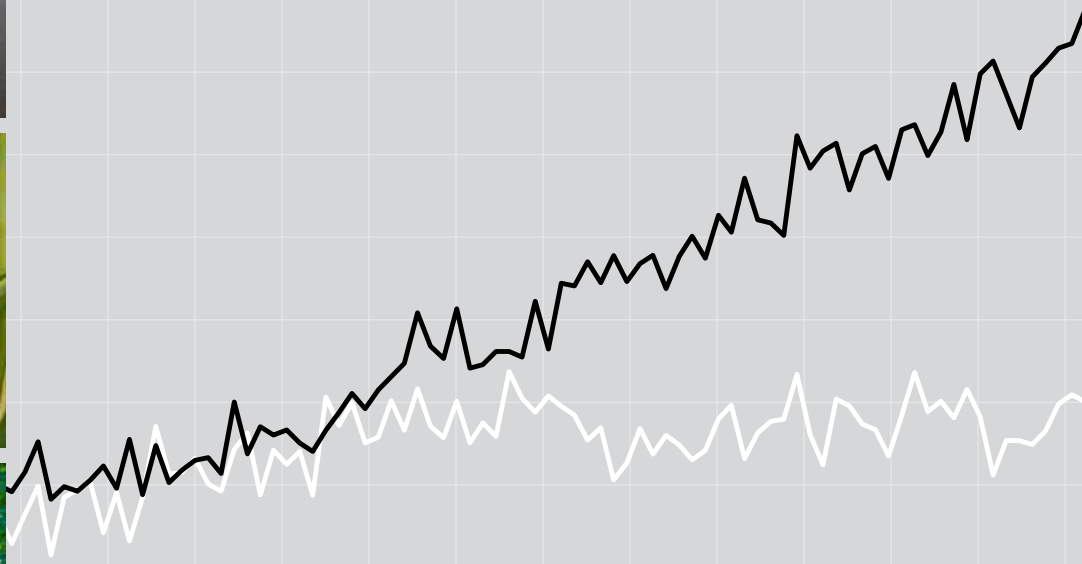
United States Environmental Protection Agency

CLIMATE CHANGE IN THE UNITED STATES

Benefits of Global Action



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EPA's climate change website features a user-friendly interface for this report with downloadable graphics. To view information about EPA's Climate Change Impacts and Risk Analysis (CIRA) project, share your thoughts on this effort, and access the corresponding Technical Appendix for this report, please visit EPA's website at: www.epa.gov/cira.

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Acknowledgments

CONTRIBUTORS

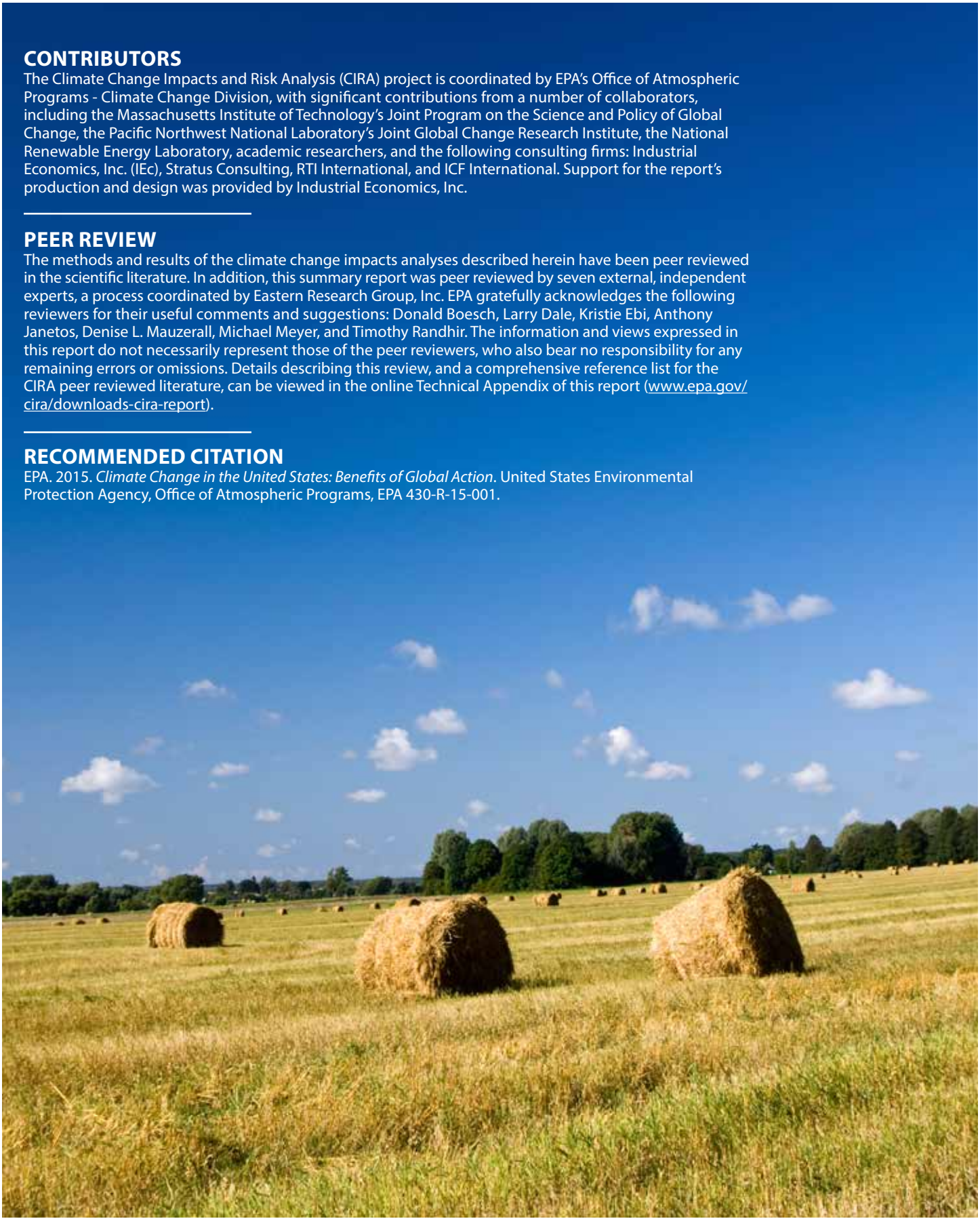
The Climate Change Impacts and Risk Analysis (CIRA) project is coordinated by EPA's Office of Atmospheric Programs - Climate Change Division, with significant contributions from a number of collaborators, including the Massachusetts Institute of Technology's Joint Program on the Science and Policy of Global Change, the Pacific Northwest National Laboratory's Joint Global Change Research Institute, the National Renewable Energy Laboratory, academic researchers, and the following consulting firms: Industrial Economics, Inc. (IEc), Stratus Consulting, RTI International, and ICF International. Support for the report's production and design was provided by Industrial Economics, Inc.

PEER REVIEW

The methods and results of the climate change impacts analyses described herein have been peer reviewed in the scientific literature. In addition, this summary report was peer reviewed by seven external, independent experts, a process coordinated by Eastern Research Group, Inc. EPA gratefully acknowledges the following reviewers for their useful comments and suggestions: Donald Boesch, Larry Dale, Kristie Ebi, Anthony Janetos, Denise L. Mauzerall, Michael Meyer, and Timothy Randhir. The information and views expressed in this report do not necessarily represent those of the peer reviewers, who also bear no responsibility for any remaining errors or omissions. Details describing this review, and a comprehensive reference list for the CIRA peer reviewed literature, can be viewed in the online Technical Appendix of this report (www.epa.gov/cira/downloads-cira-report).

RECOMMENDED CITATION

EPA. 2015. *Climate Change in the United States: Benefits of Global Action*. United States Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-15-001.



Introduction

The Earth's changing climate is affecting human health and the environment in many ways. Across the United States (U.S.), temperatures are rising, snow and rainfall patterns are shifting, and extreme climate events are becoming more common. Scientists are confident that many of the observed changes in the climate are caused by the increase in greenhouse gases (GHGs) in the atmosphere. As GHG emissions from human activities increase, many climate change impacts are expected to increase in both magnitude and frequency over the coming decades, with risks to human health, the economy, and the environment.

Actions can be taken now to reduce GHG emissions and avoid many of the adverse impacts of climate change. Quantifying the benefits of reducing GHG emissions (i.e., how GHG mitigation reduces or avoids impacts) requires comparing projections of climate change impacts and damages in a future with policy actions and a future without policy actions. Looking across a large number of sectors, this report communicates estimates of these benefits to the U.S. associated with global action on climate change.

Introduction

About this Report

This report summarizes and communicates the results of EPA's ongoing Climate Change Impacts and Risk Analysis (CIRA) project. The goal of this work is to estimate to what degree climate change impacts and damages to multiple U.S. sectors (e.g., human health, infrastructure, and water resources) may be avoided or reduced in a future with significant global action to reduce GHG emissions, compared to a future in which current emissions continue to grow. Importantly, only a small portion of the impacts of climate change are estimated, and therefore this report captures just some of the total benefits of reducing GHGs.

To achieve this, a multi-model framework was developed to estimate the impacts and damages to the human health and welfare of people in the U.S. The CIRA framework uses consistent inputs (e.g., socioeconomic and climate scenarios) to enable consistent comparison of sectoral impacts across time and space. In addition, the role of adaptation is modeled for some of the sectors to explore the potential for risk reduction and, where applicable, to quantify the costs associated with adaptive actions.

The methods and results of the CIRA project have been peer reviewed in the scientific literature, including a special issue of *Climatic Change* entitled, "A Multi-Model Framework to Achieve Consistent Evaluation of Climate Change Impacts in the United States."[1] The research papers underlying the modeling and results presented herein are cited throughout this report and are listed in Section B of the Technical Appendix.

Interpreting the Results

This report presents results from a large set of sectoral impact models that quantify and monetize climate change impacts in the U.S., with a primary focus on the contiguous U.S., in futures with and without global GHG mitigation. The CIRA analyses are intended to provide insights about the potential direction and magnitude of climate change impacts and the benefits (avoided impacts) to the U.S. of global emissions reductions. However, none of the estimates presented in this report should be interpreted as definitive predictions of future impacts at a particular place or time.

The CIRA analyses do not evaluate or assume specific GHG mitigation or adaptation policies in the U.S. or in other world regions. Instead, they consider plausible scenarios to illustrate potential benefits of significant GHG emission reductions compared to a business-as-usual future. The results should not be interpreted as supporting any particular domestic or global mitigation policy or target. A wide range of global mitigation scenarios could be modeled in the CIRA framework,[2] and results would vary accordingly. For ease of communicating results, however, this report focuses on a future where the increase in average global temperature is limited to approximately 2°C (3.6°F) above preindustrial levels—a goal relevant to international discussions on GHG emission reductions.[3]

This report includes as many climate change impacts as feasible at present, but is not all-inclusive. It is not intended to be as comprehensive as major assessments, such as those conducted by the U.S. Global Change Research Program (USGCRP), which capture a wider range of impacts from the published literature.[4] By using a consistent set of socioeconomic and climate scenarios, CIRA produces apples-to-apples comparisons of impacts across sectors and regions—something that is not always achieved, or even sought, in the major assessments. Also, the assessments typically do not monetize damages, nor do they focus on quantifying mitigation benefits. CIRA's ability to estimate how global GHG mitigation may benefit the U.S. by reducing or avoiding climate change impacts helps to fill an important literature and knowledge gap.

The CIRA analyses do not serve the same analytical purpose nor use the same methodology as the Social Cost of Carbon (SCC), an economic metric quantifying the marginal global benefit of reducing one ton of carbon dioxide (CO_2).[5] In addition, the costs of reducing GHG emissions,[6] and the health benefits associated with co-reductions in other air pollutants, are well-examined elsewhere in the literature[7] and are beyond the scope of this report.

Roadmap to the Report

SUMMARY OF KEY FINDINGS	Provides an overview of key findings and highlights of the report.
CIRA FRAMEWORK	Introduces the CIRA project, describes and briefly presents the climate projections used in the analyses, and discusses key uncertainties and boundaries of analysis.
SECTORS Health Infrastructure Electricity Water Resources Agriculture and Forestry Ecosystems	Summarizes the major findings of each of the 20 impact analyses within the six broad sectors listed to the left, including: • Background on the impact being estimated, along with a brief summary of the analytical approach to estimating the impact; • Key findings and graphics depicting the risks of inaction and the benefits of global-scale GHG mitigation; and • References to the underlying peer-reviewed research upon which these estimates are based.
OVERVIEW OF RESULTS	Presents national and regional highlights from the 20 sectoral impact analyses.
CONCLUSION	Describes the over-arching conclusions of the report.
TECHNICAL APPENDIX *(available at www.epa.gov/cira)*	• Provides a list of all peer-reviewed research papers underlying the CIRA project; • Provides comparisons of key CIRA findings to those of the assessment literature; and • Describes the treatment of adaptation across the sectoral analyses.

Summary of Key Findings

Climate change poses significant risks to humans and the environment. The CIRA project quantifies and monetizes the risks of inaction and benefits to the U.S. of global GHG mitigation within six broad sectors (water resources, electricity, infrastructure, health, agriculture and forestry, and ecosystems). Looking across the impact estimates presented in this report, several common themes emerge.[1]

Global GHG Mitigation Reduces the Frequency of Extreme Weather Events and Associated Impacts

Global GHG mitigation is projected to have a substantial effect on reducing the incidence of extreme temperature and precipitation events by the end of the century, as well as the impacts to humans and the environment associated with these extreme events.[2] For example, by 2100 mitigation is projected to avoid 12,000 deaths annually associated with extreme temperatures in 49 U.S. cities, compared to a future with no emission reductions. Inclusion of the entire U.S. population would greatly increase the number of avoided deaths, while accounting for adaptation could reduce this number.

Global GHG Mitigation Avoids Costly Damages in the U.S.

For nearly all sectors analyzed, global GHG mitigation is projected to prevent or substantially reduce adverse impacts in the U.S. this century compared to a future without emission reductions. For many sectors, the projected benefits of mitigation are substantial; for example, in 2100 mitigation is projected to result in cost savings of $4.2-$7.4 billion associated with avoided road maintenance. Global GHG mitigation is also projected to avoid the loss of 230,000-360,000 acres of coldwater fish habitat across the country compared to a future without emissions reductions.

The Benefits of GHG Mitigation Increase over Time

For a large majority of sectors analyzed, the benefits of GHG mitigation are projected to be greater in 2100 than in 2050. In addition, the benefits of GHG mitigation are often not apparent until mid-century. This delay in benefits is consistent with many studies,[3] and is attributable to inertia in the climate system. Therefore, decisions we make today can have long-term effects, and delaying action will likely increase the risks of significant and costly impacts in the future.

Adaptation Can Reduce Overall Damages in Certain Sectors

Adaptation can substantially reduce certain impacts of climate change regardless of whether future GHG levels are low or high. For example, the estimated damages to coastal property from sea level rise and storm surge in the contiguous U.S. are $5.0 trillion through 2100 (discounted at 3%[4]) in a future without emission reductions. When cost-effective adaptation along the coast is included, the estimated damages are reduced to $810 billion.

Impacts Vary across Time and Space

Important regional changes may be masked when results are presented at the national level. For example, the wildfire analysis reveals that the projected changes in the Southwest and Rocky Mountain regions are the primary drivers of national trends of increasing wildfire activity over time.

The temporal scale of climate change impacts is also important. While some impacts are likely to occur gradually over time, others may exhibit threshold (tipping point) responses to climate change, as large changes manifest over a short period of time. For example, high-temperature bleaching events projected to occur by 2025 are estimated to severely affect coral reefs in the Caribbean. Therefore, simply analyzing an impact in one time period (e.g., 2100) may mask important temporal dynamics that are relevant to decision makers.

Estimated Benefits to the U.S. in 2100

This graphic presents a selection of the estimated benefits of global GHG mitigation in 2100 for major U.S. sectors. Unless otherwise noted, the results presented below are estimates of annual benefits (or disbenefits) of mitigation in the year 2100.* Importantly, only a small portion of the impacts of climate change are estimated, and therefore this report captures just some of the total benefits of reducing GHGs.

HEALTH

AIR QUALITY

An estimated 57,000 fewer deaths from poor air quality in 2100

EXTREME TEMPERATURE

In 49 major U.S. cities, an estimated 12,000 fewer deaths from extreme temperature in 2100

LABOR

Approximately $110 billion in avoided damages from lost labor due to extreme temperatures in 2100

WATER QUALITY

An estimated $2.6-$3.0 billion in avoided damages from poor water quality in 2100†

ELECTRICITY

ELECTRICITY DEMAND

An avoided increase in electricity demand of 1.1%-4.0% in 2050‡

ELECTRICITY SUPPLY

An estimated $10-$34 billion in savings on power system costs in 2050‡

INFRASTRUCTURE

BRIDGES

An estimated 720-2,200 fewer bridges made structurally vulnerable in 2100†

ROADS

An estimated $4.2-$7.4 billion in avoided adaptation costs in 2100†

URBAN DRAINAGE

In 50 U.S. cities, an estimated $50 million-$6.4 billion in avoided adaptation costs in 2100†

COASTAL PROPERTY

Approximately $3.1 billion in avoided damages and adaptation costs from sea level rise and storm surge in 2100

* Monetary estimates for this summary are presented for either 2050 or 2100 only, and are undiscounted (2014$). See the Sectors section for the use of discounting throughout this report.

† Estimated range of results relies upon climate projections from two climate models showing different patterns of precipitation in the U.S. The IGSM-CAM projects a relatively "wetter" future for most of the U.S. compared to the drier MIROC model (see the CIRA Framework section of this report for more information).

# of Reducing Global GHG Emissions

For detailed information on the results, please refer to the Sectors section of this report.

WATER RESOURCES

INLAND FLOODING

Estimates range from approximately $2.8 billion in avoided damages to $38 million in increased damages in 2100†

DROUGHT

An estimated 40%-59% fewer severe and extreme droughts in 2100†

SUPPLY & DEMAND

An estimated $11-$180 billion in avoided damages from water shortages in key economic sectors in 2100†

AGRICULTURE AND FORESTRY

AGRICULTURE

An estimated $6.6-$11 billion in avoided damages to agriculture in 2100

FORESTRY

An estimated $520 million to $1.5 billion in avoided damages to forestry in 2100

ECOSYSTEMS

CORAL REEFS

An avoided loss of approximately 35% of current Hawaiian coral in 2100, with a recreational value of $1.1 billion

SHELLFISH

An avoided loss of approximately 34% of the U.S. oyster supply, 37% of scallops, and 29% of clams in 2100

WILDFIRE

An estimated 6.0-7.9 million fewer acres burned by wildfires in 2100†

FRESHWATER FISH

An estimated 230,000-360,000 acres of cold-water fish habitat preserved in 2100†

CARBON STORAGE

An estimated 1.0-26 million fewer tons of carbon stored in vegetation in 2100†§

‡ Results reflect the estimated range of benefits from the reduction in demand and system costs resulting from lower temperatures associated with GHG mitigation. The Electricity section in this report presents an analysis that includes the costs to the electric power sector of reducing GHG emissions.

§ See the Carbon Storage section of this report for cumulative results from 2000-2100, which show benefits of GHG mitigation for parts, and in some cases all, of the century.