20	P9/L31	It might be valuable to note that overburdened communities are likely to disproportionately benefit from decarbonization by way of reduced ground, water, and air pollution and potentially by the and increased resilience and addition of jobs from renewable energy.
21	P9/L32	If this sentence applies to climate impacts to energy systems, add that to the sentence: "Overburdened communities are disproportionately affected by climate impacts to energy systems."
22	P11/L9ff	This should start several steps earlier (i.e., "higher winter temperatures" lead to "insects survive winter" leads to "infestations damage and kill trees" leads to "increased tinder," etc.).
23	P12/L1	The word "on" in the key message title seems out of place. Suggest "Progress continues toward enhancing" or "Progress continues to enhance" or suggest rewording the title.
24	P12/L15-17	Be careful with interchanging the words "mitigation" and "adaptation." They are sometimes used interchangeably in this chapter and in this report and this will create confusion for general audiences. Here, it seems the activities for the oil industry are

		adaptive to climate impacts to infrastructure, not mitigation efforts. Suggest removing "mitigation" from this paragraph altogether since it is discussing adaptation measures to boost resiliency of energy systems and infrastructure.
25	P12-13/L22-15	The two topics—planning for energy system resilience and hardening energy systems to reduce vulnerabilities to climate change—could be combined into one shorter section. Both discus modeling advances, for instance.
26	P14/L7	Suggest defining Internet of Things devices in the text. Or just use "smart devices, like internet connected appliances and cameras" or something similar.
27	P16/L10-13	Suggest explaining what types of costs for solar and wind decreased and why this was.
28	P17/L12-16	Suggest detailing where these demonstration projects are located to improve reader convertibility with the topics.
29	P17-18/L17-18	Suggest including a description of the IRA and new two-tiered tax credit scheme that emphasizes worker protections and vulnerable communities for developers and generators to qualify for the full amount of credit. Suggest including a discussion of energy-sector workers who are vulnerable to the energy transition changes to their livelihoods.
30	P20/L14-15	Expressing confidence that frequency and intensity of extreme events will increase seems to be a broader statement of confidence than generally accepted in the professional literature since it seems to encompass all types of extreme events and cover all locations in the United States (and presumably territories).

CHAPTER 6: LAND COVER AND LAND-USE CHANGE

#	Page/Line	Comment
1	P7/L12-13	Not all wildfires are climate driven; suggest making the sentence clear that in some places there is an increase in wildfire risk due to climate change.
2	P7/L18-19	These threats also come from land-use as well, so including other stressors in this discussion would add to the complexity but also highlight the risk to these systems.
3	P7/L20	Add something here on Great Lakes shore erosion.
4	P8/L23-24	Revise to make this a complete sentence.
5	P10/L7-8	This is not consistent with Chapter 7 (Forests)—the sink is created by growing stock and harvest products. It also contradicts the citation to Pugh et al. unless the CO_2 effect on the regrowth areas is also attributed.
6	P10/L10-11	A significant land sink is not attributed to abandonment of agriculture. Domke et al. (2021) and EPA (2022) do not document this.

		Agriculture abandonment is a relatively small sink compared to forests remaining forests and urban areas.
7	P11/L32-33	Harvest and management reduce ecosystems resilience? Is this true as a general comprehensive statement? Some forest management will in fact be required such as assisted regeneration.
8	P12/L33-37	This is a confusing discussion and should be revised for clarity.
9	P13/L1-2	In other places it is the opposite; this is not a generalizable example.
10	P22/L27-28	There is substantial uncertainty in both biogeochemical and biophysical impacts of land-use and land cover change. This implies only the biophysical are uncertain, while the impacts on the carbon cycle end soils especially of different land-use management techniques is not well understood.

CHAPTER 7: FORESTS

#	Page/Line	Comment
1	P3/L1	The introduction could set up the key messages more. Perhaps it would be nice to see some introductory synopsis of what the message is and how we know it with confidence.
2	P3/L5	The introduction lists the goods and services that forests provide, including “spiritual renewal” but does not mention the Indigenous cultural values of forests and this seems important to mention up front. These cultural values are, on the other hand, covered well under Key Message 7.2.
3	P4/L3-6	It would be interesting to see the frequency distribution of the map above (i.e., the distribution of number of years by region and nationally).
4	P5/L5-8	Should include a statement that these were driven by climate change factors not natural factors. Is the increase due to climate change and is that documented? There is no reference to Domke et al. (2022), nor is it readily found in the literature. Domke et al. (2021) is there. If this is reference to an update, it is very important and should be accurately referenced.
5	P5/L17	Could be better worded. See comments in Chapter 2.
6	P5/L18-19	This sentence is described in the introduction, not Key Message 7.1; is this the right place for this sentence? It is actually covered more in the text for Key Message 7.2; perhaps move there?
7	P5/L24-26	This statement should have an example.
8	P6/L6	An example is needed of “effects.”
9	P6/L11	Make sure readers know prescribed fire is intentional.
10	P6/L19-20	What is a national scale; does this mean consistently and widespread across the United States?
11	P6/L21-23	For example, cite Andela et al. (2017), which shows that globally fire burn area is going down, perhaps because of land management/use.

12	P8/L11	This interpretation is incorrect: "western tree species are migrating poleward through seedling success (Sharma et al. 2021)." The paper said, "Whereas fecundity may be primed to lead tree migration in the West, local climate complexity that comes with rugged relief affects how migration potential should be interpreted. The combination of dry climates and fast climate change in the intermountain West explains fecundity and recruitment vectors in Fig. 3 E and F that point toward the cool, moist regional climates of the Northwest. However, for migration, these cool-moist conditions are locally found at higher elevations. The regional centroids average over this variation contributed by steep terrain."
13	P13/L16	Domke et al. (2022) is not referenced, nor can it readily be found in the literature.
14	P14/L4-9	Sources should be specified. This figure needs to be reconciled with the national GHG inventory, EPA (2022) or EPA (2021). The sinks estimate here are not consistent with Domke et al. (2021) nor the national GHG inventory. The caption needs to better describe the figure. What is NEE and other acronyms? Explain that harvested wood product (HWP) "transfers" are a sink when the areas regrow, otherwise it is a sink that does not have emissions associated with it which is different. Is NEE from the regrowth? Or from new lands converted, or CO_2 fertilization and productivity?
15	P14/L12	Change to "...are a critical component of the hydrological system and the provision of clean water." We do not think "forests produce water" is the intended meaning.
16	P15/L1-3	State that this is an example of how climate change affects forest changes and in turn other impacts, in this case water flow and flooding.
17	P16/L24-25	Figure 7.10 does not show adaptation practices. It shows land ownership.
18	P21/L6-7	This statement needs a citation.
19	P22/L11-14	The reference to Sharma et al. may have been misstated. Check if it actually shows evidence of migration, or evidence to suggest migration.
21	P22/L15	See more literature on this (e.g., Novick et al. [2022]).

CHAPTER 8: ECOSYSTEMS, ECOSYSTEM SERVICES, AND BIODIVERSITY

#	Page/Line	Comment
1	P5/L1	It would be useful to emphasize in caption as well as text that "transforming into new systems" means "transforming into new, often degraded systems less able to provide ecosystem services."
2	P5/L13	Clarify if the "delayed harvest of plants" in the Northern Great Plains means "delayed harvest of crops." Also, explain the significance of

		"loss of rivercane;" other biodiversity examples are more familiar or obvious ties to ecosystem services.
3	P7/L20	Consider including Ibanez et al. (2022) as another possible citation on multiple stressors.
4	P8/L8-10	Consider replacing words like "transformative" and "stable, which have a positive effect with "degraded" or "ecosystem collapse."
5	P10/L9	Avoid the phrase "is complex" and replace it with a more specific statement. Ecologists often use this phrase when talking about ecosystems even though what is really meant is that there are surprises, or that there are direct and indirect effects of climate change that act together on ecosystem functions (e.g., pollinator webs, food webs).
6	P11/L8	The "Monitoring Transformations" subsection could, through minor rewording, more clearly convey that these monitoring networks (Figure 8.8) have been established in recent decades in direct response to global change. The National Ecological Observatory Network (NEON) may have fully come online since NCA4. It is worth emphasizing this because otherwise it sounds as if ecologists have always monitored, when in fact this is a recent development.
7	P13/L14	This paragraph and associated Figure 8.9 are confusing because the figure exemplifies coral reef adaptation, but there is no mention in the text of corals. Instead, authors used Tetlin National Wildlife Refuge as an example, which is a great example, but it is not clear if they used the Resist-Accept-Direct (RAD) framework. The Committee suggests doing some minor rewording to address this disconnect.
8	P14/L19	Avoid using the term "complex" and replace it with something more specific.
9	P17/L13	Change "Box 8.2" to "Box 8.1" (there is no Box 8.1).
10	P19/L1	Box 8.2 is a nice example, but a few more words about why large-bodied species are vulnerable to extinction and climate change would be useful—it is the second time body size has been mentioned.
11	P20/L1	Should "disease risk," which focuses on diseases of animals and their vectors, also include plant disease (fungal and other plant pathogens) that affect natural ecosystems (e.g., Sudden Oak Death) and crops? A few possible references for discussing plant disease are Burdon and Zhan (2020) and Juroszek et al. (2020).
12	P20/L12	Table 8.1 is informative, but the Committee suggests adding a column identifying where this risk occurs in the United States.
13	P22/L7	The Committee appreciates that the statement about invasives that have declined in response to climate change is so well referenced but suggests adding a few examples into the text. The focus on the subsection is on invasives expanding due to climate change, so it is difficult to get a sense of the relative importance of these two groups.
14	P29/L16	Could emphasize not just "buy-in" from local already vulnerable communities, but solutions that are designed and led by those communities (i.e., "co-produced" with other actors).

15	P33/L27-32	The climate envelope models are used in nuanced ways to assess future climate change vulnerability. They predict habitat distribution and often use other environmental predictors in addition to climate (e.g., soil, topography, vegetation cover). There are procedures for incorporating dispersal rates (i.e., can organisms occupy shifting habitat), identifying and limiting confidence in predictions to novel environments, and focusing on habitat suitability changes within the current range (exposure). What this approach does not address is plasticity and adaptation.
16	P33/L35-37	It is not necessarily useful to think of range shifts as being driven by extreme weather events. Extreme events are likely to affect population processes via mortality and so forth, especially in combination with other global change stressors. Other modeling approaches are needed to forecast ecological changes on the order of decades, and those frameworks are being used.
17	General	An additional reference, Warren et al. (2018), could be added on range shifts (global).
18	General	The following papers on natural climate solutions could be good additional references: Griscom et al. (2017), Law et al. (2021, 2022), and Novick et al. (2022).

CHAPTER 9: COASTAL EFFECTS

#	Page/Line	Comment
1	P4/L2-4	This opening statement conflates regional and global mean change, as well as absolute and relative sea-level in confusing ways. (1) Stating that sea levels are rising and accelerating globally gives the impression that this is true everywhere, but it is not. There are many locations where relative sea-level rise in the United States is falling (e.g., some locations in Alaska) and/or not accelerating (e.g., most of the US west coast). It would be more accurate to say, "Global average sea-level is rising and accelerating due to thermal expansion…." (2) The inclusion of vertical land motion here is tricky because it is the only reference to relative sea-level in this statement. It does not represent variations in the thermal expansion and addition of water mass that are referenced in the first part of the statement. It is also a highly local (not regional) effect. It would be best to edit the second part of this opening sentence to be more specific about where the named variations occur, such as "…with variations occurring along local and regional coastlines due to…."
2	P4/L5	"Accelerating, rising" is awkward phrasing.
3	P4/L6-7	Authors should choose between feet in figure and inches in text. Reading and interpreting the text will be easier if the same units used in the text are also used in the figures.

4	P4/L10	The phrase "on average 3-7 days per year" is too vague. Is this 3-7 days in at least one location across the whole country? Or 3-7 days at every location across the country? If the latter, it is unclear how this is a useful statistic given the huge amount of spread between locations around the United States.
5	P4/L17	Missing dash in range of SLR in meters provided in the parenthetical.
6	P4/L28-29	Suggest the reference to Figure 9.2 be moved to the previous sentence, which is what the figure shows. The figure does not pertain to differences across emissions scenarios, which is what the sentence describes.
7	P4/L28-29	Include the emissions scenario the numbers in the paragraph are based on.
8	P5/L5-9	Including the idea that coastal landscapes evolve across a range of timescales due a range of climate-driven and natural phenomena is great. It would be good to provide similar context for the previous section on SLR and high tide flooding, stating that sea-level (e.g., ENSO) and tides (e.g., nodal cycle, harbor dredging) also evolve on a range of time scales due to a range of natural and climate-driven reasons.
9	P19/L26-30	A major source of uncertainty prior to 2050 is the impact of natural climate variability on the projections.
10	P20/L28-37	This paragraph needs references.

CHAPTER 10: OCEANS AND MARINE RESOURCES

#	Page/Line	Comment
1	P3/L2	Suggest beginning the sentence with the subject of the chapter, i.e., "Oceans span tropical, temperature, and polar regions; support diverse and productive marine ecosystems; and provide innumerable benefits to the US."
2	P3/L2-9	Defining and making clear that NCA5 assesses a huge region of the United States, not just the continental US, is well done here, but a simple reference to Figure 10.1 would emphasize this point.
3	P4/L8	Specify higher emissions scenarios.
4	P4/L1-11	Key Message 10.1: there are no likelihood statements provided. However, these statements may have quantitative evidence to support them, and if so, should include likelihood statements (this is also true for Key Message 10.2 and Key Message 10.3).
5	P5/L28-29	Consider adding ENSO events to the list of impactful extreme events for marine ecosystems. The last one was devastating to coral reefs throughout the Pacific.
6	P6/L1-6	Overall Figure 10.1 is a good figure, but please expand the figure caption to explain all the symbols and where the information comes from.
7	P6/L13	Suggest specifying very high emissions scenario.

8	P7/L6-8	This is an important point that could be elevated to part of the key message.
9	P7/L9	Suggest making a referenced statement somewhere in this box stating whether the severity and/or frequency of such marine heat waves is expected to increase with ongoing and future climate change.
10	P8/L1-7	Figures 10.2, 10.4, and 10.5: the figure captions should contain all the information to explain the figure as well as the citations so that the figure is self-contained.
11	P10/L17	Specify emissions scenarios.
12	P12/L10	Suggest either using a less technical term than "extirpation" or defining the term in the text.
13	P13/L4-13	Consider mentioning wave energy conversion, a nascent technology, which may be particularly useful for the west coast, Hawai'i, and USAPI, even though it is mentioned on page 10-15, line 15.
14	P15/L4-6	Here is a good place to highlight the need for continued investment and expansion of the National Ocean Observing System.
15	P18/L13-14	The Front Matter rubric emphasizes evidence and publications, not data. It would be more accurate to remove "data" from the statement here.
16	P18/L23-32	Indigenous island communities are highly impacted by ocean change (see Chapters 23 and 30) and should be highlighted here.

CHAPTER 11: AGRICULTURE, FOOD SYSTEMS, AND RURAL COMMUNITIES

#	Page/Line	Comment
		None

CHAPTER 12: BUILT ENVIORNMENT, URBAN SYSTEMS, AND CITIES

#	Page/Line	Comment
1	P1/L1	Ensure chapter title is consistent with built environment definition, and if not revise the title.
2	P3/L2	Recommend stronger first sentence.
3	P3/L3	Use of urban residents' livelihoods automatically sends a tone that this chapter is only about the urban built environment. Is that what the authors intended?
4	P3/L7	Recommend stronger first sentence, such as "recent science shows how climate change is having cascading and compounding effects on the built environment."
5	P3/L12	Suggest cross-referencing Chapters 5 (Energy Supply, Delivery, and Demand), 13 (Transportation), and 18 (Sector Interactions, Multiple Stressors, and Complex Systems).

6	P3/L14	Suggest changing "historically disadvantaged communities" to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.
7	P3/L23-25	Recommend stronger first sentence that is more accessible.
8	P3/L29	Suggest changing "historically disadvantaged communities" to a term consistent with other chapters. Other terminology suggestions include overburdened, highly impacted, or historically underinvested.
9	P3/L36-37	Suggest increasing readability for broader audiences.
10	P4/L3	Largest 10 cities plus the top 5 percent of suburbs: consider having Figure 12.1 actually show those 10 cities and the suburbs with labels using data from 2018 rather than the map shown (2015).
11	P4/L16-18	Opportunity to increase readability for broader audiences.
12	P5/L1	Figure 12.2: Suggest explaining and contextualizing the importance of the data shown. It is also difficult to tell if there are clear differences in the maps that are visible with the maps being that small. It appears that there is a mall change to states like Montana, Wyoming, and Utah. Perhaps focusing on areas that are predicted to have the greatest change would be more meaningful.
13	P5/L13	Appreciate the reference to Chapter 6 (Land Cover and Land-Use Change) but consider also including the title of the chapters when being referenced. This is consistent with cross-referencing done in other chapters.
14	P8/L9	Suggest adding something like: "If mitigation and adaptation measures are not deployed quickly and sufficiently then urban areas will continue to be significant drivers of climate change...."
15	P8/L17	Suggest modifying Key Message 12.2 title to be a statement.
16	P8/L19	Suggest replacing "existing loads" with more accessible language.
17	P8/L22	Suggest replacing "infrastructure deficits" with more accessible language.
18	P9/L6	"Linking extreme events to climate change is critical for assessing, disclosing, and managing risk to urban systems." is an important point that is just left hanging at the end of this paragraph. Suggest incorporating it into the introduction or key message and expanding on why it is important for the built environment.
19	P10/L15	Suggest referencing health impacts broadly instead of using "diseases such as asthma."
20	P11/L12	Suggest adding a specific example about the disproportionate burden on populations. For instance, Houston's urban heat island mapping showed a 17-degree difference between two neighborhoods on the same time and same day.
21	P12/L7	Consider including this point in the introduction or at the beginning of this key message.
22	P12/L14	While this section talks about the reduced "life expectancy of heating, air-conditioning, ventilation, and filtration systems as well as

		road pavements and tarmac surfaces," it does not mention the impact of people, especially overburdened and vulnerable people.
23	P12/L18	Another use of "loading" that should be clarified for broader audiences.
24	P12/L28	Perhaps an opportunity to highlight some of what is being done, such as LEED for Cities, and updates to building and zoning codes.
25	P12/L29	Very general statement. Which systems? Perhaps an opportunity to link to other chapters.
26	P12/L32	Caution how "local beliefs about climate change" is being used; perhaps local action or inaction (based on beliefs) would be another way to phrase this statement.
27	P12/L34	Perhaps provide one or more examples for how to increase awareness, or better yet, action, and provide an example of what has worked.
28	P12/L38	Suggest using more accessible language.
29	P13/L4	Add "climate" before "risks."
30	P14/L1	Suggest using a more informative statement for the key message title, such as: "Climate Action Opportunities for Cities."
31	P14/L11	Confirm the 2014 reference is needed; has this system been updated in the last 8 years? It appears to be a dated reference.
32	P14/L14	Consider referencing BRIC in this section.
33	P14/L16	Suggest providing a quantitative percentage of plans that did not explicitly address climate risks. If this information is not clear, consider rewording.
34	P14/L18	Suggest adding "and for climate adaptation and resilience." This statement is incomplete without this additional information as this section is covering both mitigation and adaptation.
35	P15/L2	Suggest defining/describing what a co-benefit is here.
36	P16/L11	"Nature based solutions" and "green infrastructure" are both mentioned here, and Figure 12.2 references "natural infrastructure." Suggest using consistent (and the most common) language.
37	P17/L6	Replace "struggle" with "seek."
38	P17/L13	Tribal communities or tribal nations?
39	P17/L17	Capitalize Chief Resilience Officers and note that some states have appointed Chief Resilience Officers.
40	P17/L18	Capitalize Chief Heat Officers and include Chief Sustainability Officers here too.
41	P18/L3	Clarify if the communities referenced here are "rural."
42	P18/L7	Clarify if taxes are declining or is revenue declining.
43	P18/L12	Give examples of states that are exceptions.
44	P18/L13	Which cities? This chapter should have more specific examples and less generalities.
45	P18/L15	Is it capacity, or ability, due to constraints including capacity?
46	P18/L29	Suggest changing the first sentence to read, "Local urban planning efforts incorporating climate actions show varying progress…."

47	P18/L37	Provide examples of what is working.
48	P19/L3	Consider reworking this paragraph for readability.
49	P20/L3	Consider "residents'" interests instead of "citizens'."
50	P22/L2	Consider explaining why cities are underreporting GHG emissions.
51	P27/L5	Consider resident support instead of citizen support.

CHAPTER 13: TRANSPORTATION

#	Page/Line	Comment
1	P1/L2-5	Text can be added to define mobility in addition to the current language on the transportation network.
2	P1/L11-14	Text can be added on planning for future transport needs for people.
3	P1/L16-19	An opportunity to add text on emerging mobility options.
4	P3/L14	Are risk assessment and long-term costs the key to equitable investments? Lines 20-21 provide concrete suggestions: "Inclusive decision making and data-informed processes."
5	P3/L24	Replace "remains" with "is." Not long ago (2016), the power sector was the largest sector.[5]
6	P3/L25	Perhaps replace "industry" with "sector."
7	P3/L32	Limiting global warming requires a path toward "achieving net-zero."
8	P4/L10	Remove the White House citation.
9	P6/L4-6	Remove, "Cells with few or no bullets…" and complete a more comprehensive literature review.
10	P6/L1-6	Table 13.1 caption uses term "bullets" in line 5. However, the table does not include bullets.
11	P8/L5	Spell out "DOT" acronym since this is its first use.
12	P9/L9	Perhaps replace "greater" with "increasing" or quantify what it is greater than.
13	P10/L13-14	Perhaps replace the first "expected" since the sentence currently reads as "expected to perform well beyond expected."
14	P13/L3	For most scientists, "significantly" would imply some test and confidence. Replace with a less loaded word.
15	P15/L1-6	This paragraph, which continues from the previous page, lacks citations.
16	P15/L27-28	Mention "non-combustion electricity generation." It would be helpful to have a sentence devoted to the implications of fuel cell technology for transport.
17	P19/L18	This is the only time "rural" was mentioned in the entire chapter.
18	P19/L23	Spell out "TSU" acronym since this is its first use.
19	P19/L34	Replace "…from other authors" to "…from other chapters."
20	P21/L32-36	Replace semicolons with commas or break up the sentence.

[5] See https://afdc.energy.gov/data/10802.

CHAPTER 14: AIR QUALITY

#	Page/Line	Comment
1	P3/L35-36	Give examples of human-caused emissions.
2	P4/L25	Remove the period in "warming (KM 14.5)., is…."
3	P5/L4	Remove the underscore in "concentrations in the Northeast_."
4	P5/L8-11	The caption for Figure 14.1 needs to be self-contained, and have citations.
5	P6/L1-2	Font size of figure title changes.
6	P6/L4-5	The figure captions should describe everything in the figure and explain all the acronyms. It looks quite busy: consider converting this to a mean and a range for each color instead?
7	P7/L34	Remove "and" in "problems, and worse outcomes for birth...."
8	P8/L5-6	Climate change could increase the odds of wildfires, although land conversion is likely to decrease the land available for wildfires, so it may not be so certain that activity will increase. Perhaps modify to "…the chance of wildfires in many regions will increase."
9	P9/L3-5	Figure 14.3 caption should describe what is being shown: are these model- or observation-based? The grey versus the colored dots? Figure captions should be self-contained.
10	P18/L15-22	Figure 14.10 is not very clear and seems unnecessarily busy. Perhaps just showing the range of values would be clearer.
11	P18/L19	Spelling error in "…(in 2020 US collars)."
12	P23/L21-34	This paragraph is missing citations: please include appropriate citations. Additionally, there was no previous citation to the epidemiology and toxicology studies that are referenced again here.
13	P26/L34	Add period between "change Conclusions."

CHAPTER 15: HUMAN HEALTH

#	Page/Line	Comment
1	P3/L16-18	This key message needs a confidence rating after the first sentence.
2	P4/L10	Suggest using a dash instead of a comma.
3	P5/L1-4	These two sentences could benefit from more specific details or examples. Is the second sentence referring to just the west or the entire Unites States?
4	P5/L7-9	Suggest linking wildfire smoke to air quality first then associating it with impacts, and suggest defining cardiovascular-, cerebrovascular-, and respiratory-related health issues in line or providing examples of each.
5	P5/L16	Clarify if increased rabies exposure referring to human exposure or animal exposure. If not to humans, please clarify the link to increased animal exposure to rabies and human risk as the tick-borne disease section does in line 36 on the same page.

6	P5/L25	Suggest defining "vector."
7	P6/L12	Suggest making the key the same color code as the images on the map.
8	P6/L19-20	This section is about both food and water; therefore, the first sentence should include water as well. Suggested text: "Climate change negatively impacts food security, nutrition, water security, and water quality, which harms health, particularly for communities."
9	P7/L23	Is the word "relatives" intended to be a different word? Otherwise, consider clarifying the meaning of "fauna relatives."
10	P7/L27	This sentence is missing a citation.
11	P8/L13	If possible, provide a more recent reference for this sentence.
12	P10/L3-4	The first sentence in the key message needs a confidence rating.
13	P10/L17	"BIPOC" and "low-wealth communities" may be fine words here, but the language to define specific vulnerable populations should be consistent across chapters in the report. As the language is now, many chapters use different terms to define similar populations. Suggest conformity and consistency across chapters.
14	P10/L25-27	Suggest listing the six climate-related hazards in the caption of Figure 15.4.
15	P11/L29-33	Suggest referencing Chapter 16 (Tribes and Indigenous Peoples) for these two sentences.
16	P11/L30-31	It is not necessarily clear what "on the frontlines of climate change" means. Suggest defining in-line.
17	P12/L13	Suggest defining "redlining" inline and given that this term is used throughout the report it may also be included in a glossary.
18	P12/L17-21	Consider explaining why Black and Latinx communities are more likely to live in areas with high air-pollution levels.
19	P12/L24-27	Does the use of "women" here refer to all women? Additionally, clarify what populations women are being compared to when stating that they are more likely to live in poverty.
20	P13/L14	Describe why or how the discriminatory beliefs impact care.
21	P13/L15-25	In the Figure 15.5 caption, specify what the underlying socioeconomic and demographic factors are. What does the sentence about a seemingly decreasing trend mean? Instead of "That would explain…" specify what "that" is. The first four sentences in this caption are unclear and unspecific.
22	P14/L6	Suggest a different word than "mainstream." Consider also revising these sentences to have consistent tenses and reduce wordiness; they are confusing as written. A possible rewording could be "Proactive and continuous risk-management is critical to human health and well-being, particularly to protect at risk groups and health care facilities. Integrated approaches emphasize health in policies for food, infrastructure, water, and sanitation."
23	P15/L2	Suggest clarifying why is there a growing "at risk" population and who this population includes.

24	P15/L1-31	This section is missing the climate connection; audiences need that connection to be made overtly.
25	P15/L32-37	This section is missing the climate connection; audiences need that connection to be made overtly.
26	P16/L3-12	This section is missing the climate connection; audiences need that connection to be made overtly.
27	P17/L13-24	This section is missing the climate connection; audiences need that connection to be made overtly.

CHAPTER 16: TRIBES AND INDIGENOUS PEOPLES

#	Page/Line	Comment
1	P3/L1-12	The introduction would benefit from more text before the images that take up almost two full pages.
2	P4/L12	Suggest ending the current sentence with a connection to Figure 16.3: "…strategies for adaptation to those changes which includes a holistic worldview."
3	P6/L3	Suggest "legal systems" rather than "legal environments."
4	P6/L23	Add the word "climate" in to replace "the" so that it reads "for the heightened severity of climate disruption."
5	P6/L25	Omit the word "their."
6	P7/L8-9	Suggest reordering to reflect the order of the key message as written and add energy if kept in this key message.
7	P8/L4	Remove the period between "barriers" and "(Figure 16.4."
8	P9/L1-23	This section on COIVD-19 should reference the Focus on COVID-19 and Climate Change. If looking for an area to slim down, this paragraph is quite long and could be shortened.
9	P10/L8-11	This holding did not occur in a vacuum; it is based on the evolving US tribal law and policy (here assimilation) from the 18th to the 20th century that influenced tribal actions. Suggest clarifying this in text to reflect this distinction: "Due to the evolution of colonial policies and US tribal law from the 18th century to present day, and the influence those laws and policies had on Indigenous actions, some Indigenous peoples face intricate land-based jurisdictional circumstances today that prevent recovery of their historically occupied territory. For example, the US Supreme Court's holding in *Carcieri v. Salazar* (2009) prohibited contemporary land restoration for certain Indigenous peoples that historically acted on colonialist laws and policies."
10	P10/L11-12	Please add transition sentence between first paragraph to the second paragraph under "relocation."
11	P10/L25	Do these opportunities (a range of options) currently exist or is the use of the word "opportunities" to imply a change or possibility for progress? The options or changes could be explained in more detail.

12	P13/L5-8	This sentence would benefit from an explanation why funding is not often distributed in "ways" (typo, not "was") that Indigenous peoples can access.
13	P13/L15-16	Suggest providing examples of coordinated infrastructure projects that mutually support one another.
14	P13/L16	Please correct to be "Indigenous peoples'."
15	P14/L19	"Knowledge" can be both singular and plural: suggest removing the "s" from "knowledges."
16	P15/L3	The term "peoples" is more commonly used than "persons."
17	P15/L15	Please correct to be "Bureau of Indian Affairs'."
18	P16/L26	Suggest adding the research term, "land-based healing incitive" (Johnson-Jennings et al., 2020; Redvers, 2020).
19	P20/L28-38	This is a great overview and could possibly be summarized or placed into introduction of chapter.

CHAPTER 17: CLIMATE EFFECTS ON US INTERNATIONAL INTERESTS

#	Page/Line	Comment
1	P3/L6-9	The final sentence of the first paragraph of the introduction is policy prescriptive and should be reworded slightly.
2	P3/L16-17	The final sentence is too vague to be meaningful and should be revised.
3	P3/L16-25	Suggest removing this paragraph as it does not seem relevant to the chapter topic.
4	P4/L22-24	Last sentence of Key Message 17.1 is policy prescriptive and should be reworded slightly.
5	P6/L3	In Figure 17.1, the bullet "Climate resilience" under the heading "Climate resilience" is redundant and should be removed.
6	P12/L10-11	The projection reported in the sentence is not present in the referenced source.
7	P12/L25-26	Rising sea levels should not be listed as "less well quantified." Sea-level rise is well observed and quantified.
8	P12/L26-27	Increasing average temperatures are not the concern. Global average warming is a useful indicator of climate change, but the impacts to health and agriculture will be regionally specific due to shifting patterns of temperature and precipitation.
9	P16/L2	The discussion suffers with combining observations and projections in one sentence (e.g., poverty rates).
10	P21/L21	Suggest using a different word than "significant," as it is an undefined term.

CHAPTER 18: SECTOR INTERACTIONS, MULTIPLE STRESSORS, AND COMPLEX SYSTEMS

#	Page/Line	Comment
1	P6/L18-22	Is this an example of polarization or systematic discrimination?
2	P6/L25-28	Not clear what this has to do with complex systems.
3	P13/L4-16	Paragraph has no citations.
4	P13/L11-16	Sentence filled with jargon.
5	P13/L19-26	Does the deep uncertainty to the complexity of the systems or the scenarios?
6	P14/L6-8	Sentence is true but can price signals exacerbate unequal impacts?
7	P16-17/L26-10	Traceable account for Key Message 18.1: The Committee questions the ranking of high confidence in this emerging field. Many of the findings are based on one study, Reed et al. (2022), which is not consistent with the definition of high confidence provided in the Front Matter.

CHAPTER 19: ECONOMICS

#	Page/Line	Comment
1	P4/L3	Lipton et al. (2018) is about migraines. From the title of the publication, it is not clear it has anything to do with climate change.
2	P4/L16	The literature is filled with studies on the economic impact of climate change on agriculture and only one citation is given here. Does the new work on agriculture completely negate older studies (e.g., Rosenzweig and Parry, 1994)?
3	P6/Table 19.2	"Student Learning" row: The Park et al. study finds that the adverse impact can be offset by use of air conditioning.
4	P9/Figure 19.1	The figure is hard to read and might be easier to read if it is displayed in a landscape format.
5	P18/L27-28	The literature on climate change and violence is thin and needs a lot more analysis to establish a reasonable level of confidence.
6	P18/L24-27	Judicial decisions, political turnover, etc. seems to be somewhat speculative.
7	P21/L11-33	Consider including uncertainties about societal changes (e.g., population, income, and technology).
8	P24/L3-17	Consider including adaptation.

CHAPTER 20: SOCIAL SYSTEMS AND JUSTICE

#	Page/Line	Comment
1	P4/Figure 20.1	Consider clarifying the purpose of this figure. Is the purpose to introduce three dimensions of justice for assessment analysis?
2	P8/L15	Add a period after "2017)…."

3	P9/Figure 20.2	This figure does not provide essential information and could be described in one to three sentences.
4	P10/L8	Remove the period between "society. (Oreskes…."
5	P13/Figure 20.3	If this figure intends to demonstrate that social systems influence migration and that climate change may exacerbate but that planned relocation could increase just outcomes, the message is not well understood through this Bronfenbrenner ecological framework and more recent frameworks have been presented in the literature.
6	P14/L11	Add a period after "…2022)."
7	P14/L22	Use lowercase "h" in "Hired."
8	P15/L17	Remove "a" in the "right to a fair…."
9	P15/L19	Add a comma between "oil gas."
10	P17/L18	Suggest "Indigenous knowledge" instead of "Indigenous knowledges."
11	P18/L11	Replace "such" with "human."
12	P21/L30	Italicize "high confidence" for consistency.
13	P23/L31	Add "a" between "identify [a] research gap" and remove "research."
14	P26/L8-9	Add "is" between "Much of that literature [is] also based…."

CHAPTER 21: NORTHEAST

#	Page/Line	Comment
1	P4/L18	Suggest using more recent projections if possible, and the statement could benefit from some people-focused context
2	P4/L27	Suggest expanding this discussion. The Northeast is heating faster than most regions of North America and extreme heat events cause more deaths each year than all other extreme weather events combined. This should be reflected in a more balanced summary of extreme precipitation and extreme heat impacts.
3	P4/L31	Social impacts are suggested but there is little mention of social impacts afterward.
4	P4/L34	Suggest using the term "hurricane" instead use of "cyclone," based on the NOAA definition: "Hurricanes, typhoons, and cyclones are actually all the same type of storm, but have different names based on where they form. In the North Atlantic and central and eastern North Pacific, these storms are called "hurricanes." In the western North Pacific, they are called "typhoons" and in the South Pacific and Indian Ocean, they are called "cyclones."[6]
5	P4/L36	Suggest "projected" rather than "expected." This is a numerical projection and is probably based on a specific scenario which should be mentioned in the text.

[6] Tropical cyclones are rare in the South Atlantic: https://www.noaa.gov/education/resource-collections/weather-atmosphere.

6	P5/L1	Increased nighttime temperatures also have significant implications for public health.
7	P5/L11	"Pluvial" should be defined parenthetically as "fluvial" is in line 18.
8	P5/L16-17	Needs a reference.
9	P6/L27-39	The paragraph is not specific to the Northeast region.
10	P6/L30	Cite Chapters 14 (Air Quality) and 15 (Human Health).
11	P8/L12	Suggest using "climate change" rather than "warming" because the sentence includes discussion of acidification.
12	P12/L30-38	The discussion of oxygen loss lacks explanation for general audiences and introduces related concepts (added nutrient load) without showing the connection.
13	P14/L14	The term "mitigation" is used in the context of adaptation as mitigation of impacts.
14	P14/L38	Based on racial discrimination is an important omission. Redlining is an important example of structural racism that has many present-day ramifications that have increased vulnerability to climate impacts.
15	P15/L6-17	Suggest noting implications for morbidity/mortality as well.
16	P16/L10-13	These lines present an opportunity to identify connections between important equity-related issues (e.g., air quality, urban areas, redlining, environmental justice).
17	P16/L13	"Reasons for the regional differences are unclear." Please see literature on redlining and urban heat islands as well as air quality and environmental justice literature.
18	P16/L18	Perhaps "genital and urinary" rather than "genitourinary."
19	P16/L23-33	Important to integrate the idea of a just transition here with broad implications not only for energy insecure populations but also for impacts to fossil fuel-dependent livelihoods and communities particularly in West Virginia.
20	P17/L22-23	Suggest adding "structural, political, and socioeconomic."
21	P17/L33	Suggest adding "and burdens" so the sentence reads "…benefits and burdens…."
22	P18/L17-20	The sentence could be interpreted as being policy prescriptive. Alternative wording could be "In response to the announcement of intended withdrawal from the Paris Agreement in 2017 (the withdrawal had to wait 3 years), states, municipalities, tribes, and businesses...."
23	P26/L5	Suggest adding "households" to communities and businesses (there are a number of state-level incentives for household-level mitigation).
24	P27/L3	Suggest giving context on the Federal Emergency Management Agency (FEMA) flood map underestimation of risk.
25	P28-29/L26-19	Lack of well-defined metrics is another important obstacle for private-sector investment.
26	P29/L14	Cites "USA facts 2021" as the only source for the paragraph.

27	P32/L5-7	The discussion on research gaps regarding Key Message 21.2 mentions "multiple sources, especially farmers…" regarding droughts and high moisture. This appears to be introducing new evidence and is not cited. Recommend moving this to the text on Key Message 21.2.
28	P34/L6-14	An additional question is whether jurisdictions will be able to overcome non-financial barriers to adaptation (since finance is covered in Key Message 21.5).

CHAPTER 22: SOUTHEAST

#	Page/Line	Comment
1	P3/L2	The word "eons" is too technical. Consider rephrasing.
2	P3/L8	The word "animus" is too technical. Consider rephrasing.
3	P3/L11	The word "chattel" is too technical. Consider rephrasing.
4	P4/L12	Suggest including research on Ida or any of the major storms more recent than Katrina.
5	P9/L25	Please specify what "the region" represents.
6	P11/L9	Suggest also including North Carolina (Cherokee).
7	P11/L26-27	Change to present tense.

CHAPTER 23: US CARRIBEAN

#	Page/Line	Comment
		None

CHAPTER 24: MIDWEST

#	Page/Line	Comment
1	P3/L26	Wording choice. Once something is "built" it is "aging." Perhaps cite the median age of infrastructure here?
2	P4/L16	There is no likelihood statement.
3	P4/L23	Annually may be used incorrectly. Suggest clarifying by stating that "annual precipitation has increased," not that "it increased annually."
4	P5/L3-7	It is not clear that the left panel is properly explained and related to the others.
5	P8/L18	Please change to "crop insurance losses continue."
6	P10/L8, 11	There is no likelihood statement.
7	P15/L9	There is no likelihood statement.
8	P15/L32-33	This sentence leaves the reader wondering why this difference.
9	P16/L18-19	Suggest clarifying this logic. Certainly, other regions have higher population.

10	P19/L3-5	This diagram shows the annual values, from which one can infer the change. Suggest removing first two words.
11	P20/L15-19	This sentence ("Sufficient...") borders on tautology. Perhaps "more" are needed but that begs the question how much more. Perhaps the chapter authors can be more specific here. Twice as many? Or perhaps the sentence can say that Centers for Disease Control and Prevention (CDC) suggests a model of how increases in resources correlates with improved outcomes.
12	P20/L29	There is no likelihood statement.
13	P20/L30	This fails to mention the electric grid, one of three sectors mentioned in the key message first sentence.
14	P20/L32	"…are in need of repair." Can this be quantified? What fraction? What dollar value? Or provide some other sense of the magnitude of the problem.
15	P21/L3	"Recent grades" assumes the reader knows what is being graded; please rephrase.
16	P21/L19	"...high (A1B) and very high (A2)" The chapter authors should consider how to mix Special Report on Emissions Scenarios (SRES) and later scenario generations, so the reader does not get confused or overwhelmed.
17	P23/L14	Does this imply that a return period of 1 year signifies an extreme event? Also, given the non-stationarity, should chapter authors not be encouraging the use of exceedance probability language?
18	P25/L31-34	This suggests an interesting challenge. Is there any assertion that this small percent increase poses a problem? Is the annual value really the most helpful one to cite?
19	P27/L19	Is the type of aquifer the most important information about the groundwater system to convey? Perhaps the status of the groundwater system would be more pertinent in this report. Given the topics discussed in the text, a map of what percent of water resources comes from groundwater may be more pertinent. Also use only or mark the Midwest boundaries.
20	P28/L24	"Precipitation is expected to increase…" on the order of 1 percent according to the key message.
21	P29/L8	Suggest citing literature that demonstrates change versus variability.
22	P30/L7	Change "impact of" to "impact on."

CHAPTER 25: NORTHERN GREAT PLAINS

#	Page/Line	Comment
1	P4/L1-3	Suggest defining the region; which states are included? Add some context for the region.
2	P4/L2-3	The sentence could be written about any region.
3	P4/L7-8	Suggest splitting this sentence into two sentences.

4	P4/L26-27	A region diversifying could be a lot of different things—for example, economic diversification; suggest "experiencing population diversification" or "becoming more culturally diverse."
5	P5/L14-15	"Challenges" is used twice in this sentence; suggest using "changes" the second time the word is used.
6	P6/L15-16	This language (days then nights in parentheticals) is confusing; suggest clarifying in text.
7	P6/L17-19	Suggest clarity in language by inserting introductory sentence: "The region has experienced less very cold days (defined as a maximum temperature of 0°F or lower) than the historic average (defined as …) for the past few decades. For instance, there have been less very cold days than the long-term average in Montana since 1985, in...."
8	P6/L22-26	Insert "resources" after "on groundwater." Suggest describing whether this is in the whole Northern Great Plains (NGP) region or just some states? Suggest citation of Siirila-Woodburn et al. (2021).
9	P9/L15	Suggest mentioning the states that are headwater states for the Colorado River basin.
10	P12/L18-24	Spiritual health is mentioned in the key message language and not in the supporting text. Please incorporate spiritual health into supporting text or remove from key message language.
11	P12/L26-27	Rephrase with active voice to remove passive voice: "Literature recognizes a spectrum of…."
12	P12/L31	Note that the Burke and Yazd studies are about national mental health risks, not specifically about the NGP. This is not the only place in the chapter where national studies are cited to for a statement about the NGP region. Please ensure that citations to literature discussing national trends are represented that way in the supporting text.
13	P13/L18-19	Is there any more recent literature on West Nile virus or vector-borne diseases in the region than 2014? Check Chapter 15 (Human Health).
14	P14/L5-8	Suggest defining nutrient load to incorporate the volume of the nutrient, passing through a single location, over a set period of time rather than just the volume. Is there more recent literature on this than 2014-2015?
15	P15/L4-23	Suggest renaming "loss of biodiversity" to "compound biodiversity impacts of climate events" to mirror earlier section discussing "compound health impacts of climate events."
16	P18/L11-20	This section (three paragraphs) is unclear. The example is Texas, but then discusses outages in the NGP region. Were there power outages in NGP states due to Texas strains on the grid? Suggest revising to improve clarity and indicate the relationship to NGP region. Move last sentence up. Use active voice where possible. A rewrite could be something like this: "Climate change impacts and mitigation efforts are expected to increase energy demand across North America. Higher summer temperatures and heatwaves are expected to increase energy demand across the country, while higher winter temperatures

		and fewer cold snaps are expected to reduce energy demand for heating in the Northern Great Plains. Increased energy demands from outside the Northern Great Plains will place demands on regional energy resources and electricity supply. Climate change will also stress energy infrastructure (e.g., rail, pipelines, distribution lines, transmission lines). Energy infrastructure is vulnerable to climate extremes. For instance, the power outages that resulted from the 2021 extreme cold event in Texas illustrate the importance and connection between demand, supply, and distribution across the US during extreme weather events."
17	P18/L21-37	Add in transition phrases and sentences; this section reads rather choppy. Discuss the expected impacts of energy-sector changes to energy-sector jobs.
18	P20/L19	Offset "and exacerbating existing" with commas.
19	P20/L27	Rather than contextualize this as "renewable and nonrenewable" suggest "shifts in energy demand, production, and policy will change land-use needs for low and zero carbon energy infrastructure and development" to improve consistency with other chapters in the report (Chapters 5 [Energy Supply, Delivery, and Demand] and 32 [Mitigation]).
20	P21/L11	Since there is some discussion on mitigation, the section heading should be changed to state that it covers barriers to mitigation and adaptation.
21	P21/L15-16	It is not accurate to say this region discourages a transition and economic diversification. It is accurate to say there is resistance to turning completely away from fossil resources entirely. Suggest citation of Righetti et al. (2021).
22	P21/L18-19	This paper cited does not discuss water regulations and rights and this is not accurate without more clarification. What water regulations and rights are the chapter authors referring to here? Please clarify.
23	P22/L4-11	Integrate with energy discussions in Chapters 5 (Energy Supply, Delivery, and Demand) and 32 (Mitigation). This chapter could be from a different report with only categorization of "renewables" versus "non-renewables" and that categorization oversimplifies the issues. See discussion of other low- and zero-carbon technologies in other chapters: Chapter 32 (Key Message 32.4); labor section on page 29 (Key Message 32.2); Low-carbon fuels needed for some transport and industry applications; and Chapter 5 page 5-17. Nuclear, innovated low-, negative-, and zero-carbon solutions, increased production of low-carbon electricity including nuclear as well as fossil fuel electricity with CCUS.
24	P23/L10	This section omits discussion about the transition period between now and when the nation can be more fully reliant on renewables. The IRA reflects this with funding mechanisms for industry and commercial build out. Suggest more inclusive discussion of this

		transition period and the IRA support for many different types of energy development to better align with other chapters in the report (see comment above).
25	P23/L19-21	Nuclear also requires significant water for cooling; hydrogen does as well for production. Biofuels do use significant water for irrigation and for cooling if burned for electricity. Water use within a state is controlled by state law; water use for water that crosses state lines will be impacted by various federal and state legal mechanisms and can be quite complex.
26	P23/L25-26	Clarify if the planting of low-input tall grasses is already happening or should happen.
27	P23/L34-35	Drawbacks are not considered here. Depending on how used, e.g., if biofuels are burned for electricity production, a significant amount of water is still needed for cooling, just like fossils.
28	P24/L2	Please add the state the prairie pothole region is in.
29	P28/L16-28	Without a definition, the term “prior appropriation” is not likely to be well understood by broad audiences. Prior appropriation affords a right to use (not own) water. Put in simplified terms, the first person to put water to a beneficial use has the right to continue to use that water and if their use does not continue, neither does the water right. Most western states have codified the prior appropriation doctrine into statutes that define beneficial use, prioritize certain uses, and administer water rights through a permitting system that specifies administrative and or court processes necessary to modify water rights. In line 18, it would be more accurate to say the “ability to acquire water rights” rather than the “reallocation” because, legally, the water right would need to be sold or abandoned or enlarged, which all have different impacts on priority. When discussing water rights under the Colorado River Compact (CRC) then allocation is the correct word, but the CRC is not discussed until the next sentence. The phrase “turning water users off” in line 28 is not accurate, though it is “puny.” Suggest removing first half of sentence. Start sentence with “Different approaches....”
30	P28/L32-34	Please provide some examples of drought planning and improving ranch resilience.
31	P29/L8-9	The sentence reads as being policy prescriptive but can be easily revised to be policy informative, for example, “In response to flooding, improved monitoring was instituted….”
32	P30/L33-36	This sentence should mention public lands.
33	P32/L12	With the image above, it is hard to tell what “this work” is referencing—the image in Figure 25.10 or the previous text? Citing to the figure and moving the image to after all of the text in this section might make more sense.

CHAPTER 26: SOUTHERN GREAT PLAINS

#	Page/Line	Comment
1	P6/L11-13	Is this estimate for the whole nation or just for this region? The statement needs clarification.
2	P33/L13-14	The statement about faith-based organizations "praying for those who suffer" is inappropriate for NCA5 and should be removed from this sentence.

CHAPTER 27: NORTHWEST

#	Page/Line	Comment
1	P4/L6-8	Give example of damage in Washington and Oregon (i.e., "…as witnessed by [x] in Washington and Oregon…").
2	P6/L3	Should be "Table 27.1."
3	P7/L1	Suggest key message title be more of a statement: "Frontline Communities Affected Most by Climate Impacts."
4	P7/L19	Remove "are" in "While are many types of…."
5	P9/L8	Suggest "community resilience" instead of "community resiliency."
6	P9/L16	Suggest chapter references include the chapter title, consistent with other chapters.
7	P9/L22	Suggest tribes and Indigenous communities be included in the recommended glossary. Also suggest "both on and off reservations" is not needed and may not be inclusive of all tribal experiences in the way the chapter authors desire.
8	P9/L31	Suggest managed retreat language be as inclusive as possible and consistently used throughout all chapters. Consider any possible linkages to Chapter 9 (Coastal Effects).
9	P11/L11	Consider using "wildfire" instead of "fire."
10	P12/L27	Consider using more accessible language for "extirpations."
11	P13/L9	Seems like there is a missing word after "endangered."
12	P14/L6	Suggest title be a statement, not a label. May want to include salmon.
13	P15/L25	Should be "increased."
14	P16/L7	Suggest key message title be a statement: "Climate Changes Impacts on Economies and Livelihoods."
15	P16/L14	Suggest referencing Chapter 11(Agriculture, Food Systems, and Rural Communities).
16	P16/L16	Add citation.
17	P18/L1	Suggest referencing Chapter 9 (Coastal Effects).
18	P18/L13	Suggest referencing Chapter 7 (Forest).
19	P18/L14	Remove "'s" from "Northwest's."
20	P19/L22	Suggest title be more of a statement.
21	P20/L15	Suggest key message title be a statement. Also, currently this section is focused on water, transportation, and energy only. Suggest "Built Infrastructure" is too broad of a title for the current content. Authors

		should limit title to "Climate Impacts on Infrastructure Systems," or expand the content that follows.
22	P20/L17	Key Message 27.1 includes housing; however, housing is not referenced below. Suggest including housing below (preferred) or removing housing from the key message.
23	P20/L25	Suggest providing more focus by saying infrastructure systems are threatened.
24	P21/L8	Add citation.
25	P24/L8	Suggest Box 27.4 be assessed to determine if this is necessary or if there is a way to better integrate or connect with a number of other boxes and the Focus On…Feature on wildfire.
26	P24/L28	If kept, include chapter title in reference.
27	P24/L34	If kept, include chapter title in reference.
28	P25/L6	If kept, include chapter title in reference.
29	P25/L9	Suggest key message title be more of a statement.
30	P25/L16	"Climate resilience" instead of "Climate resiliency."
31	P26/L3	Spell out "BIPOC" since first time using this acronym or replace with "people of color" to be more consistent with language used throughout the chapter.
32	P26/L4	Should be "additional."
33	P26/L14-16	Suggest mentioning PM standard to help reader gauge significance of 95 micrograms.
34	P28/L1	Remove "and" in "preparedness for and disasters…."
35	P28/L20	Suggest "Address Inequities" instead of "Bridge Inequities."
36	P29/L20	Spell out "BLM" acronym to avoid ambiguity.
37	P30/L15	Suggest more accessible language here (e.g., "Northwest Environmental Sense of Place").
38	P32/L6	Should be "medicinal plants."
39	P34/L5-6	Add citation.
40	P38/L11	Should be "adaptation."
41	P39/L6	Add space between "Government" and "2021."
42	P40/L36	Convention is to say, "Indigenous knowledges."
43	P41/L16	Statement "…that the region" seems incomplete.
44	P42/L12	Should be "impacts on [not of] tribal…."
45	P42/L26	Replace "is" with "are."

CHAPTER 28: SOUTHWEST

#	Page/Line	Comment
1	P3/L11	Should sea-level rise be included in this list of impacts? It has been going on for many decades.
2	P4/L12	The population of the Southwest is strongly urbanized, but the region/landscape is notable for its vast rural and wild areas, sparsely populated overall.

3	P6/L1	Walton et al. (2017) is worth including here.
4	P6/Figure 28.2a	Any notions why soil moisture is shown increasing across interior California and Nevada here, despite other expectations projected in Chapter 3 (Earth System Processes)?
5	P7/L11	This projection of decreasing rainfall is only supported by a couple of studies and is likely to be very geographically variable (e.g., see Figure 6 in Niraulta et al. (2017)—the source for this statement in Chapter 4 [Water]—which shows a lot of place-to -place, model-to-model, differences in recharge outcomes).
6	P7/L16	Pumping "can cause" land subsidence but does not always and does not everywhere even in the Central Valley. There are drawdown thresholds that have to be crossed before subsidence begins.
7	P7/L31	No nature-based options listed?
8	P10/L1	Marine species compositions and geographic distributions. The arrival of new species far from their historical ranges is generally the most public-obvious change in this regard.
9	P10/L16	No citation. Is this from Chapter 10 (Oceans and Marine Resources) of the draft NCA5 report or someplace else?
10	P11/L10	Is "fishers" the correct word here?
11	P11/L15-16 and 30-31	Notably more reference to nature-based/nature-informed solutions here than in Key Message 28.1.
12	P12/L6	Saltwater intrusion changing groundwater quality (especially) and tables.
13	P13/L3	The Delta is not shown in these maps. The easternmost water body shown in upper panels is Suisun Bay, just below the mouth of the Delta.
14	P14/L8-9	In contradiction to the assertion here, Chapter 3 (Earth System Processes) (Key Message 3.12) notes and cites literature that frost hazards from "false springs" increase in current projections. Please revise to acknowledge, correct, or coordinate the assumption here with that finding.
15	P15/L16	Consider adding "forestry" to this list of vulnerable producers. Forestry is not generally considered agricultural, but it fits in among these dryland working lands in a way that is not discussed anywhere else in this chapter (notably not under Key Message 28.5).
16	P16/L14	This discussion focuses strictly on managing farmed fields but neglects the problems that will have to be managed on the increasing fallowed fields—distinct but of equal regional importance.[7]
17	P17/L7	These programs require a lot of foreknowledge of what outcomes are desired. Is this a place to mention potential for maladaptations sticking to current insurance goals and programs past their useful era?

[7] See https://calmatters.org/commentary/2022/08/drought-requires-new-strategies-for-managing-cropland and https://www.ppic.org/publication/land-transitions-and-dust-in-the-san-joaquin-valley.

18	P17/L37-38	The economic and livelihood impacts of the 2012-2016 California drought have proved more complex than might be expected at first glance (e.g., far less agricultural-economic impact overall); please consider incorporating perspectives from recent studies, like Medellín-Azuara et al. (2016).
19	P18/L23	Is California intentionally left off this list? Is this just a study-design aspect of the cited article or is California simply not like these others?
20	P19/L30	Is there any other epoch that provides numbers of hospitalizations to compare this 2018-2020 number to?
21	P19/L33	Consider adding pre-natal, natal, and neo-natal outcomes to this list (e.g., Amjad et al., 2021).
22	P19/L38	The term "cocci" should be used instead of Valley Fever because the World Health Organization and CDC are increasingly moving away from geographic stigmatizing names (e.g., COVID-19). It is an illness that often goes unrecognized until someone is ill, which can mask the geography of the disease. The 100-year projections are for cocci to become far more widespread at the end of the century,[8] so that the name Valley Fever will be even less appropriate; this projection would also be good to mention here.
23	P20/L9	The sudden appearance of SSP5-8.5 here is out of place compared to the more frequent use of "extreme emissions" and other scenario descriptors elsewhere in the report and chapter.
24	P22/L4	There is notably little white in the interior Southwest of these maps; but also, notably little land in many of those interior areas (much of Nevada, New Mexico, Utah, and Colorado) that already has few if any intensively harvested agricultural lands.
25	P23/L14	Is "immigrants apprehended" an accepted sampling/metric of the origins of migrants into the Southwest in general?
26	P23/L18	Should "loss of financial resources/livelihoods" be included in this list of drivers?
27	P24/L2	Financial and political constraints?
28	P24/L8	Where is the private sector in all of this?
29	P24/L29	Some long-term context on the role of wildfires in Southwest landscapes and livelihoods would be useful to set the stage for the list of recent events here.
30	P25/L13	Change "is" to "has also been."
31	P25/L13	Mudslides "and debris flows."
32	P25/L15	It would be worthwhile noting that climate change is projected to make these "heavy rains" heavier (cite Chapters 2 [Climate Trends] and/or 3 [Earth System Processes]). Although Murray et al. (2021) presumably focuses on coastal communities, this risk is in no way limited to coastal settings. See also Cordeira et al. (2019).
33	P25/L26	Houses "and infrastructure."

[8] See https://insideclimatenews.org/news/22042022/valley-fever-climate-change.

34	P25/L15-16	Here and elsewhere, acknowledge that heavy rains are projected to become even more heavy under climate change.
35	P25/L24	If possible, provide a number that this fraction amounts to, or at least a number for the total impact, so that the reader knows whether the small fraction is a large or small amount in absolute terms.
36	P26/L14	Does the forestry industry belong in this list of vulnerable industries?
37	P26/L14	It would be worth including the forestry industry itself in this list.
38	P27/L5	Bark beetles should be mentioned.
39	P27/L15	California-important work is worth citing here (e.g., Westerling, 2018).
40	P27/L27	This is as close as this chapter comes to acknowledging the climate-driven issue of bark beetles and the disturbances and wildfire risks they cause.
41	P28/L10	See Xu et al. (2022), which demonstrates 20 percent reductions of surface-air warming trends on and around managed forecasts and lands.
42	P28/L26	First mention of fire weather. This is a key instigator of wildfire in the Southwest. The question of whether instances of dire fire weather will increase with climate change is as important as the long-term secular changes in general dryness, etc.
43	P28/L30	The introduction of Indigenous ways of managing fire is a major topic around the Southwest. This late introduction of the topic is unfortunate. It should be discussed earlier and more.
44	P28/L30	In context of Key Message 28.4, at least, the lack of any mention of wildfire impacts on infirm and limited mobility persons, and remote underserved, under connected, and easily isolated communities is a problem (see, e.g., Blunt et al., 2022, California Burning; or Gee and Anguiano, 2021, Fire in Paradise, for examples).
45	P29/L27	For a study that documents this for the entire Southwest, and indeed the continental United States, see Albano et al. (2022).
46	P30/L6	The temporal variability of recharge rates and locations is even less well understood. It is also more directly tied to understanding and quantifying the likely impacts of climate change on recharge.
47	P30/L11	Add atmospheric rivers to this list of precipitation mechanisms/modes that need more climate-change research.
48	P30/L19	This reliance on intuition is problematic here. At the very least, history tells us that Indigenous and rural people and communities are often better "equipped" with traditional ecological knowledge to not locate themselves where risks are high.
49	P31/L2-3	Provide a citation for this statement. There are dozens of studies that have shown that snow-fed streamflow (runoff) amounts have not been declining, in contrast to snowmelt timing, among others. If this statement is intended to mean that the part of runoff that comes from the declining snowpacks is declining, this may be true; but runoff in (historically) snow-fed streams of the Southwest has not been shown

		to be declining (e.g., Barnett et al., 2008). If the former is what this is intended to say, please reword to be clearer.
50	P35/L34	West Nile virus is not discussed in the body of this chapter and does not belong in this traceable account.
51	P37/L7	It is odd that, after not referencing Westerling's seminal work at all in the body of this chapter, his work appears front and center in this traceable account. The traceable account should not introduce new citations.

CHAPTER 29: ALASKA

#	Page/Line	Comment
1	P3/L4-6	Suggest adding references for, "glaciers are shrinking, permafrost is thawing, and sea ice is diminishing. The growing season is longer, and fish, birds, wildlife, and insects have increased in numbers in some areas and dropped sharply in others."
2	P3/Figure 29.1	Title in text does not match title embedded in figure. Add scale and legend. Great caption. This could be an example for other figures that synthesize a large amount of information.
3	P4/L11	"…a wide variety of more recent arrivals" is unclear. Does this mean that recently non–Alaska Native Indigenous peoples have migrated to Alaska? If so, is that number represented in the one fifth population reference?
4	P4/L11	Suggest using more precise language than "recent arrivals." For example, briefly discuss the periods of settlers arriving to the state.
5	P4/L14-16	Suggest adding references.
6	P4/L25-27	Suggest adding references.
7	P5/L4-9	What are the projections under other scenarios? Or justify why only RCP8.5 was used.
8	P5/L10	Suggest revising "Many of the most evident" to "More obvious impacts."
9	P5/L10-14	Suggest adding references for each of these claims. The Committee notices that the ocean and climate related statements are much better referenced overall as compared to the cryosphere related references.
10	P5/L20-27	Projections of a wetter Alaska are treated as almost beneath notice, but it is likely that in a warmer Alaska, more precipitation is likely to cause even more transportation and ecosystem issues and accelerate the thawing of permafrost. Alaska is already seeing more intense and prolonged storms due to poleward migration of Pacific storm tracks and possibly increased meridional loops and flows associated with thawing of the Arctic Ocean.
11	P5/L28	Change "affect" to "will affect." This paragraph is not strictly or even mostly about the climate changes thus far, and instead is mostly about projections.

12	P5/L31	Suggest changing "limit" to "constrain."
13	P5/L33-34	Suggest adding references.
14	P6/Figure 29.2	The park road illustration doesn't accurately capture the nature of the problem. Briefly describe why these two case studies were chosen for the figure. Page 29-6, line 4: Change tourist economy to tourism economy. The Ocean Conservancy is cited, but it would be better to cite the sources of data presented in the figure.
15	P7/L3-11	This discussion could be strengthened if it were expanded on some. Why is responding to climate change uniquely complicated in Alaska?
16	P7/L7-8	This is not the most illustrative example. An earthquake is a very different kind of event as compared to climate change. For example, there are good warning and coordination systems in place, and so "Alaskans working together" is true, but they are supported by extensive, established systems of response.
17	P8/Table 29.1	Suggest adding or editing to "nature-based solutions."
18	P8/Table 29.1	This is a really nice table. The table could be improved by removing some jargon (i.e., ecosystem based) and also adding key message numbers.
19	P8/L6	Key Message 29.1. Our Health: Suggest adding likelihood evaluations. Consider an alternate word to resilience or expand on this—resilience to what?
20	P9/L1-3	Suggest adding references to support this statement and use more precise language than "many Alaskans".
21	P9/L14-16	This could be strengthened with more references.
22	P10/L10-11	This statement: "adaptations have the potential to exacerbate these inequalities" could use some additional context. It reads somewhat abstract; perhaps offer an example?
23	P10/L23-24	Could chapter authors say something more specific about how rabies and climate are connected? For example, "…with potential connections to changing climate conditions, because of the shifting range of species [citation]."
24	P10/L32-39	Suggest chapter authors more explicitly connect the dots between harmful algal blooms (HABs) and food sources, to further discuss why HABs matter for human health. It is not explicit in this paragraph.
25	P11/L3-6	Was this because of indoor plumbing? How do other factors like co-habitation affect this relationship? If more than one factor is described in the study, it might be better to frame this as a contributing factor versus a causal relationship.
26	P11/L12	A figure allowing the reader to envision how the pass is structured and works here would be very effective.
27	P11/L19-20	"As an example illustrates" is odd wording. Is there supposed to be an example here that is missing?
28	P11/L21-22	Suggest adding a reference for the link between mold and pregnancy.

29	P11/L28-36	The Committee agrees with the points raised on mental health impacts due to climate change. However, the citations are on First Peoples located in Canada. We suggest referencing research conducted with Alaska Natives or generalize the statements. If citations are not available, then suggest changing "Alaska Native populations whose ... are particularly vulnerable" (line 33) to "are potentially vulnerable."
30	P12/L1-11	This paragraph addresses COVID-19 essentially from the perspective of "is the health care system up to 'it' for COVID and other disasters." But in Alaska, the problem of getting people to the health care system is often the real crux. Some discussion of how transportation improvements play into the effectiveness of the health care system would be very helpful here.
31	P15/Figure 29.5	Very nice figure. The Committee suggests adding a summary in the caption as to why the proportion of race by region matters.
32	P16/L16	Whose data are these from fall 2018?
33	P18/L3-4	Consider adding to each of these claims (climate change contributing to collapse and collapse undermining jobs/ways of life).
34	P19/Figure 29.7	Significant parts of Alaska's "modern" economics and services base have been built upon, and rely upon, the fossil fuel industry. As much as any place in the country, when mitigation requires major changes and cutbacks of that industry, what will be the impacts on Alaska's communities?
35	P20/L5	How many fishery disasters has Alaska had? Since 14 are listed perhaps add total number of disasters (e.g., 14 of X) or omit the number entirely.
36	P20/L11-12	Consider adding references here for how climate change is impacting each species listed.
37	P21/L5-10	Suggest adding references.
38	P22/Figure 29.8	Perhaps the authors can find another image to better convey their point of importing fish into a fishing community.
39	P22/L5	Key Message 29.4. Our Built Environment: Suggest rephrasing part of the key message to consistently format the likelihood statements (i.e., "Further warming will to lead to greater needs and costs for maintenance or replacement of buildings, roads, airports, and other facilities (*high confidence*, *very likely*)).
40	P23/L22-23	Might consider adding something about how there have been efforts to broadly model permafrost, but localized assessments are not available, and cite associated modeling efforts.
41	P24/L5	Consider using a different term than managed retreat because of its problematic connotations.
42	P24/L10-18	Authors might consider briefly mentioning the legal challenge related to relocation, in that no one entity seems to be legally responsible to pay for these moves.

43	P24/L27	This paragraph discusses climate impacts on the fossil fuel industry but should discuss the impact of (likely) major changes in that industry, in reaction to climate change, on Alaska.
44	P25/L14-18	This could be strengthened by adding references to support the discussion about conflicts over fish and wildlife resources.
45	P29/L11-14	This section could be strengthened with a good definition of security. The differing kinds of security explained feel like they were forced together, but a good definition could help make this section more coherent.
46	P30/Figure 29.13	Suggest splitting this figure into two because the text and information is nearly too small to read.
47	P30/L16-21	This section could be strengthened with more references.
48	P30/L22	The Committee is unclear as to whether this paragraph is mostly talking about opening of the Bering Sea, versus more about opening of the Arctic Ocean traffic.
49	P31/L25	This word likely should not be italicized, because it is not within a key message.
50	P32/Box 29.7	Nice balance of local perspective and the broader context needed to understand the comment. This could be a reference for the other boxes.
51	P32/L12	Change "would" to "will."
52	P39/L29	Consider adding climate impacts on other racial/ethnic groups in Alaska to the research gaps section.

CHAPTER 30: HAWAI'I AND US-AFFILIATED PACIFIC ISLANDS

#	Page/Line	Comment
1	P10/L14	How does rising temperature affect freshwater resources? Is there a reference that directly relates temperature to freshwater resources? The other factors listed are clearly relevant, but temperature should be removed from the list if no reference exists to provide a verifiable physical link.
2	P10/L24	Most traditional fishponds (at least in Hawai'i) are saltwater or brackish. This section is about freshwater resources, so please clarify that this refers to traditional freshwater fishponds or remove if not.
3	P10/L25	Same as above for energy and microgrids. Are these related to freshwater resources?
4	P11/L14-15	This should be added to research gaps on page 30-36.
5	P12/L4-5	Is there information about such declines for the Pacific Islands in particular?
6	P12/L16	Is the semicolon supposed to be after the Galappaththi reference?
7	P12/L17	Should this be "and *decrease* local access?"
8	P13/L16-19	This sentence was challenging to digest quickly. Suggest replacing "flooding depressing" with "increased flood frequency depressing."

		Also suggest replacing the semicolon with a period. The sentence about Hawai‘i is a separate statement.
9	P14/L20	Suggest replacing “length, this increases” with “length, the project increased.”
10	P16/L9-13	The citations provided here pertain to the increases in the physical climate events, but the way this sentence is phrased, it could be read as if these references connect the physical events to health (which they do not). To avoid confusion and misattribution, it would be best to restructure this sentence to lead with stating the that the physical events will increase with the stated references, and then follow with the statement that the events will be connected to increasing health impacts and add references (perhaps referring to those in the following paragraph).
11	P18/L17-26	This paragraph only mentions climate in passing. Suggest reworking to provide more concrete connections to climate (rather than general epidemiological trends), perhaps via the references on line 20?
12	P21/L11	Period missing at the end of the paragraph.
13	P32/L33-34	A word is missing in this sentence between “protecting” and “from.”
14	P40/L11-14	This is pertinent information that should be repeated for any key messages that use these models (or similar) as a basis.

CHAPTER 31: ADAPTATION

#	Page/Line	Comment
1	P3/L5-7	Refer to Chapters 2 (Climate Trends) and 3 (Earth System Processes) rather than literature.
2	P3/L9-14	It seems this point on whether incremental adaptation is sufficient, which is critical to the chapter, should not be in the introduction, but addressed in more depth in the key messages. The first sentence is quite vague. Hard for the reader to know where the statement applies.
3	P3/L13	Suggest including “regions” with levels and sectors.
4	P3/L28-30	This is policy prescriptive. Could say “Shi and Moser find….”
5	P7/L9-11	This sentence is unclear as written. Fossil fuel reliant communities cannot adapt?
6	P7/L32-34	This is a very important sentence given the emphasis of the chapter on the need for transformative adaptation. Is the failure of incremental adaptation expected under all climate change scenarios, for example, even those limiting warming to 2 or 1.5°C?
7	P8/L5-7	Does the statement about insufficiency of funding for adaptation consider the funding for adaptation in the Bipartisan Infrastructure Bill and the Inflation Reduction Act, both enacted in 2022?
8	P9/L5	Suggest key message title be more of a statement and less of a label.
9	P13/L1	Suggest key message title be more of a statement and less of a label.
10	P13/L24	Suggest adding wildfire to this list.

11	P14/L15	Suggest changing out "amenities" for something more detailed like "economic development" or "workforce."
12	P14/L15	Are matching funds also a barrier?
13	P14/L32	Does this fire reference refer to urban fires of wildfires?
14	P16/L5	Suggest either including communities after "wealthy" or rewording the sentence to be clearer. Adaptation for well-resourced communities may lead to negative outcomes for already overburdened communities.
15	P16/L26	Suggest key message title be more of a statement and less of a label.
16	P18/L3	Please add states to "some cities and utilities," as some states also have centralized offices focused on resilience and/or sustainability.
17	P18/L14	Suggest adding the chapter title with the reference.
18	P18/L18-25	The paragraph is policy prescriptive but can be rewritten.
19	P19/L23	The paragraph is policy prescriptive.
20	P20/L21	Suggest key message title be more of a statement and less of a label.
21	P24/L9	Suggest key message title be more of a statement and less of a label. Suggest more approachable language like "Paying for Adaptation."
22	P24/L11	Recommend ordering the key message statements with medium confidence statements last, not first.
23	P25/L30	Remove "but."
24	P26/L1	Figure 31.6 may not communicate what the authors are trying to communicate. Rethink if this should be showing that there is no financial incentive to proactively adapting coastal properties and if proactive adaption costs are missing from rail or so faint they cannot be seen. It also appears that no additional costs are similar to reactive adaptation costs.
25	P27/L22	Suggest adding titles to the key messages being referenced here and throughout.
26	P27/L23	Suggest adding titles to the key messages being referenced here and throughout.
27	P28/L34	Suggest adding titles to the key messages being referenced here and throughout.

CHAPTER 32: MITIGATION

#	Page/Line	Comment
1	P3/L2-4	This sentence is a confusing sentence to start out the chapter with. Also, the introduction is short. Suggest starting with a summary or definition statement about mitigation (like the second sentence, line 5) and then providing an overview of the chapter before delving into key messages.
2	P3/L19	Suggest in-line definition of the Paris Agreement and description of nationally determined contributions (line 25) for general audiences.

3	P3/L22-24	Please add to the sentence that net-zero can be reached earlier than mid-century depending on considerations of international equity and burden-sharing (van Soest et al., 2021). Reaching net zero before mid-century would also likely be a lower cost scenario (Schaeffer et al., 2020).
4	P3/L28	If the number is negative 6 percent or a decline, suggest spelling out negative or stating that this is a decline.
5	P4/L1	In the figure, the net-zero label on the graph is a bit confusing because the graph shows just emissions, not emissions and sinks. Suggest relabeling the graph to highlight the years when emissions reductions goals will occur rather than the "net zero emissions benchmarks."
6	P4/L15-16	Suggest defining key GHG "sources" and "sinks" in this section, and then describing major trends among those. Suggest adding projections 50 and 100 years into the future to meet statutory charge. In this first section, suggest including citations for where all the data are from.
7	P4/L18	Is there a reason the net emissions are depicted with the end year of 2019 rather than 2020 or 2021? Perhaps pandemic-related anomalies? Suggest explaining this in the traceable accounts section.
8	P5/L5-6	Suggest a citation after this sentence.
9	P5/L9-11	This sentence is not clearly written. Suggest more clearly specifying what is offsetting what and suggest defining emissions intensity and energy intensity in-line, for audiences: "changes in US energy-related emissions were primarily driven by increases in population and GDP per capita. However, these increases were offset by decreases in energy related GHG emissions, emissions intensity, and energy intensity. Energy intensity refers to ___, while emissions intensity refers to ____." Does "Decreases in energy emissions" refer to energy intensity? If yes, then please use "energy intensity" so the supporting text aligns with the labels in the figure.
10	P6/L1-6	Suggest describing the relationship between the energy sector and the electricity sector (e.g., electricity sector emissions comprise what portion of energy sector emissions).
11	P6/L1-6	Suggest explaining why coal use declined and renewables increased (e.g., tax credits, gas prices).
12	P6/L7-12	Spell out "MWh" and ensure broad audiences can understand the figure.
13	P6/L14-20	Suggest noting what forms of transportation use the fuels listed and are the highest emitters (e.g., cars, trains, planes). Be specific so audiences can understand linkages to their lives.
14	P6/L19-20	Suggest defining what "vehicle-km" is for the audiences. Suggest clarifying text: "improvements in energy per vehicle-km were more modest" (and suggest what a negative 8.6% means). Also, consider including a time range for when the change the sentence discusses occurred.

15	P11/L4	This is a great example of an in-line definition and provides a great reference for how to do this where the Committee has suggested adding in-line definitions in other places.
16	P11/L17-27	May want to consider defining "dispatchable or firm" for audiences.
17	P11/L29-31	Great job including recent developments (i.e., IRA), though the IRA is likely to help all electricity sources not just solar and wind.
18	P11/L35-36	The phrase "assuming appropriate market structures and incentives" is unclear. Please add more language to clarify what this clause actually means.
19	P12/L10-13	Consider adding a sentence discussing the ability to expand transmission and interregional infrastructure.
20	P13/L1-2	Figure 32.9(b) is not clear in what it is depicting, and the caption is not helpful to describe it. Suggest adding labels to the figure on the y-axis and indicating the timescale on the graph.
21	P14/L3	List examples of alternative fuels (i.e., "such as …").
22	P15/L7-13	This sentence is hard to follow, particularly the last two clauses: "fundamental changes in processes as well as carbon capture and storage." What are the fundamental changes in processes referred to? What are the challenges expected with CCUS? Suggest: "Similarly most industrial energy demand could be electrified using existing technologies. Achieving net-zero emissions in some industries may present special challenges—particularly related to the costs of supplying high-temperature heat with electricity, adapting to changes in processes, and developing regulatory frameworks to support carbon capture and storage projects."
23	P16/L4	Offset "thus" with commas.
24	P16/L9	How is this food wasted? Individuals, in production, by commercial industry? Give examples if possible.
25	P16/L31-34	Not sure "tasty" fits well in this sentence.
26	P24/L9-15	This discussion is very similar to the discussion under Key Message 32.2 that discusses shifting diets. It could be mentioned there and removed from here to save space.
27	P28/L1-6	Figure 32.16 is not cited to in any of the supporting text.
28	P31/L28-33	This discussion might warrant mention of recent legislative actions attempting to address these disparities (e.g., IRA tax credits for electric vehicles, two-tier tax credit system now encouraging consideration of apprenticeships and community where sited).
29	P32/L1-5	This caption needs much more description.
30	P34/L1-4	Suggest caption include description of what classifies a "mitigation" activity. Many cities, universities, and local groups have acted in the absence of state leadership. Some states have governor leadership (i.e., executive orders) without legislative action, vice versa, or both.
31	P38/L1-6	Figure 32.22: The Committee recognizes that this figure is under development, but as presently depicted, it is unclear based on the multiple titles and labels on the figure whether the figure is depicting emissions reduction potential by abatement measure, savings per

		abatement measure, cost per MMT of CO2e offset by each abatement measure, incremental cost per MMT of CO2e offset by each abatement measure, or some combination because the language and labels indicate all of the above. The Committee suggests adding much clearer labels, titles, and very clear caption text to explain this figure in both this chapter and Chapter 1 (Overview) (Figure 1.18). The x-axis should be labeled in the correct units and the box should be labeled in the correct units with the color gradients much more distinct (blues and yellows are not distinguishable from each other). In the caption, the term "marginal costs" should be explained as well as the key takeaways from the figure. Please give an example for the audiences from/using the figure.

FOCUS FEATURE ON COVID-19 AND CLIMATE CHANGE

#	Page/Line	Comment
1	P F3-2/L8	Please add Mora et al. (2022) to the references.

APPENDIX 3

#	Page/Line	Comment
1	P A3-3/L1-7	Figure should be self-standing so more information about each panel needs to be presented.

APPENDIX 4

#	Page/Line	Comment
1	P A4-8/L3-22	The discussion on billion-dollar disasters needs to note the complexity of this indicator and how it is not just influenced by change in frequency and intensity of extreme events but also by exposure to such events. The Committee's comments on the billion-dollar damages figures in Chapter 1 (Overview) and in Chapter 2 (Climate Trends) point out that the increase in the number of billion-dollar disasters may also be the result of increased population, particularly in hazardous areas, and in property values rising faster than the Consumer Price Index. Indeed, this indicator provides an excellent opportunity to discuss the complexity of some indicators, particularly those that measure societal impacts. The discussion should point out that such impacts can be affected by many factors.

Appendix B
Committee Member Biographical Sketches

Joel B. Smith (*Chair*) is an independent researcher and member of the National Academies' Advisory Committee to the US Global Change Research Program (USGCRP). Mr. Smith has provided technical advice, guidance, and training on assessing climate change impacts and adaptation to international organizations, the US government, states, municipalities, and the nonprofit and private sectors. He was a member of the National Academy of Sciences' Panel on Adapting to the Impacts of Climate Change. He was a coordinating lead author or lead author on the Third, Fourth, and Fifth Assessment Reports of the Intergovernmental Panel on Climate Change. Mr. Smith was also an author of three US National Climate Assessments (NCAs), including Chapter Lead on the International Chapter for the fourth NCA. He has been a consultant since 1992, having worked for Hagler Bailly, Stratus Consulting, and Abt Associates. He worked for the US Environmental Protection Agency (EPA) from 1984 to 1992, where he was the deputy director of the Climate Change Division. Mr. Smith received a BA from Williams College in 1979 (graduating magna cum laude), and an MPP from the University of Michigan in 1982. Mr. Smith served as a Special Government Employee with EPA from May 2021 through February 2022; he did not work on matters directly relevant to USGCRP. Over the past 5 years, Mr. Smith co-authored a peer-reviewed paper with Marcus Sarofim (co-author on NCA5 Chapter 19 [Economics]), who at the time was a client at EPA while Mr. Smith worked at Abt Associates, and he serves as a member of the Advisory Committee to the USGCRP with Kris Ebi (co-author on NCA5 Chapter 15 [Human Health]).

Marissa Aho, AICP, has served as the Policy Director/Chief Resilience Officer for the Washington State Department of Natural Resources since July 2021. She previously served as the first Chief Resilience Officer for the cities of Los Angeles and Houston. She led the development and implementation of the cities' resilience strategies (Resilient Los Angeles and Resilient Houston) that are focused on preparing for catastrophic events and addressing chronic stressors. She is a member of the American Institute of Certified Planners. She has a BA in political science and communications, legal institutions, economics, and government from American University and a Master of Planning from the University of Southern California. Ms. Aho has worked with multiple NCA5 contributors in different capacities over the past 5 years: she served on the Resilient Los Angeles working group with Juliette Finzi Hart (co-author of NCA5 Chapter 9 [Coastal Effects]) and Emmanuel Crisanto Liban (lead author on NCA5 Chapter 13 [Transportation]), she was the project lead on a Climate Assessment for Houston that Katharine Hayhoe (co-author of NCA5 Chapter 2 [Climate Trends]) was hired to conduct, she worked with Laura Patino (contributor of NCA5 Chapter 26 [Southern Great Plains]) on Resilient Houston, she also worked with Earthea Nance (co-author for NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]) on multiple projects in Houston, and she served as a Chief Resilience Officer with Daniel Zarrilli (co-author of NCA5 Chapter 21[Northeast]) and both contributed to 100 Resilient Cities work.

Shanondora Billiot (United Houma Nation) is an assistant professor at Arizona State University. Her research uses mixed methods to understand Indigenous-specific risk and

protective factors to global environmental change exposure and pathways to health outcomes within Indigenous populations with the goal to co-develop adaptation activities. Dr. Billiot is currently a co-principal investigator on an interdisciplinary team exploring resilience, culture, climate, and movement among an Indigenous community on the Gulf Coast funded by a Gulf Research Program Thriving Communities Grant. She serves as a Technical Advisory Member of the Climate Change Taskforce for the National Congress of American Indians and is a member of the Community Board for Engagement and Evaluation of the Gulf Research Program within the National Academies of Sciences, Medicine, and Engineering. She earned a PhD in social work from Washington University in St. Louis as a Henry Roe Cloud visiting doctoral fellow at Yale University.

Michael Dettinger (NAE) is a visiting researcher at the Center for Western Weather and Water Extremes at the Scripps Institution of Oceanography and a part-time researcher at the Desert Research Institute. He retired from the US Geological Survey (USGS) as a senior research hydrologist in 2019 after 38 years studying climate and water resources in the western United States. Dr. Dettinger continues his research on hydroclimatic variability, extremes (including atmospheric rivers and droughts), and climate change impacts and adaptations. He is a fellow of the American Geophysical Union (AGU) and the American Association for the Advancement of Science, a member of the National Academy of Engineering, and is a recipient of two California Climate Science Service Awards. He has authored more than 150 scientific articles in scholarly journals and books, more than 30 government reports, and 100 articles and reports in other outlets. These publications have been cited more than 32,000 times in the scientific literature, with more than 70 cited 100 or more times each. He was a lead author of the 2013 Third National Climate Assessment Water Resources chapter, co-edited State of Bay-Delta Science Reports in 2008 and 2016, led the California Fourth Climate-Change Assessment Sierra Nevada Region Report in 2018, and was the AGU Tyndall Lecturer on History of Global Environmental Change in 2021. He earned his MS in civil engineering at the Massachusetts Institute of Technology and his PhD in atmospheric sciences at the University of California, Los Angeles, in 1997. In the past 5 years, Dr. Dettinger has published on California's Fourth Climate Change Assessment report, California drought, climate change scenarios, and extreme precipitation. He has also given technical and public talks in recent years on local-to-regional climate change science. Dr. Dettinger has collaborated with three NCA5 contributors over the past 5 years: he has co-authored a publication and collaborated on a workshop panel with Paul Ullrich (co-author on NCA5 Chapter 3 [Earth System Processes]), collaborated on a Nevada State Climate-Change Vulnerability Assessment with Stephanie McAfee (co-authored NCA5 Chapter 4 [Water]), and he served as a principal investigator on a USGS-funded Southwest Climate Adaptation Science Center with Erica Fleischman (co-author on NCA5 Chapter 27 [Northwest]).

Janet Franklin (NAS) is the Endowed Campanile Foundation Department of Geography at San Diego State University. She is a Distinguished Professor of Biogeography Emerita, retired from the University of California, Riverside. Her work addresses the impacts of human-caused landscape change on the environment. Her research has garnered new insights into the impact of fire regimes on ecosystems and the role of early humans in shaping ecological communities. In 2014, Dr. Franklin was elected to the National Academy of Sciences (NAS) for her significant advancement of the understanding of human impacts on ecosystems by developing novel species distribution models, combined with innovative geospatial analysis and extensive fieldwork. She

is currently a member of the NAS Geographical and Geospatial Sciences Committee and served as the co-chair of the joint NAS-Royal Society Forum on Climate Change & Ecosystems (2018). She received her PhD and MA in geography and a BA in environmental biology from the University of California, Santa Barbara. Dr. Franklin co-published an editorial introduction to "Climate Change and Ecosystems—Threats, Opportunities, and Solutions" in the *Philosophical Transactions of the Royal Society B*. Dr. Franklin has co-authored publications over the past 5 years with Forrest M. Hoffman (co-author on NCA5 Chapter 3 [Earth System Processes]) and David Hondula (co-author on NCA5 Chapter 12 [Built Environment, Urban Systems, and Cities]).

Jada Garofalo is an associate in the Domestic Environment and Natural Resources Division at Abt Associates. Her expertise intersects multiple topic areas, including climate impacts, adaptation, and mitigation; environmental regulations; water law, regulation, and policy; energy and energy-transition regulation and policy; health, including nutrition, and infectious and vector-borne diseases; and social and environmental justice issues. Ms. Garofalo blends her science and legal skills to develop purposeful research and policy in the climate arena. Currently, she is engaged in interdisciplinary project leadership, management, and development on issues related to climate impacts and adaptation to the energy, environment, health, and water sectors, and climate mitigation. Ms. Garofalo earned her BS in food science and human nutrition in 2010, followed by her MS in climate science and policy in 2014, and her JD in environmental law in 2019. As an attorney, Ms. Garofalo has represented clients on siting of wind development projects and has served as a panelist for webinars on legal considerations for advanced and renewable energy and clean energy standards. Ms. Garofalo has recent publications on rare earth elements, carbon capture, and CO_2 pipelines. Ms. Garofalo conducts work under a contract for the US Army Corps of Engineers with Ariane Pinson (federal coordinating lead author on NCA5 Chapter 4 [Water]).

Shineng Hu is an assistant professor in the Division of Earth and Climate Sciences, Nicholas School of the Environment, Duke University. Dr. Hu specializes in climate dynamics and air–sea interactions. The main goal of his research is to understand the ocean's role in global climate variability and change through the interaction with the atmosphere. Dr. Hu received the National Aeronautics and Space Administration's Earth and Space Sciences Fellowship in 2014-2017, the Scripps Institutional Postdoctoral Fellowship and the Lamont-Doherty Postdoctoral Fellowship in 2018. Dr. Hu obtained his BS in atmospheric science from Peking University in 2012, and his PhD in climate dynamics from Yale University in 2018.

Richard Jackson (NAM) is professor emeritus at the University of California, Los Angeles, Fielding School of Public Health, where he was the department chair in environmental health sciences. A pediatrician, he has served in many leadership positions with the California Health Department, including the highest as the State Health Officer. He served as the director of the Centers for Disease Control and Prevention's National Center for Environmental Health for 9 years and received the Presidential Distinguished Service Award. He was elected to the National Academy of Medicine (NAM) in October 2011, where he was the co-leader of its Climate Interest Group and in October 2022, he received NAM's David Rall medal for service. Dr. Jackson was instrumental in establishing the California Birth Defects Monitoring Program and instigating state and national laws to reduce risks from pesticides, especially to farm workers and

to children. He has received the John Heinz Award for national leadership in the Environment; the Sedgwick Memorial Medal, the highest award of the American Public Health Association; and the Henry Hope Reed Award for his contributions to architecture. Dr. Jackson co-authored the books *Urban Sprawl and Public Health*, *Making Healthy Places*, and *Designing Healthy Communities*. Dr. Jackson earned an MPH in epidemiology from the University of California, Berkeley, and an MD from the University of California, San Francisco, School of Medicine.

Rachael Jonassen is the director of Climate Change and Greenhouse Gas Management programs in the Environmental and Energy Management Institute as well as an associate research professor of urban sustainability at The George Washington University. Her primary appointment is in the Department of Engineering Management and Systems Engineering. She served as the senior climate scientist at the Logistics Management Institute advising the Obama administration and New York City on greenhouse gas management and climate impacts after 4 years at the National Science Foundation (NSF), directed carbon cycle science and biogeoscience research and represented NSF at the United States Global Change Research Program, leading on international efforts on carbon cycle research and managing the North American Carbon Program. Prior she was a professor of hydroclimatology where she developed and applied downscaling methods for climate change assessments for hydroelectric systems and biogeographic problems and supported the US Department of Energy on high-level nuclear waste efforts. She was recognized for her service at NSF with the Director's Award and is a fellow of the Geological Society of America. She serves on the National Cooperative Highway Research Program panel 15-61. Dr. Jonassen holds a PhD and an MS from The Pennsylvania State University and a BA from Dickinson College. Dr. Jonassen advises international climate change mitigation and adaptation with the Asian Development Bank, the World Bank, and the United Nations. Through the Center for Climate and Security, she is a signatory of "A Climate Security Plan for America."

Natalie Mahowald is the Irving Porter Church Professor of Engineering at Cornell University in the Department of Earth and Atmospheric Sciences. Before joining Cornell in 2007, she completed her postdoctoral work at Stockholm University, was an assistant professor at the University of California, Santa Barbara (1998-2002); and was a Scientist (I, II, and III) at the National Center for Atmospheric Research (2002-2007). The focus of Dr. Mahowald's work is on natural feedbacks in the climate system, how they responded in the past to natural climate forcings, and how they are likely to respond in the future. This includes building new parameterizations within Earth system models that couple new areas: for example, aerosols and biogeochemistry, or fires within the Earth system, or the impacts of land-use on aerosols and the carbon cycle. Dr. Mahowald has received several awards and recognitions throughout her career, including the American Meteorological Society Henry G. Houghton Award, American Meteorological Society Fellow, American Geophysical Union Fellow, American Association for the Advancement of Science Fellow, and Guggenheim Foundation Fellow. She served as the lead author on two Intergovernmental Panel on Climate Change (IPCC) reports: Assessment Report 5, Working Group I and the Special Report on 1.5°C (SR1.5). She earned her MS in natural resource policy at the University of Michigan and her PhD in meteorology at the Massachusetts Institute of Technology in 1996. Dr. Mahowald has made public statements on SR1.5 of the IPCC and testified on the same topic to the House Committee on Science, Technology, and Space.

Regan F. Patterson is a newly appointed assistant professor of civil and environmental engineering at the University of California, Los Angeles (UCLA). Her research focuses on the intersection of air quality engineering, sustainable transportation, and environmental justice. She was previously the Transportation Equity Research Fellow for the Congressional Black Caucus Foundation (CBCF), where she conducted intersectional transportation policy analysis and research. Prior to joining the CBCF, Dr. Patterson was a postdoctoral research fellow at the University of Michigan Institute for Social Research, where she examined the linkages between air pollution and racial residential segregation. Dr. Patterson was a recipient of the US Environmental Protection Agency's Science to Achieve Results Fellowship, Switzer Environmental Fellowship, and the University of California (UC), Berkeley, Chancellor's Fellowship. Her dissertation research modeled the air quality and environmental justice benefits of state and local transportation policies for mitigating exposure to traffic-related air pollution. She earned her PhD in environmental engineering at UC Berkeley. She holds a BS in chemical engineering from UCLA and an MS in environmental engineering from UC Berkeley.

Yueming (Lucy) Qiu is an associate professor in the School of Public Policy at the University of Maryland, College Park. Her research group focuses on using big data with quasi-experimental and experimental methods to answer empirical questions related to the interactions among consumer behaviors, energy technologies, and incentives. Her research projects have been funded by the National Science Foundation, the Sloan Foundation, the Electric Power Research Institute, the US Department of Defense, and the Water Research Foundation. Dr. Qiu received her PhD from Stanford University and BS from Tsinghua University.

Charles (Chuck) Rice is a University Distinguished Professor and holds the Vanier University Professorship at Kansas State University as a professor of soil microbiology in the Department of Agronomy. He teaches courses and conducts research on soil health and climate change impacts. Dr. Rice received the honorary title of National Associate of the National Academies of Sciences, Engineering, and Medicine. He was named the Hugh Hammond Bennett Awardee by the Soil and Water Conservation Society, which recognizes exceptional service and national and international accomplishments in the conservation of soil, water, and natural resources. Internationally, he served on the United Nations' Intergovernmental Panel on Climate Change to author a report on climate change in 2007 and 2014 and was among scientists recognized when that work won the Nobel Peace Prize in 2007. Dr. Rice is a fellow of the Soil Science Society of America, the American Society of Agronomy, and the American Association for the Advancement of Science. He has also served in numerous capacities with professional societies including the president of the Soil Science Society of America in 2011. Dr. Rice currently chairs the Board on Agriculture and Natural Resources at the National Academies. He earned his degrees from Northern Illinois University and the University of Kentucky.

Anjali Sauthoff is an environmental health scientist who works with the government, nonprofit organizations, academia, and businesses on climate change, public health, equity, data justice, and the use of geospatial technology for scientific communication. She leads the Westchester County Climate Crisis Task Force Health and Community Resilience teams, develops university capstone projects, and works with communities to address equitable climate mitigation and adaptation. Dr. Sauthoff's prior academic research centered on the development of models to estimate exposure to air pollution and on strategies to decrease greenhouse gas emissions from

the transportation sector. She received her master's degree in neurobiology and behavior from SUNY Stony Brook and her PhD in environmental health science from Columbia University. Dr. Sauthoff currently serves on the New York State Climate Impact Assessment Health and Safety technical working group. She recently published a book chapter titled "Social Determinants of Health as a Framework for Addressing Urban Climate Adaptation" (D. Mutnick, C. Griffiths, eds., *The City Is an Ecosystem: Sustainable Education, Policy, and Practice*, London: Routledge), which focused on urban climate adaptation and justice.

David L. Skole is a professor of forestry and the director of the Global Observatory for Ecosystem Services in the Department of Forestry at Michigan State University. Prior to that he was a research professor at the Institute for the Study of Earth Oceans and Space at the University of New Hampshire. Dr. Skole is an advisor to the Forest Investment Program (World Bank Group) and led the development of its monitoring and reporting toolkit. His research focuses on the role of forestry and agriculture in global climate change, the use of geographical information for sustainable development and natural resource management, new methods and applications of Earth observations for global environmental change analytics, and mitigation and adaptation. He is the chair of the United Nations Program on Global Observations of Forest Cover; the National Science Foundation Advisory Committee on Environmental Research and Education; and the International Geosphere Biosphere Programme's Core Project on Land Use and Cover Change. He has been a member of several committees of the National Academies, including the Committee on Earth Science and Applications from Space. Dr. Skole earned a PhD in natural resources from the University of New Hampshire and a BA and an MS from Indiana University. He is now active in the emerging carbon financial markets and applications of his research to carbon sequestration and domestic and international climate change mitigation programs, and in developing methods for carbon offsets under cap-and-trade carbon regulations. This includes work with the California Climate and Forest Fund and the Chicago Climate Exchange, membership on US government advisory groups, and an advisory role for the Michigan Department of Natural Resources.

Philip R. Thompson is an associate professor in the Department of Oceanography at the University of Hawai'i at Manoa and the director of the University of Hawai'i Sea Level Center (UHSLC). As director of the UHSLC, he oversees the operation of an international network of sea-level monitoring stations—many distributed throughout the Pacific Islands—as well as the curation of widely cited sea-level datasets. He also serves as the principal investigator (PI) for research projects funded by the US Geological Survey, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration focused on understanding decadal climate variability, future tidal flooding, and the interaction of sea-level and waves in the nearshore environment. An emerging theme in his work is the co-production of research that facilitates science-based coastal management and tools that support effective science communication. Dr. Thompson earned a PhD in physical oceanography from the University of South Florida in 2012 and a BS in physics from North Carolina State University in 2004. Dr. Thompson has had professional ties with a number of contributors to NCA5 over the past 5 years: he has co-authored two papers with William Sweet (co-author of NCA5 Chapter 9 [Coastal Effects]), he has two current projects that are being funded by PI-CASC who is directed by Mari-Vaughn V. Johnson (federal coordinating lead author on NCA5 Chapter 30 [Hawai'i and US-Affiliated Pacific Islands]), he is a co-principal investigator on a current project with

Curt Storlazzi (co-author of NCA5 Chapter 30 [Hawai'i and US-Affiliated Pacific Islands]), one of his current grants partially funds Christopher Shuler (co-author of NCA5 Chapter 30 [Hawai'i and US-Affiliated Pacific Islands]), he is the direct supervisor of Matthew Widlansky (technical contributor of NCA5 Chapter 30 [Hawai'i and US-Affiliated Pacific Islands]), and he has co-authored many papers with and has a current PI/co-PI relationship on three federally funded projects with Benjamin Hamlington (co-author of NCA5 Chapter 3 [Earth System Processes]).

Kristin Timm is a research associate at the Alaska Climate Adaptation Science Center at the International Arctic Research Center, University of Alaska Fairbanks. She previously worked and studied with the Center for Climate Change Communication at George Mason University and has spent more than a decade working as a science education project manager and professional science communicator. Dr. Timm's expertise is in science and climate change communication, and the people and processes at the interface of science and society. Her dissertation investigated news coverage of the Fourth National Climate Assessment and the factors that influenced it. She has received several awards for her work, including the US Geological Survey Eugene M. Shoemaker Communication Award for effectiveness communicating complex scientific concepts. Dr. Timm has a PhD in communication from George Mason University and an MSc in interdisciplinary studies (science communication) and a BA in rural development: land, resources, and environmental management, both from the University of Alaska Fairbanks. Dr. Timm has collaborated with a number of contributors to NCA5 over the past 5 years: she has co-authored publications with Aparna Bamzai (co-author on NCA5 Chapter 25 [Northern Great Plains]), Shawn Carter (federal coordinating author on NCA5 Chapter 8 [Ecosystems, Ecosystem Services, and Biodiversity]), Jeremy Littell (co-author on NCA5 Chapter 29 [Alaska]), and Katharine Mach (chapter lead on NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]). She co-authored publications and presently is co-chairing a journal special issue with Julian Reyes (co-author on NCA5 Chapter 27 [Northwest]) and Louie Rivers (co-author on NCA5 Chapter 22 [Southeast]), she has a proposal in preparation with Heidi Roop (co-author on NCA5 Chapter 24 [Midwest]), and she has co-authored publications and collaborated on proposals with Sarah Trainor (co-author on NCA5 Chapter 29 [Alaska]) and Kripa Akila Jagnnathan (co-author on NCA5 Chapter 18 [Sector Interactions, Multiple Stressors, and Complex Systems]).

Gary Yohe is the Huffington Foundation Professor of Economics and Environmental Studies (Emeritus) at Wesleyan University. He has published more than 150 scholarly articles on climate change and climate policy or economics germane to climate change of climate policy. He has published more than 70 opinion and communication pieces alone and with colleagues Richard Richels, Henry Jacoby, and Benjamin Santer in venues like *Scientific American*, *The Hill*, *The Guardian*, *Yale Climate Connections*, and the like. Springer Nature is publishing a collection of 35 of these essays later this year. As a very senior member of the Intergovernmental Panel on Climate Change, he shared the 2007 Nobel Peace Prize. He has served as the co-vice-chair of the Third US National Climate Assessment and on many National Academies' panels—including Susan Solomon's Stabilization Panel and both the Adaptation Panel and overarching panel of America's Climate Choices. Dr. Yohe was educated at the University of Pennsylvania and received his PhD in economics from Yale University in 1975. Dr. Yohe has written an opinion piece article for *The Hill* titled "GOP-Controlled House: Children Playing Poorly in the Climate Change Sandbox" in November 2022.