

About This Report

This report assesses the science of climate change and its impacts across the United States, now and throughout this century. It integrates findings of the U.S. Global Change Research Program (USGCRP)¹ with the results of research and observations from across the U.S. and around the world, including reports from the U.S. National Research Council. This report documents climate change-related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels.

Report requirements, production, and approval

The Global Change Research Act¹ requires that every four years, the USGCRP prepare and submit to the President and Congress an assessment of the effects of global change in the United States. As part of this assessment, more than 70 workshops were held involving a wide range of stakeholders who identified issues and information for inclusion (see Appendix 1: Process). A team of more than 300 experts was involved in writing this report. Authors were appointed by the National Climate Assessment and Development Advisory Committee (NCADAC)², the federal advisory committee assembled for the purpose of conducting this assessment. The report was extensively reviewed and revised based on comments from the public and experts, including a panel of the National Academy of Sciences. The report was reviewed and approved by the USGCRP agencies and the federal Committee on Environment, Natural Resources, and Sustainability (CENRS). This report meets all federal requirements associated with the Information Quality Act (see Appendix 2: IQA), including those pertaining to public comment and transparency.

Report sources

The report draws from a large body of scientific, peer-reviewed research, as well as a number of other publicly available sources. Author teams carefully reviewed these sources to ensure a reliable assessment of the state of scientific understanding. Each source of information was determined to meet the four parts of the IQA Guidance provided to authors: 1) utility, 2) transparency and traceability, 3) objectivity, and 4) integrity and security (see Appendix 2: IQA). Report authors made use of technical input reports produced by federal agencies and other interested parties in response to a request for information by the NCADAC;² other peer-reviewed

¹ The USGCRP is made up of 13 Federal departments and agencies that carry out research and support the nation's response to global change. The USGCRP is overseen by the Subcommittee on Global Change Research (SGCR) of the National Science and Technology Council's Committee on Environment, Natural Resources and Sustainability (CENRS), which, in turn is overseen by the White House Office of Science and Technology Policy (OSTP). The agencies within USGCRP are: the Department of Agriculture, the Department of Commerce (NOAA), the Department of Defense, the Department of Energy, the Department of Health and Human Services, the Department of the Interior, the Department of State, the Department of Transportation, the Environmental Protection Agency, the National Aeronautics and Space Administration, the National Science Foundation, the Smithsonian Institution, and the U.S. Agency for International Development.

² The NCADAC is a federal advisory committee sponsored by the National Oceanic and Atmospheric Administration under the requirements of the Federal Advisory Committee Act.

1 scientific assessments (including those of the Intergovernmental Panel on Climate Change; the
2 U.S. National Climate Assessment’s 2009 report titled *Global Climate Change Impacts in the*
3 *United States*;³ the National Academy of Science’s *America’s Climate Choices* reports;⁴ and a
4 variety of regional climate impact assessments, conference proceedings, government statistics
5 (such as population census and energy usage); and observational data. Case studies were also
6 provided as illustrations of climate impacts and adaptation programs.

7 **Box: A Guide to the Report**

8 The report has eight major sections, outlined below:

- 9 • **Overview and Report Findings:** gives a high level perspective on the full National
10 Climate Assessment and sets out the report’s 12 key findings. The Overview synthesizes
11 and summarizes the ideas that the authors consider to be of greatest importance to the
12 American people.
- 13 • **Our Changing Climate:** presents recent advances in climate change science, which
14 includes discussions of extreme weather events, observed and projected changes in
15 temperature and precipitation, and the uncertainties associated with these projections.
16 Substantial additional material related to this chapter can be found in the Appendices.
- 17 • **Sectors:** focuses on climate change impacts for seven societal and environmental sectors:
18 human health, water, energy, transportation, agriculture, forests, and ecosystems and
19 biodiversity; six additional chapters consider the interactions among sectors (such as
20 energy, water, and land use) in the context of a changing climate.
- 21 • **Regions:** assesses key impacts on U.S. regions – Northeast, Southeast and Caribbean,
22 Midwest, Great Plains, Southwest, Northwest, Alaska, Hawai‘i and the Pacific Islands –
23 as well as coastal areas, oceans, and marine resources.
- 24 • **Responses:** assesses the current state of responses to climate change, including
25 adaptation, mitigation, and decision support activities.
- 26 • **Research Needs:** highlights major gaps in science and research to improve future
27 assessments. New research is called for in climate science in support of assessments,
28 climate impacts in regions and sectors, and adaptation, mitigation, and decision support.
- 29 • **Sustained Assessment Process:** describes an initial vision for and components of an
30 ongoing, long-term assessment process.
- 31 • **Appendices:** Appendix 1 describes key aspects of the report process, with a focus on
32 engagement; Appendix 2 describes the guidelines used in meeting the terms of the federal
33 Information Quality Act; Appendix 3 supplements the chapter on *Our Changing Climate*
34 with an extended treatment of selected science issues; Appendix 4 provides answers to
35 *Frequently Asked Questions* about climate change; Appendix 5 describes scenarios and
36 models used in this assessment; and Appendix 6 describes possible topics for
37 consideration in future assessments.

38 **- end box -**

1 **Overarching perspectives**

2 Four overarching perspectives, derived from decades of observations, analysis, and experience,
3 have helped to shape this report: 1) climate change is happening in the context of other ongoing
4 changes across the U.S and the globe; 2) climate change impacts can either be amplified or
5 reduced by societal decisions; 3) climate change related impacts, vulnerabilities, and
6 opportunities in the U.S. are linked to impacts and changes outside the U.S., and vice versa; and
7 4) climate change can lead to dramatic tipping points in natural and social systems. These
8 overarching perspectives are briefly discussed below.

9 *Global change context*

10 Climate change is one of a number of global changes affecting society, the environment, and the
11 economy; others include population growth, land-use change, air and water pollution, and rising
12 consumption of resources by a growing and wealthier global population. This perspective has
13 implications for assessments of climate change impacts and the design of research questions at
14 the national, regional, and local scales. This assessment explores some of the consequences of
15 interacting factors by focusing on sets of crosscutting issues in a series of six chapters: Energy,
16 Water, and Land Use; Biogeochemical Cycles; Indigenous Peoples, Lands, and Resources;
17 Urban Systems, Infrastructure, and Vulnerability; Land Use and Land Cover Change; and Rural
18 Communities. The assessment also includes discussions of how climate change impacts cascade
19 through different sectors such as water and energy, and affect and are affected by land-use
20 decisions. These and other interconnections greatly stress society's capacity to respond to
21 climate-related crises that occur simultaneously or in rapid sequence.

22 *Societal choices*

23 Because environmental, cultural, and socioeconomic systems are tightly coupled, climate change
24 impacts can either be amplified or reduced by cultural and socioeconomic decisions. In many
25 arenas, it is clear that societal decisions have substantial influence on the vulnerability of valued
26 resources to climate change. For example, rapid population growth and development in coastal
27 areas tends to amplify climate change-related impacts. Recognition of these couplings, together
28 with recognition of multiple sources of vulnerability, helps identify what information decision-
29 makers need as they manage risks.

30 *International context*

31 Climate change is a global phenomenon; the causes and the impacts involve energy-use,
32 economic, and risk-management decisions across the globe. Impacts, vulnerabilities, and
33 opportunities in the U.S. are related in complex and interactive ways with changes outside the
34 U.S., and vice versa. In order for U.S. concerns related to climate change to be addressed
35 comprehensively, the international context must be considered. Foreign assistance, health,
36 environmental quality objectives, and economic interests are all affected by climate changes
37 experienced in other parts of the world. Although there is significantly more work to be done in
38 this area, this report identifies some initial implications of global and international trends that can
39 be more fully investigated in future assessments.

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Thresholds, tipping points, and surprises

While some climate changes will occur slowly and relatively gradually, others could be rapid and dramatic, leading to unexpected breaking points in natural and social systems. Although they have potentially large impacts, these breaking points or tipping points are difficult to predict, as there are many uncertainties about future conditions. These uncertainties and potential surprises come from a number of sources, including insufficient data associated with low probability/high consequence events, models that are not yet able to represent all the interactions of multiple stresses, incomplete understanding of physical climate mechanisms related to tipping points, and a multitude of issues associated with human behavior, risk management, and decision-making. Improving our ability to anticipate thresholds and tipping points can be helpful in developing effective climate-change mitigation and adaptation strategies (Ch. 2: Our Changing Climate; Ch. 29: Research Needs; and Climate Appendices 3 and 4).

Risk management framework

Authors were asked to consider the science and information needs of decision-makers facing climate-change risks to infrastructure, natural ecosystems, resources, communities, and other things of societal value. They were also asked to consider opportunities that climate change might present. For each region and sector, they were asked to assess a small number of key climate-related vulnerabilities of concern based on the risk (considering likelihood and consequence) of impacts. They were also asked to address the most important information needs of stakeholders, and to consider the decisions stakeholders are facing. The criteria provided for identifying key vulnerabilities in each sector or region included: magnitude, timing, persistence/reversibility, scale, and distribution of impacts, likelihood whenever possible, importance of impacts (based on the perceptions of relevant parties), and the potential for adaptation. Authors were encouraged to think about these topics from both a quantitative and qualitative perspective, and to consider the influence of multiple stresses whenever possible.

Responding to climate change

While the primary focus of this report is on the impacts of climate change in the United States, it also documents some of the actions society is taking or can take to respond. Responses to climate change fall into two broad categories. The first involves “mitigation” measures to reduce future climate change by reducing emissions of heat-trapping gases and particles, or increasing removal of carbon dioxide from the atmosphere. The second involves “adaptation” measures to improve society’s ability to cope with or avoid harmful impacts and take advantage of beneficial ones, now and in the future. At this point, both of these response activities are necessary to limit the magnitude and impacts of global climate change on the United States.

More effective mitigation measures can reduce the amount of climate change, and therefore reduce the need for future adaptation. This report underscores the effects of mitigation measures by comparing impacts resulting from higher versus lower emissions scenarios. This shows that choices made about emissions in the next few decades will have far-reaching consequences for climate change impacts throughout this century. Lower emissions will reduce the rate and lessen the magnitude of climate change and its impacts. Higher emissions will do the opposite.

1 While the report demonstrates the importance of mitigation as an essential part of the nation's
2 climate change strategy, it does not evaluate mitigation technologies or policies or undertake an
3 analysis of the effectiveness of various approaches. The range of mitigation responses being
4 studied includes, but is not limited to, policies and technologies that lead to more efficient
5 production and use of energy, increased use of non carbon-emitting energy sources such as wind
6 and solar power, and carbon capture and storage.

7 Adaptation actions are complementary to mitigation actions. They are focused on moderating
8 harmful impacts of current and future climate variability and change, and taking advantage of
9 possible opportunities. While this report assesses the current state of adaptation actions and
10 planning across the country in a general way, the implementation of adaptive actions is still
11 nascent. A comprehensive assessment of actions taken, and of their effectiveness, is not yet
12 possible. This report documents some of the actions currently being pursued to address impacts
13 such as increased urban heat extremes and air pollution, and describes the challenges decision-
14 makers face in planning for and implementing adaptation responses.

15 **Traceable accounts: process and confidence**

16 The “traceable accounts” that accompany each chapter: 1) document the process the authors used
17 to reach the conclusions in their key messages; 2) provide additional information to reviewers
18 and other readers about the quality of the information used; 3) allow traceability to data and
19 resources; and 4) provide the level of confidence the authors have in the main findings of the
20 chapters. The authors have assessed a wide range of information in the scientific literature and
21 various technical reports. In assessing confidence, they have considered the strength and
22 consistency of the observed evidence, the skill, range, and consistency of model projections, and
23 insights from peer-reviewed sources.

24 When it is considered scientifically justified to report the likelihood of particular impacts within
25 the range of possible outcomes, this report takes a plain-language approach to expressing the
26 expert judgment of the author team based on the best available evidence. For example, an
27 outcome termed “likely” has at least a two-thirds chance of occurring; an outcome termed “very
28 likely,” has more than a 90% chance. Key sources of information used to develop these
29 characterizations are referenced.

1 **References**

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