21. FEDERAL BUDGET EXPOSURE TO CLIMATE RISK

The climate crisis poses a serious threat to the United States economy and human welfare with a narrowing timeframe to invest in opportunities to avoid the most catastrophic impacts. Changes in the average range of climate conditions and increasingly frequent and intense extreme weather events will continue damaging the physical integrity of our infrastructure, the livable and social conditions of our communities, the health of our people and natural ecosystems, and the productivity of major economic sectors. All of these changes will increasingly and severely impact communities, businesses, and governments.

The impacts of climate change on businesses and communities are broad: escalating costs and lost revenue as a direct or indirect result of a changing climate is significant and varied. Across the United States, estimated damages from a subset of storms, floods, wildfires, and other extreme climate-related weather events have already grown to about $120 billion a year over the past five years.[1] The most severe harms from climate change fall disproportionately upon socially vulnerable populations, and racial and ethnic minority communities are particularly vulnerable to climate impacts.[2] The Federal Government plays a critical role in helping American families, businesses, and communities recover from the impacts of extreme weather events – often acting as an insurer of last resort. Communities and businesses also face impacts from other slower-moving climate hazards, such as sea-level rise. The Federal Government must ensure that Americans have access to housing and healthcare that is safe and affordable as well as access to critical transportation and communication infrastructure. Climate change increases the need for Federal support in these areas.

As broad economic damages from climate change grow, so does the impact of the climate crisis on the Federal budget. The Federal Government's budget is directly and substantially at risk from expected lost revenues and increasing expenditures due to climate change damages in coming decades, such as increasing costs from physical damages to our nation's infrastructure and healthcare expenditures, the instability of certain subsidized insurance programs, and accelerating instability that threatens global security. Although the presence of risk to the U.S. economy and to the Federal budget across a broad set of exposures is clear, significant work is needed to quantify the total potential risk to American taxpayers. However, the overall welfare risk to the economy, from impacts on putlic health to business, will be larger than the impact on our fiscal balance sheet.

Identifiable Costs

The Office of Management and Budget (OMB) assessments found that the Federal Government could spend between an additional $25 billion to $128 billion annually due to just six climate-related financial risks included in this report—disaster relief, flood insurance, crop insurance, healthcare expenditures, wildland fire suppression spending, and flood risk at Federal facilities – and considering only a limited scope of total potential damages to those programs. Table 21-1 summarizes quantified annual estimated expenditures of these assessed programs (in 2020$) in projected ranges to mid- and late-century. Many other risks to the Federal budget are apparent but have not yet been quantified, such as the risks to national security, changes to ecosystems, and infrastructure expenditures which can each have wide-ranging and diffuse effects to the budget.

Additionally, the OMB long-range budget projections found that Federal revenues could be 7.1 percent lower annually by 2100 (about $2 trillion in today's terms) under a scenario in which climate change reduced U.S. GDP by 10.0 percent compared to a no-further-warming counterfactual, as projected by the Network for Greening the Financial System as the tail risk under current policies.[3]

The following summary of select programmatic assessments is intended to provide illustrative examples of how climate change could impact future Federal expenditures. The cost assessments herein are not an estimate of the total Federal budget exposure to climate risk, but rather demonstrative ranges of potential individual programmatic costs based on climate scenarios. Future projections like these include a high degree of uncertainty caused by multiple factors, including the pathway of greenhouse gas (GHG) emissions rates, advances in adaptation and resilience technologies, unforeseen changes in relevant policy, and others. The summary of currently identifiable costs is likely underestimated, due to unmodeled impacts like those listed in the above paragraph. Thus, unmitigated climate change is expected to leave a more significant imprint on the Federal budget over the course of this century, though this summary is a useful foundational step in assessing the overall impact.

[1] National Oceanic and Atmospheric Administration, National Centers for Environmental Information. (2021, Nov. 17). U.S. Billion- Dollar Weather and Climate Disasters. *https://www.ncdc.noaa.gov/billions/*

[2] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003.

[3] NGFS. (2021). NGFS Climate Scenarios for central banks and supervisors. *https://www.ngfs.net/sites/default/files/ngfs_climate_scenario_technical_documentation_final.pdf*.

Table 21–1. SUMMARY OF QUANTIFIED FEDERAL CLIMATE RISK EXPOSURE PROJECTED CHANGE IN ANNUAL EXPENDITURES OF ASSESSED PROGRAMS[1]

(Billions of 2020 dollars)

Current Expenditures	Mid-Century[5]			Late-Century		
	Mean	Lower	Higher	Mean	Lower	Higher
Crop Insurance[2]	NA	NA	NA	$1.2	$0.3	$2.1
Coastal Disasters	$14.6	$4.4	$32.5	$49.6	$21.9	$94.3
Healthcare	$1.0	$0.2	$1.8	$11.3	$.8	$21.9
Wildland fire Suppression[3]	$1.7	$0.8	$2.3	$3.7	$1.6	$9.6
TOTAL[4]	$17.3	$5.4	$36.6	$65.8	$24.6	$127.9

[1] "Lower" estimates are largely based on assessments assuming Representative Concentration Pathway (RCP) 4.5, which the NCA4 framed in 2018 as a "lower" scenario with less warming—generally associated with lower population growth, more technological innovation, and lower carbon intensity. "Higher" estimates are largely based on assessments assuming RCP8.5, which the NCA frames as a "higher" scenario—generally associated with higher population growth, less technological innovation, and higher carbon intensity.

[2] The crop insurance analysis was only conducted for late century.

[3] The median of all wildland fire suppression simulations is used in the "Mean" column, so outliers in the "Higher" scenario are not overemphasized in the results.

[4] Several Federal financial risks are not included in this table due to the nascent ability to quantify future expenditures in this field. Some other future expenditures, such as flood insurance are not expected to increase because rate-setting policies yield actuarially fair premiums with the ability to adjust as climate conditions change.

[5] The science of estimating Representative Concentration Pathways (e.g. RCP4.5 and RCP8.5) has evolved since NCA4 was released in 2018. RCP8.5, for instance has been viewed by some researchers as an extreme scenario and considered an under estimate by other researchers. Specific climate scenarios, and time periods can vary across this paper's assessments due to differences in available studies, datasets, and models. As a result, findings are comparable across risk assessments at an order-of-magnitude scale.

Crop Insurance

The Fourth National Climate Assessment[4] (NCA4) found that climate change is anticipated to shift agricultural production regions. Average crop yields for most major commodities are projected to decline, not only from climate-change induced drought intensification but also increasingly frequent natural disasters such as flooding. Particularly, crops which are planted in the spring—such as corn, soybeans, and sorghum—are more likely to experience declines in productivity due to excessive heat and dryness during summer in the Midwest.[5] However, some crops, such as winter wheat and barley, may experience increased yields from higher temperatures in the spring since these crops are planted in the fall and harvested in early summer. While there could be some benefits to climate change for production of a few individual crop types, models project a net negative impact on overall crop production.[6] Previous research has estimated that county-level temperature trends caused 19% of the national-level Federal crop insurance gross indemnities from 1991 to 2017.[7]

The Federal Crop Insurance Program (FCIP) provides subsidized insurance for losses of crops caused by natural events.[8] FCIP subsidizes the crop insurance premiums and the administrative expenses for private sector implementation, with premium subsidies being the majority of the Federal costs of the program.[9] In 2021, farmers paid 37% of the total crop insurance premium, with the remaining 63% being subsidized by the Federal Government. Over 100 agricultural commodities had crop insurance policies available and the liability for the program totaled $136.6 billion with premium subsidies totaling $8.6 billion in 2021. While a wide variety of crops are covered by crop insurance, 60% of the liability is for corn, soybeans, and wheat.[10]

The U.S. Department of Agriculture (USDA)—Economic Research Service (ERS) developed projected costs of the FCIP with a multi-stage model.[11] Given that the majority of crop insurance liability is for corn, soybeans, and wheat, the researchers focused on the three, which are also the most widely grown crops in the United States. The researchers established historical relationships between crop yield (crop production per acre) and weather variables. The models fitted to this historical data were then used to project yields out to the end of the century,

[4] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. *https://doi.org*.

[5] Gowda, P., J.L. Steiner, C. Olson, M. Boggess, T. Farrigan, and M.A. Grusak. (2018). Agriculture and Rural Communities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 391–437. *https://doi.org/10.7930/NCA4.2018.CH10.*

[6] Ibid.

[7] Diffenbaugh, N. S., Davenport, F. V., & Burke, M. (2021). Historical warming has increased US crop insurance losses. Environmental Research Letters, 16(8), 084025.

[8] Federal Crop Insurance Act, 7 U.S.C. §§ 1501 et seq.

[9] 7 U.S.C. § 1508.

[10] Risk Management Agency, U.S. Department of Agriculture. (2021). Summary of Business. *https://www.rma.usda.gov/SummaryOfBusiness*

[11] Crane-Droesch, B. A., Marshall, E., Rosch, S., Riddle, A., Cooper, J., & Wallander, S. (2019). Climate change and agricultural risk management into the 21st century. Economic Research Report-Economic Research Service, USDA, (266). *https://www.ers.usda.gov/publications/pub-details/?pubid=93546*

using information relating to GHG emissions from two different warming scenarios: a higher emissions scenario and a moderate emissions scenario.[12] For the time period examined, the researchers compared the total expected insurance premiums in 2080 under each scenario to a baseline climate (1981-2013) scenario using a forty-year period in the climate model output (2060-2099) to capture to expect yield risk. The projected yields are then entered into an economic model were that simulates the producers' crop choice, planted acres, and crop prices under the various yields produced by the different climate scenarios. The resulting crop price and yield distributions from the economic model are then used to project crop insurance premiums and subsidies. Researchers' calculations assume the most popular form of crop insurance for corn, soybeans, and wheat, called Revenue Protection (RP), for all insured acreage in the projections. RP provides farmers with a guaranteed percent of their anticipated revenue.[13]

Federal expenditures on crop insurance premium subsidies are expected to increase 3.5 to 22 percent due to climate change-induced crop losses through the late century.[14] USDA ERS found that under the moderate emissions scenario, the subsidies for crop insurance premiums would be about 3.5 percent higher compared to a climate similar to that of the recent past—an increase of roughly $330 million per year in 2020 dollars by the late century. Under the higher emissions scenario, the projected increase in crop insurance premium subsidies is 22 percent—an approximate increase of $2.1 billion per year (2020$) by the late century.

The USDA is taking a number of actions to address the rising costs associated with climate change.[15] Most notably, USDA is advancing a Partnership for Climate-Smart Commodities initiative that is providing voluntary incentives farmers to deploy practices that sequester carbon and reduce GHGs from their operations, while developing new markets for agricultural commodities produced with climate smart practices.[16] Under this initiative, USDA has explicitly identified a suite of farming practices—such as the utilization of cover crops, low or no tillage, agroforestry, and the like— that are eligible and is applying measurement, monitoring and verification techniques to confirm the climate benefits associated with these practices.[17] Also USDA is supporting cover crops by explicitly identifying it as a good farming practice and ensuring termination guidelines for cover cropping are up to date, reflect best available science, and are flexible for new regions and practices to ensure that farmers are not inadvertently discouraged from cover cropping.[18] Lastly, USDA has modified existing programs to support climate-smart practices.[19] By better integrating climate-smart practices, such as cover cropping, into crop insurance, farmers should be able to increase soil health and potentially help mitigate climate change by sequestering GHGs.[20] The Administration looks forward to working with the Congress to address climate change through climate-smart agriculture and provide a competitive advantage for American producers of climate-smart commodities, including small and historically underserved producers and early adopters, and through voluntary incentives to reduce climate risk.

Coastal Disaster Response

According to the National Oceanic and Atmospheric Administration (NOAA), 40 percent of Americans live in counties on the coast.[21] Data from the Congressional Budget Office (CBO) shows that, from 2005-2016, the vast majority of Federal funds dedicated to federally-declared hurricanes and inland storms were spent on strong Atlantic hurricanes that hit major metropolitan areas.[22] Three disaster declarations alone[23] comprised over 80 percent of these Federal funds.[24] Further, according to NOAA's Billion Dollar Weather and Climate Disasters Database, from 1980-2020, the top 6 disasters for inflation-adjusted total (including non-Federal) damages to the United States were all major[25]Atlantic hurricanes (1992 Andrew, 2005 Katrina, 2012 Sandy,[26] 2017 Harvey,

[12] Like any projections, this analysis requires assumptions, such as the model does not include structural shifts in technology.

[13] Risk Management Agency, U.S. Department of Agriculture. Revenue Protection. *https://www.rma.usda.gov/en/Policy-and-Procedure/Insurance-Plans/Revenue-Protection*

[14] Note there are annual fluctuations in total premium subsidy due to factors, such as prices, crop choices, and acreage planted. The percentages in the analysis assume a baseline premium subsidy value of $9.4 billion (2020$).

[15] E.O. 14008. Sec 216. *https://www.federalregister.gov/d/2021-02177/p-85*

[16] U.S. Department of Agriculture. Partnerships for Climate-Smart Commodities. *https://www.usda.gov/climate-solutions/climate-smart-commodities*

[17] Ibid.

[18] 7 U.S.C. § 1508(a)(11).

[19] Risk Management Agency, U.S. Department of Agriculture. (2021). Crop Insurance Supports Environmentally Friendly Practices. *https://www.rma.usda.gov/en/About-RMA/Who-We-Are/Administrators-Message/2021-Messages/April-30*

[20] Climate Hubs, U.S. Department of Agriculture. Cover Cropping to Improve Climate Resilience. *https://www.climatehubs.usda.gov/hubs/northeast/topic/cover-cropping-improve-climate-resilience#*: *https://www.climatehubs.usda.gov/hubs/northeast/topic/cover-cropping-improve-climate-resilience*

[21] Office of Coastal Management,National Oceanic and Atmospheric Administration. (2021, Nov. 23). Economics and Demographics. *https://coast.noaa.gov/states/fast-facts/economics-and-demographics. html.*

[22] Congressional Budget Office. (2019). Expected costs of damage from hurricane winds and storm-related flooding. *https://www.cbo.gov/publication/55019*.

[23] (a) Ike, Gustav, and Fay; (b) Sandy; and (c) Rita, Wilma, Katrina, and Ophelia

[24] Congressional Budget Office. (2019). Expected costs of damage from hurricane winds and storm-related flooding. *https://www.cbo.gov/publication/55019*.

[25] A major hurricane is a hurricane that is category 3 or above. Reference for footnote: National Hurricane Center and Central Pacific Hurricane Center. "Saffir-Simpson Hurricane Wind Scale." Accessed Jan. 2, 2022. *https://www.nhc.noaa.gov/aboutsshws.php*.

[26] Hurricane Sandy, a Category 3 hurricane in Cuba, was an unusually large storm that impacted the New York Metropolitan Area, causing a large amount of damage even though it hit landfall in the United States as a Category 1 hurricane. Reference for footnote: Eric S. Blake, Todd B. Kimberlain, Robert J. Berg, John P. Cangialosi and John L. Beven II. (2013). Tropical cyclone report: Hurricane Sandy (AL182012). National Hurricane Center. *https://www.nhc.noaa.gov/data/tcr/AL182012_Sandy.pdf*.

2017 Irma, 2017 Maria).[27] Hurricane Katrina was the most expensive.[28] Damages from tropical cyclones, including hurricanes, are correlated to storm intensity. Because climate change is projected to increase the intensity of tropical cyclones,[29] damages are similarly expected to increase. Additionally, the frequency of coastal flooding is anticipated to increase over time with climate changes.[30]

The largest impact of climate change on Federal expenditures to ameliorate coastal disasters can then be approximated by the impact of climate change on Atlantic hurricanes. Literature on hurricanes in the Atlantic basin indicates that climate change has already and will likely continue to increase the severity of Atlantic hurricanes. While there is still uncertainty in how climate change will affect the frequency of tropical cyclones, with many studies suggesting a decrease in global frequency,[31] there is some evidence that the frequency of the most intense of these storms will increase in the Atlantic and North Pacific. [32]

In 2016, CBO[33] simulated hurricane frequency in a climate-changed world using information from two other studies,[34,35] and then CBO translated these simulated hurricanes to total future damages, both in 2050 and in 2075. Based on recent history, the percentage of hurricane damages covered by the Federal Government has increased along with hurricane intensity. Therefore, for Federal spending increases, CBO approximated that Federal spending would encompass 40-80 percent of damages in their simulations.[36]

Based on methodology modifications to update results from CBO (2016),[37,38] OMB estimates that annual Federal spending increases on coastal disaster response spending are projected to range from $4-$32 billion (2020 USD) annually,[39] with a mean of $15 billion, in 2050.[40] By 2075 these annual increases due to projected hurricane frequency reach $22-$94 billion (2020$), with a mean increase of $50 billion. The method for developing these estimates takes into consideration the increased frequency of hurricanes impacting U.S. coastal areas as well as growth in coastal development and real GDP.

As with other climate change-related impacts, the Administration is taking a whole-of-government approach to addressing and mitigating the severity of coastal damage. The White House has formed a Coastal Resilience Interagency Working Group that is co-lead by the Council for Environmental Quality and NOAA. Through the Interagency Working Group, agencies are sharing best practices and coordinating their investments in improving coastal resilience, including through the use of nature-based solutions such as restoring coastal wetlands, planting mangroves, and investing in other natural barriers that reduce damage from sea rise and storm surges. The Federal Emergency Management Agency (FEMA) has four "hazard mitigation assistance programs" to mitigate flood risk and build more resilient communities. The Infrastructure Investment and Jobs Act (IIJA)[41] codified the Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM) Act,[42] establishing a new program at FEMA "to provide capitalization grants to States or eligible tribal governments to establish revolving loan funds to provide hazard mitigation assistance to local governments to reduce risks to disasters and natural hazards."[43] NOAA operates a "Digital Coast" platform, which provides the "data, tools, and training communities need to address

[27] National Centers for Environmental Information (NCEI) and National Hurricane Center, National Oceanic and Atmospheric Administration. (2021, Oct. 8). Costliest U.S. tropical cyclones. *https://www.ncdc.noaa.gov/billions/dcmi.pdf*.

[28] List of disaster costs from National Oceanic and Atmospheric Administration, National Centers for Environmental Information. (2021, Oct. 8). U.S. Billion-Dollar Weather and Climate Disasters. *https://www.ncdc.noaa.gov/billions/*.

[29] Kossin, J.P., T. Hall, T. Knutson, K.E. Kunkel, R.J. Trapp, D.E. Waliser, and M.F. Wehner.(2017). Extreme storms. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 257-276, doi: *http://doi.org/10.7930/J07S7KXX*

[30] Fleming, E., J. Payne, W. Sweet, M. Craghan, J. Haines, J.F. Hart, H. Stiller, and A. Sutton-Grier. (2018). Coastal Effects. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 322–352. *https://doi.org/10.7930/NCA4.2018.CH8*

[31] Knutson, T., S.J. Camargo, J.C.L. Chan, K. Emanuel, C.H. Ho, J. Kossin, M. Mohapatra, M. Satoh, M. Sugi, K. Walsh, L. Wu. (2020). Tropical cyclones and climate change assessment: Part II: Projected response to anthropogenic warming. Bulletin of the American Meteorological Society, 101(3): E303-E322. *https://doi.org/10.1175/BAMS-D-18-0194.1*.

[32] Kossin, J.P., T. Hall, T. Knutson, K.E. Kunkel, R.J. Trapp, D.E. Waliser, and M.F. Wehner, 2017: Extreme storms. In: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 257-276: *http://doi.org/10.7930/J07S7KXX*.

[33] Congressional Budget Office. (2016). Potential increases in hurricane damage in the United States: Implications for the federal budget. *https://www.cbo.gov/publication/51518*.

[34] Knutson, T.R., J.J. Sirutis, G.A. Vecchi, S. Garner, M. Zhao, H.S. Kim, M. Bender, R.E. Tuleya, I.M. Held, & G. Villarini. (2013). Dynamical downscaling projections of twenty-first-century Atlantic hurricane activity: CMIP3 and CMIP5 model-based scenarios. Journal of Climate, 26(17). *10.1175/JCLI-D-12-00539.1*. (As cited in CBO (2016).)

[35] Emanuel, K. A. (2013). Downscaling CMIP5 climate models shows increased tropical cyclone activity over the 21st century. Proceedings of the National Academy of Sciences, 110(30), 12219-12224. doi: *10.1073/pnas.1301293110*. (As cited in CBO (2016).)

[36] Congressional Budget Office. (2016). Potential increases in hurricane damage in the United States: Implications for the federal budget. *https://www.cbo.gov/publication/51518*.

[37] Some notable methodology changes that were incorporated, among others: (a) Removing the National Flood Insurance Program (NFIP) portion due to changes to the NFIP program, (b) Including into the cost estimate the entirety of the interaction effect between growth along the coast and climate change, further making simplifying assumptions to assign these proportions in 2050 and for boundary estimates of 2075, and (c) Using recent economic data from the Bureau of Economic Analysis [updated GDP for 2020, GDP deflators] and population projections from CBO [Congressional Budget Office. (2021, Mar). "Demographic Projections."].

[38] Congressional Budget Office. (2016). Potential increases in hurricane damage in the United States: Implications for the federal budget. *https://www.cbo.gov/publication/51518*.

[39] Ranges reflect the middle third of damage draws from CBO simulations, along with CBO assumptions regarding federal spending and new assumptions outlined in the footnote preceding the previous footnote.

[40] Note the Federal baseline spending on coastal disasters is assumed to be $20.9 billion (2020$).

[41] Infrastructure Investment and Jobs Act (Public Law 117–58).

[42] 42 U.S.C. § 5135.

[43] FEMA Press Release: Infrastructure Deal Provides FEMA Billions for Community Mitigation Investments (2021), *https://www.fema.gov/press-release/20211115/infrastructure-deal-provides-fema-billions-community-mitigation-investments*.

coastal issues."[44] Several Federal agencies and academic institutions make up the Interagency Sea Level Rise and Coastal Flood Hazard and Tool Task Force, which recently published the Sea Level Rise Technical Report, providing the Federal Government and others with sea-level rise scenarios for the United States.[45]

National Flood Insurance Program

Flooding—including flooding from hurricanes—is, "the most common and the most expensive natural disaster in the United States."[46] Yet fewer than 60% of single-family homeowners, living in areas where mandatory flood insurance applies, purchase flood insurance even though premiums are subsidized at two-thirds the actuarially fair market rate.[47] According to the NCA4 and NOAA's Global and Regional Sea Level Rise Scenarios for the United States reports, climate change will (a) cause tide and storm surge heights to increase and will lead to a shift in U.S. coastal flood regimes, (b) contribute to the increased severity of hurricanes, and (c) increase precipitation in the Midwest, with impacts on riverine flooding.[48,49] Because of climate change, North Atlantic hurricanes are anticipated to increase in intensity, likely leading to a larger number of major hurricanes but an uncertain change in the overall total number of cyclones.[50]

The National Flood Insurance Program (NFIP) is a program in which, both through private insurance companies as fiscal agents and through a direct program, the Federal Government sells flood insurance to homeowners and businesses in NFIP participating communities.[51,52] NFIP currently provides nearly $1.3 trillion of flood coverage for over five million policyholders.[53] NFIP requires premiums to be actuarially sound, with exceptions for discounts or subsidies to certain property types.[54,55,56,57] Until 2021, premiums were largely based on a structure's elevation within a regulatory flood insurance rate map (FIRM). FIRM only reflects flood hazards at the time the map is updated and do not account for potential future flood risk.[58] NFIP pays claims out of collected premiums and, if losses exceed collections, the amounts are borrowed from the U.S. Treasury, which is set by statute.[59] Because NFIP guarantees flood losses as a federal obligation, larger than anticipated long-term losses can theoretically, and have in the past, become the responsibility of the Federal Government. NFIP is not designed to support large-loss hurricanes, and as a result, Congress has extended NFIP's borrowing capacity and canceled debt in the past.[60]

[44] Federal Emergency Management Agency. (2021). Infrastructure deal provides FEMA billions for Community Mitigation Investments. FEMA.gov. *https://www.fema.gov/press-release/20211115/infrastructure-deal-provides-fema-billions-community-mitigation-investments*.

[45] 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, & C. Zuzak. (2022). Global and regional sea-level rise scenarios for the United States: Updated mean projections and extreme weather level probabilities along U.S. coastlines. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. *https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf*.

[46] Includes flooding from hurricanes. Quoted from: Federal Emergency Management Agency. (2021, May 12). Defining a property's unique flood risk. Video. Retrieved December 22, 2021, from *https://youtu.be/oi2g-0GfgMk*

[47] Wagner, K. (forthcoming). Adaptation and adverse selection in markets for natural disaster insurance. American Economic Journal: Economic Policy. *https://www.aeaweb.org/articles?id=10.1257/pol.20200378&from=f*.

[48] United States Global Change Research Program. (2018). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Vol. II. (Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart, Eds.). doi:10.7930/NCA4.2018.

[49] Global and regional sea-level rise scenarios for the United States: Updated mean projections and extreme weather level probabilities along U.S. coastlines. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pp. *https://oceanservice.noaa.gov/hazards/sealevelrise/noaa-nos-techrpt01-global-regional-SLR-scenarios-US.pdf*.

[50] Knutson, T., Camargo, S. J., Chan, J. C. L., Emanuel, K., Ho, C. H., Kossin, J., . . . Wu, L. (2021, March 1). Tropical cyclones and climate change assessment: Part II: Projected response to anthropogenic warming. Bulletin of the American Meteorological Society, 101(3), E303-322. *https://doi.org/10.1175/BAMS-D-18-0194.1*

[51] The National Flood Insurance Act of 1968, 42 U.S.C. §§ 4001 et seq.

[52] Federal Emergency Management Agency. (n.d.). Floodsmart.gov: National Flood Insurance Program. Floodsmart.gov: About. Retrieved December 22, 2021, from Floodsmart.gov: *https://www.floodsmart.gov/about*

[53] Federal Emergency Management Agency. (n.d.). Flood Insurance. FEMA.gov. Retrieved November 3, 2021, from FEMA.gov: *https://www. fema.gov/flood-insurance*

[54] 42 U.S.C. § 4014 and 42 U.S.C. § 4015.

[55] Horn, D. P., & Webel, B. (2021). Introduction to the National Flood Insurance Program. Report R44593. Washington, D.C.: Congressional Research Service. *https://crsreports. congress.gov/product/pdf/R/R44593*

[56] Congressional Budget Office. (2017). The National Flood Insurance Program: Financial soundness and affordability. Washington, D.C. Retrieved from *https://www.cbo.gov/system/files/115th-congress-2017-2018/reports/53028-nfipreport2.pdf*

[57] 42 U.S.C. § 4014(a)(1); 42 U.S.C. § 4015(c)(actuarial rates); 42 U.S.C. 4014(a)(2)(discounts for certain properties built before FEMA published its initial flood insurance rate map (FIRM) or December 31, 1974, whichever is later); 42 U.S.C. 4014(e)-(f) and 4014 Note (discounts for properties behind certain levees under construction or repair); 42 U.S.C 4015(i)(Discounts for properties newly mapped into a special flood hazard area); 42 U.S.C. 4056 (discounts for policies when a community joins the NFIP and before FEMA has published a FIRM for the community).

[58] Horn, D. P. (2021). National Flood Insurance Program: The Current Rating Structure and Risk Rating 2.0. Congressional Research Service. Retrieved February 28, 2022 from *https://crsreports.congress.gov/product/pdf/R/R45999*. Cackley, Alicia Puente (2021). National Flood Insurance Program: Congress Should Consider Updating the Mandatory Purchase Requirement. U.S. Government Accountability Office. Retrieved February 28, 2022 from *https://www.gao.gov/assets/gao-21-578.pdf*

[59] 42 U.S.C. § 4016.

[60] After the 2005 hurricane season (Katrina, Rita, and Wilma), Congress extended NFIP's borrowing limit. After Hurricane Sandy in 2012, Congress further extended the borrowing ability of the program. In 2017, Congress cancelled $16 billion in debt to allow NFIP to pay for Harvey, Irma, Maria, and other 2017 losses. Horn, D. P. (2021). A brief introduction to the National Flood Insurance Program. Washington, D.C.: Congressional Research Service. Retrieved from *https://crsreports.congress.gov/product/pdf/IF/IF10988*

FEMA has designed a new rating methodology, Risk Rating 2.0, and the first phase was rolled out in 2021. The new system considers a variety of variables to profile properties individually, in line with modern actuarial science.[61] Under Risk Rating 2.0, all NFIP premiums will be actuarially sound reflecting a single property's unique flood risk and over time this new methodology will help close the gap between premiums and losses, even as the risk changes due to climate change and other effects.[62,63,64]

To apply the two climate scenarios to the NFIP, the program utilized Katrisk: one of a few "catastrophe models" used by NFIP to analyze the flood insurance program in the face of different, currently unrealized, risk scenarios.[65] Along with a baseline scenario, NFIP focused on a lower and higher scenarios in both 2050 and 2100, leading to five scenarios.[66] NFIP ran simulations to determine typical losses (average annual loss, or "AAL"), 1-in-20 annual loss levels, and 1-in-50 annual loss levels.[67] All scenarios use NFIP's property portfolio as it currently exists;[68] the baseline scenario is a simulated expected loss in today's environment and the other four scenario simulations expose today's portfolio of properties to a potential future risk with climate change.[69] In other words, the simulation damages represent losses associated with a portfolio of today's properties in NFIP exposed to climate risk that the United States will see in the upcoming decades. Since the property portfolio does not fundamentally change, as one would expect it to between now and the end of the century, this modeling must be understood to be an illuminating risk exercise with somewhat strong assumptions.

In a baseline scenario, a Gross AAL is $3.3 billion.[70] However, under the lower climate change scenario, this increases to $3.5 billion by 2050 and $4.6 billion by 2100. Under the higher climate change scenario, the AAL scenario is $3.7 billion by 2050 and $6.1 billion by 2100. The increases in the 1-in-20-year loss event and 1-in-50-year loss event are noteworthy. The 1-in-20-year loss event is $10.3 billion in the baseline scenario, and the year 2100 losses increase to $13.9 billion (+35%) under the lower scenario and $16.9 billion (+64%) under the higher scenario. The 1-in-50-year loss event is $17.2 billion in the baseline scenario, and the year 2100 losses increase to $22.6 billion (+31%) under the lower scenario and $26.5 billion (+54%) under the higher scenario. In the higher scenario late century, the current portfolio of properties has a 1-in-50-year loss event equal to $20 billion larger than an average annual loss—a difference which is only $14 billion without climate change. Under the risk assumptions, by definition, consecutive or close in time years with 1-in-20 or 1-in-50 losses are rare, but historically, high risk years have caused the NFIP to face shortfalls. If these actuarially rare scenarios are to occur again with climate-change

[61] Federal Emergency Management Agency. (2021). Risk Rating 2.0: Equity in action. FEMA.gov. Retrieved 11 Jan 2022 from *https://www.fema.gov/flood-insurance/risk-rating*

[62] See (1) Federal Emergency Management Agency. (2021, April). Risk Rating 2.0 is equity in action (Fact Sheet). Retrieved December 22, 2021, from *FEMA.gov: https://www.fema.gov/sites/default/files/documents/fema_rr-2.0-equity-action_0.pdf* and (2) Federal Emergency Management Agency. (2021, April 1). FEMA updates its flood insurance rating methodology to deliver more equitable pricing (Press Release HQ-21-079). Retrieved December 22, 2021, from *Fema.gov: https://www.fema.gov/press-release/20210401/fema-updates-its-flood-insurance-rating-methodology-deliver-more-equitable*

[63] Implementation of Risk Rating 2.0 will occur fully by April 1, 2022 with some statutory exceptions. A notable statutory exemption is that premiums are not allowed to rise more than 18% annually. Implementation date and footnote from: Federal Emergency Management Agency. (2021, April). Risk Rating 2.0 is equity in action (Fact Sheet). Retrieved December 22, 2021, from *FEMA.gov: https://www.fema.gov/sites/default/files/documents/fema_rr-2.0-equity-action_0.pdf*

[64] While the new rating system is actuarially fair, there are still risks to the Federal Government from unprecedented large disasters. Despite the development of the Risk Rating 2.0 methodology, mandatory purchase requirements are still tied to the FIRM, which may not adequately depict flood hazards. Risk Rating 2.0 adjusts annual policies as risk changes year-to-year but it cannot account for an unprecedented disaster, even if that disaster represents a new normal because of climate change. FEMA has purchased reinsurance as a risk mitigation strategy to cover a portion of eligible losses occurring during a single large event.

[65] This is one of many models used by NFIP to model climate risk; other models may have slightly different results.

[66] Baseline, low 2050, high 2050, low 2100, high 2100

[67] The 1-in-20 and 1-in-50 annual loss levels are annual loss levels at which the yearly losses are larger than precisely 95% and 98% of loss years.

[68] Specifically, NFIP used its policy holders as of May 31, 2020.

[69] The other four scenario simulations take the properties in the portfolio—as they currently are—and expose them to a simulated climate world that would exist in each of the four respective scenarios. The Katrisk model simulation considers, "losses and probability distributions from storm surge, inland flood, and tropical cyclone-induced precipitation flooding sources."

[70] Figures in this paragraph are in 2020 dollars.

Table 21–2. KATRISK GROSS AAL AND OCCURRENCE EXCEEDANCE PROBABILITIES UNDER BASELINE AND CLIMATE SENSITIVITY SCENARIOS, LOWER (RCP 4.5) AND HIGHER (RCP 8.5) (2020 USD)

(In millions of dollars)

		Lower		Higher	
	Baseline	Mid-Century (2050)	Late Century (2100)	Mid-Century (2050)	Late Century (2100)
Gross AAL	$3,317	$3,539	$4,648	$3,734	$6,098
Increase over baseline	....	7%	40%	13%	84%
1–in–20 loss level	$10,315	$11,025	$13,906	$11,370	$16,896
Increase over baseline	....	7%	35%	10%	64%
1–in–50 loss level	$17,208	$18,476	$22,591	$18,996	$26,507
Increase over baseline	....	7%	31%	10%	54%

increased intensity storms, the Federal Government will face higher losses, should it need to subsidize NFIP.

The simulation in this analysis assumes the 2020 NFIP property portfolio and projects America as it is today into a climate world of the future. As such, the economic or the fundamentals may change course over the century. Long-term macroeconomic indicators may influence the housing market: property values may go up (or down) in real terms, current policyholders may choose to purchase more flood insurance, and/or non-customers may change their mind and purchase a policy. Further, climate change or the move to Risk Rating 2.0 may prompt more adaptation—or increasing incomes may further development of the coast. The floodplain may become more expansive, and more people may be at risk of flooding. These changes are not part of the simulation. Finally, Katrisk is one of many models used by NFIP to model climate risk; other models may have slightly different results. As the country sees realization of the climate change time series, and as Risk Rating 2.0 is rolled out, more work may need to be done to analyze how NFIP risk models are behaving. The full risk may hinge on whether the 2005, 2012, and 2017 hurricane seasons are simply three bad draws of a well-modeled system—or whether actuarial modeling will need to continue to change along with climate change.

FEMA's Risk Rating 2.0 helps mitigate the impact of climate change and makes FEMA programs more equitable. By incorporating more flood risk variables, such as flood frequencies and multiple flood types, Risk Rating 2.0 provides policyholders with more information they need to mitigate the impacts of future flooding.[71] The 2022 and 2023 Budgets proposed a means-tested program that would provide assistance to low- and moderate-income policyholders.

Further, FEMA runs several mitigation programs: the Building Resilient Infrastructure and Communities (BRIC) program, the Flood Mitigation Assistance (FMA) program, the Hazard Mitigation Grant Program (HMGP),[72] and the program created by the Safeguarding Tomorrow through Ongoing Risk Mitigation (STORM Act) that could help to reduce the risk of flooding on NFIP policyholders.[73]. FEMA, NOAA, USGS, and other agencies collaborate in a number of ways to develop data and mapping that support flood hazard identification, risk reduction, and risk communication. Some of this supports the NFIP, such as water levels, bathymetric, topographic, and land cover data and various types of modeling by NOAA that are used in FEMA NFIP flood studies. Multiple federal agencies (NOAA, USGS, USACE, USDA) participate on FEMA's Technical Mapping Advisory Council, providing advice to the FEMA Administrator on flood risk analysis and mapping practices in support of the NFIP. Federal agencies are also working together under the National Climate Task Force's Flood Resilience Interagency Working Group on science and decision-support services to identify and mitigate future flood hazards, including sea-level rise and other climate impacts.

Federal Property and Resource Management

Federal facilities face a number of climate change-related hazards, including increased flood risks, extreme weather events, and fire. For example, flooding damage from heavy downpours is projected to increase in various regions across the country.[74] Also, sea-level rise is expanding the coastal floodplain, causing increased frequency and magnitude of coastal flooding and compound ing damages from storm surges. This increase has led to record numbers of events that cause over $1 billion in damages.[75]

The extent of future changes in flood risk has not been estimated across the full Federal inventory. For instance, assets that were not assessed include national security-sensitive facilities, as well as several types of non-building assets such as transportation and communications infrastructure. However, using the Federal Real Property Profile Management System (FRPP MS), OMB and FEMA assessed flood risks to Federal facilities by overlaying property data with flood maps.[76] OMB and NOAA also evaluated the FRPP MS dataset using NOAA's Sea Level Rise Viewer to assess inundation risk at coastal facilities.

The assessment identified over 40,000 individual Federal buildings and structures with a total combined replacement cost of $81 billion (2020$) located in the current 100-year floodplain. Based on current FEMA floodplain maps, this represents roughly 9 percent of the subset of records and 10 percent of the subset replacement value. Approximately 160,000 structures, with a total replacement cost of $493 billion (2020$) were also identified within the current 500-year floodplain.[77]

Of over 57,000 inventory records reviewed in coastal areas, OMB and NOAA identified 10,250 individual Federal buildings and structures, with a combined replacement cost of $32.3 billion, that would be inundated or severely affected by typical high tide under an eight-foot sea-level rise scenario. Under a ten-foot 'worst case' sea-level rise scenario, over 12,195 individual Federal buildings and

[71] Risk Rating 2.0 produces premiums that are equitable and reflect the unique flood risk of a building. FEMA's legacy rating system does not consider repair costs, which means many policyholders with lower-value homes are paying more than they should and policyholders with higher-value homes are paying less than they should. Consideration of the cost to rebuild is key to an equitable distribution of premiums across all policyholders because it is based on the value of their home and the unique flood risk of their property. Also considering the cost to rebuild is not only more equitable, but is also consistent with industry standard.

[72] 42 U.S.C. §§ 5133 (BRIC), 42 U.S.C. § 4104c (FMA), 5170c (HMGP).

[73] 42 U.S.C. § 5135.

[74] AECOM, 2013. The Impact of Climate Change and Population Growth on the National Flood Insurance Program through 2100. Prepared for the Federal Emergency Management Agency.

[75] National Oceanic and Atmospheric Administration, National Centers for Environmental Information. (2021, Nov. 17). U.S. Billion-Dollar Weather and Climate Disasters. *https://www.ncdc.noaa.gov/billions/*.

[76] Exec. Order No. 13327, 69 Fed. Reg. 5897 (Feb. 6, 2004) Federal Assets Sale and Transfer Act of 2016 (FASTA); (Pub. L. 114-287).

[77] Note that 'total replacement cost' does not represent projected Federal expenditures. Expenditures on Federal facilities due to future flooding is not projected and is expected to be a subset of the summed total replacements costs.

structures would be inundated, with total combined replacement cost of over $43.7 billion.

The Biden Administration has taken several proactive steps to reduce the risk of flooding to Federal facilities. The Administration reactivated the development of a Federal Flood Risk Management Standard (FFRMS) through a Flood Resilience Interagency Working Group to ensure that agencies expand management from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain for Federal actions and federally funded projects. In addition, in 2020 General Services Administration (GSA) conducted a high-level assessment of the flood vulnerabilities of assets under its jurisdiction. GSA has started the process of integrating considerations for the financial impacts of the physical and transition risks of climate change into GSA decision-making processes, including leveraging U.S. Global Change Research Program information for more resilience capital projects. OMB and the Council on Environmental Quality (CEQ) are also exploring options to integrate climate change considerations into capital planning and program management, such as how forward-looking climate information can be incorporated into major acquisitions.

Housing

In addition to the aforementioned exposure through the NFIP, the Federal Government provides mortgage insurance for both single family and multifamily housing, primarily through programs within the Federal Housing Administration (FHA), Veterans Benefits Administration (VBA), and USDA Rural Housing Service, and facilitates liquidity for home loans through secondary guarantees provided by the Government National Mortgage Association (Ginnie Mae). Through housing credit programs, the Federal Government promotes homeownership and affordable housing among various target groups, including low- and moderate-income people, veterans, and rural residents. At the end of FY 2021, the four largest single-family programs had a combined gross exposure of $2.09 trillion, accounting for approximately 17% of the total mortgage market. [78] Although the analysis below is focused on single family housing, similar risk factors affect the multifamily and rental markets.

There is a well-established and growing body of literature which highlights the increased financial risks that climate change will bring to the housing sector and to the Federal Government in its role as guarantor of mortgages and mortgage-backed securities.[79] This is likely to grow in the short-term because of market imperfections related to risk perceptions of homebuyers.[80] Increased storm severity, flooding, wildland fires, and other natural disasters are acute physical risks that severely impact communities, which in turn can lead to higher default claim payments and lower recoveries in the event of default.[81] Such increased defaults would translate into faster prepayments on underlying mortgage-backed securities, and thus could lead to a loss of guarantee fee income to Ginnie Mae or cause it to become successor to a defaulted issuer portfolio. Additionally, chronic physical risks in the form of repeated disasters may eventually lead homeowners and renters to reconsider whether a particular neighborhood or entire community is too vulnerable to natural disasters to consider rebuilding. As with acute physical risks from specific disasters, this may affect localized home values and lead to lower recoveries in the event of default. Further, adaptation costs—such as the increased cost of building new homes or retrofitting existing structures to withstand increased disaster severity or frequency—may price out already vulnerable populations from a chance at homeownership and affordable housing more generally.[82] Finally, lenders who participate in these programs are also likely to incur increased operating costs and liquidity strains based on increasingly severe and frequent effects of climate change.

Although there is still uncertainty as to how much these risks will impact the Federal housing portfolio, even small changes in default, recovery, and prepayment assumptions affect the expected cost to the Federal Government. These risks and costs will be spread unevenly over the portfolio, but recent disaster such as Hurricanes Irma and Harvey, and major wildland fires in the West, indicate the magnitude that these events may have on Federal costs. During these disasters, Federal housing agencies may be called upon to change their normal operations, such as by altering default mitigation waterfalls (i.e., the order in which lenders may offer default alternatives to borrowers), which can also increase expected costs.

Each year, agencies estimate the total size of the housing market and their likely market share based on the economic assumptions of the President's Budget. The Budget projects $614 billion in primary guarantees will be provided by the four largest single-family housing guarantee programs in 2023. On a present value basis, even a one percent relative increase in events of default would increase the expected cost of these programs by $110 million, and a one percent relative decrease in recoveries after defaults would incur an additional cost of $107 million based on sensitivity analyses conducted by FHA, VBA, and USDA. While this is not an explicit projection of damages, the impact of increasingly severe climate change could clearly induce even larger Federal costs, especially when compounded over time. Similar analysis is also applicable to the multi-family housing market, which was not included in the totals listed above. In addition

[78] Urban Institute Housing Finance Policy Center, Housing Finance at a Glance, February 2022. *https://www.urban.org/sites/default/files/publication/105511/housing-finance-at-a-glance-a-monthly-chartbookfebruary-2022_1.pdf*

[79] Reinsurance Association of America, Statement for the Record, United States House of Representatives Committee on Financial Services, (May 4, 2021).

[80] Laura A Bakkensen, Lint Barrage, Going Underwater? Flood Risk Belief Heterogeneity and Coastal Home Price Dynamics, The Review of Financial Studies, 2021, hhab122, *https://doi.org/10.1093/rfs/hhab122*

[81] Paulo Issler, Richard H. Stanton, Carles Vergara-Alert, and Nancy E. Wallace, Mortgage Markets with Climate-Change Risk: Evidence from Wildfires in California (July 1, 2020). Available at SSRN: *https://ssrn.com/abstract=3511843*

[82] Sean R. Becketti, The Impact of Climate Change on Housing ad Housing Financing (September 23, 2021). Available at SSRN: *https://ssrn.com/abstract=3929571*

to direct financial risks, increasingly severe and frequent effects of climate change may also increase the administrative cost of operating these programs.

Healthcare

Scientific literature examines health impacts from climate change in several key areas: temperature-related death and illness; changes to air quality; extreme weather events; vector-borne diseases; water-related illness; food safety, nutrition, and distribution; and mental health and well-being. For instance, more frequent, severe, prolonged extreme heat events will lead to elevated temperature exposure and increased heat-related deaths and illnesses.[83] Worsened air quality from surface ozone and higher pollen counts will elevate the risk of cardiovascular and respiratory illness.[84] Climate change is also expected to alter the risk of vector-borne disease by changing the distribution of existing disease vectors and causing new vector-borne pathogens to emerge.[85] All of these pathways can cause an increase in both premature death (mortality) as well as non-fatal health problems (morbidity). Higher morbidity rates in particular cause healthcare utilization to grow over the long-term, increasing total healthcare expenditures by private insurers as well as public programs like Medicare and Medicaid since higher morbidity rates in particular cause healthcare utilization to grow, increasing total healthcare expenditures by private insurers as well as public programs like Medicare and Medicaid.[86]

Research projects increases in premature death due to air quality and heat-related mortality by the end of the century. For instance, more than 100,000 annual premature deaths are projected in the United States from heat-related mortality under a higher emissions scenario.[87,88] Other research estimates tens of thousands of avoided deaths from air pollution in scenarios where GHG emissions are significantly reduced by the end of the century.[89]

The Environmental Protection Agency's (EPA) Framework for Evaluating Damages and Impacts (FrEDI) was used to quantify morbidity and mortality at mid- and late-century while also referencing two main GHG emission scenarios that were referenced in NCA4. FrEDI provides a method of utilizing existing climate change sectoral impact models and analyses to create estimates of the physical and economic impacts of climate change by degree of warming. Mortality estimates are available for air quality and extreme temperatures, whereas both mortality and morbidity estimates are available for valley fever, southwest dust, and wildfires. The quantified assessments presented in this chapter are limited to morbidity impacts.

Commensurate with some expected public health effects of climate change, and assuming a consistent Federal share of Medicare and Medicaid ratio of spending, OMB estimates that Federal climate-related healthcare spending in a few key areas could increase by between $824 million and $22 billion (2020$) dollars by the end of the century.[90] This increase alone would tally up to approximately 1 percent of additional national health expenditures. OMB estimates that additional Federal healthcare costs due to climate change specifically related to valley fever, southwest dust, and wildfires could range from $169 million to $353 million by the end of the century. Since morbidity estimates for ozone and particulate matter are currently unavailable under FrEDI, this assessment does not include an updated quantification of potential Federal health expenditures related to future ozone and PM2.5 scenarios. As several health-related climate impacts were not able to be quantified in this assessment, such as mental and behavioral health impacts, it is possible that total actual Federal healthcare spending increases will be significantly higher than those presented in this Chapter.

The Federal Government continues to prioritize actions that strengthen Americans' access to quality, affordable healthcare, including activities that will help address current and future health risks caused by climate change. For instance, the Department of Health and Human Services (HHS), the EPA, and NOAA co-lead an Extreme Heat Interagency Working Group that coordinates the Federal response to debilitating and often deadly extreme heat events. Among other initiatives, NOAA and HHS are increasing the availability of information about extreme heat events and their ramifications, including increased hospitalizations associated with such events. EPA is evaluating the impacts of extreme heat on disadvantaged and underserved populations and is funding a "cooling communities" initiative. The Department of Labor has initiated a heat-related worker safety standard-setting and enforcement initiative. Also, the Department of Transportation and the USDA are investing in infrastructure and urban forestry programs that will reduce urban heat island ef-

[83] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

[84] National Climate Assessment (NCA 2018): Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. *https://nca2018.globalchange.gov/*

[85] Rocklöv, J., Dubrow, R. Climate change: an enduring challenge for vector-borne disease prevention and control. Nat Immunol 21, 479–483 (2020). *https://doi.org/10.1038/s41590-020-0648-y*

[86] This is an initial assessment and OMB is interested in expanding the analysis in future iterations.

[87] Shindell, D., Zhang, Y., Scott, M., Ru, M., Stark, K., & Ebi, K. L. (2020). The effects of heat exposure on human mortality throughout the United States. GeoHealth, 4, e2019GH000234. *https://doi.org/10.1029/2019GH000234*

[88] Bressler, R.D., Moore, F.C., Rennert, K. et al. Estimates of country level temperature-related mortality damage functions. Sci Rep 11, 20282 (2021). *https://doi.org/10.1038/s41598-021-99156-5*

[89] Fernando Garcia-Menendez, Rebecca K. Saari, Erwan Monier, and Noelle E. Selin Environmental Science & Technology. 2015; 49 (13), 7580-7588 *https://pubs.acs.org/doi/abs/10.1021/acs.est.5b01324*

[90] This calculation sums estimates on air quality impacts from a previous 2016 OMB assessment (adjusted for inflation), plus recent OMB morbidity impact assessments for valley fever, southwest dust, and wildfires: OMB, 2022. Climate Risk Exposure: An Assessment of the Federal Government's Financial Risks to Climate Change. Office of Management and Budget (forthcoming).

fects. To assist the Nation in preventing and preparing for the health impacts of climate change, the Department of Health and Human Services has established the Office of Climate Change and Health Equity. The office is working with each Division of the Department to identify relevant measures to assist in climate change adaptation for health, with a special emphasis on protecting communities that are experiencing the greatest burden of climate impacts and health disparities. It is also working across the Federal Government and in collaboration with the private sector to establish guidance for enhancing the resilience of health systems. HHS agencies that provide insurance coverage and services are also collaborating to protect beneficiaries from the worst impacts of climate change. These agencies are exploring updates to Centers for Medicare and Medicaid facility requirements to better anticipate climate risks and exploring flexibilities that will allow more authorized spending in response to the health challenges associated with climate change (e.g., spending on air filtration).

Wildland Fire Management

Climate change is contributing to an increase in wildland fire extent[91] across the western United States and Alaska. The NCA4 found the increasing duration of the wildland fire season in the western United States is primarily caused by higher temperatures and earlier snowmelt. While wildland fire is more commonly associated with the western United States, the NCA4 notes that the southeastern United States is projected to experience increasing wildland fire activity due to climate change. The damages associated with wildland fire have been increasing over the past several decades.

The effects of climate change on wildland fire are complex and go beyond the weather's direct impact on fire behavior: for example, climate change is also increasing the likelihood of tree mortality from drought and insect outbreaks which subsequently increases the risk of wildland fire.[92] In addition, the impacts of climate change on wildland fire behavior interact with other human impacts on the environment such as increased development that expands the wildland urban interface. The complex problem of increasing risk of damage from wildland fire will require collective action across a wide variety of agencies and jurisdictions in the coming years.

The Federal Government has developed a sophisticated, multi-agency response to wildfires that is coordinated through the National Interagency Fire Center in Boise, Idaho.[93] Through the NIFC, the USDA's Forest Service (FS) and the Department of the Interior's (DOI) land management agencies work together as a single unit in responding to wildfires, in close coordination with State and local partners. Unfortunately, due to climate change, the size and intensity of wildfires has been increasing dramatically in recent years.

Recent historical trends show a strong upward trend in acres burned by wildland fire and consequently in wildland fire suppression costs. While the number of reported wildland fires across the United States has trended downward over the last 30 years, the number of acres burned by wildland fire is rising. In 2015, 2017, and 2020, over 10 million acres burned annually. By 2020, the 10-year average of burned acres exceeded 7.5 million, almost 150% higher than the 10-year average of burned acres 26 years ago.[94] The 10-year average for federal funding of wildland fire suppression has also been trending upward for decades. The 10-year average in 1994 was $723 million (2020$) for the FS and DOI combined. Twenty-six years later, the 10-year average has climbed to $2.2 billion (2020$).[95]

Researchers at the USDA FS projected acres burned by wildland fire and wildland fire suppressions expenditures for FS and DOI during mid-century (2041-2059) and late century (2081-2099) periods. The researchers made these projections, for the FS and DOI, by first estimating historical acres burned in each of eight regions of the continental United States using the historical monthly average of daily maximum temperature and historical monthly average of daily vapor pressure deficit in each of those regions. Wildland fire suppression expenditures were then estimated as a function of acres burned. Using these estimated historical relationships, the researchers then projected acreage burned and wildland fire suppression expenditures in the future under different climate conditions. The FS researchers utilized moderate radiative forcing ("moderate emissions") and high radiative forcing ("higher emissions") scenarios, which are inputs to project changes in climate factors like temperature and precipitation through General Circulation Models (GCMs). The researchers used five different GCMs to obtain a broad band of results under differing assumptions. The results were compared to the historical period 2006-

[91] 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://www.fs.fed.us/rm/pubs_journals/2020/rmrs_2020_parks_s002.pdf*.

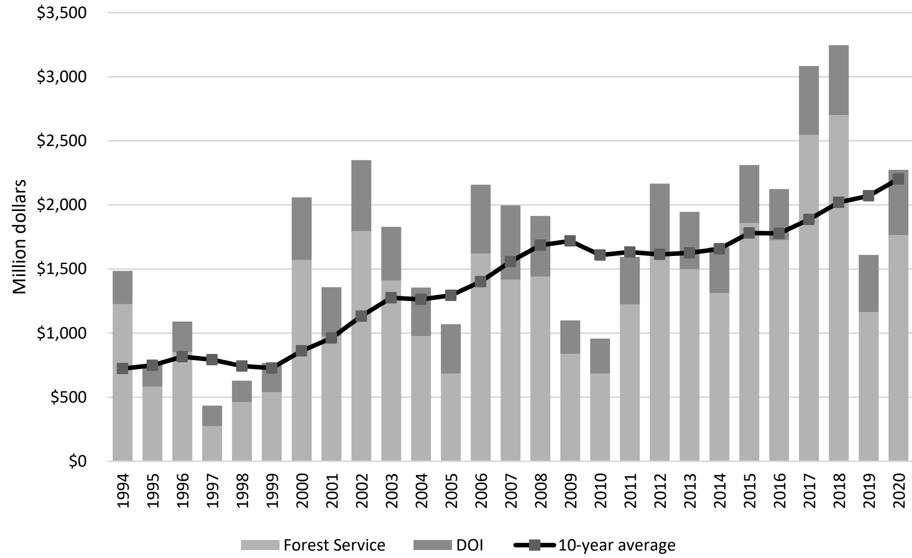
[92] Vose, J.M., D.L. Peterson, G.M. Domke, C.J. Fettig, L.A. Joyce, R.E. Keane, C.H. Luce, J.P. Prestemon, L.E. Band, J.S. Clark, N.E. Cooley, A. D'Amato, and J.E. Halofsky. (2018). Forests. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 232–267. *http://doi.org/10.7930/NCA4.2018.CH6*

[93] Because wildland fires do not respect jurisdictional boundaries, wildland fire suppression requires coordination across Federal agencies and various levels of government. The Department of the Interior (DOI) is responsible for wildland fire management on federal lands managed by DOI, including lands under the Bureau of Land Management and National Park Service and tribal lands. Wildland fires in the National Forest System are the responsibility of the U.S. Department of Agriculture's Forest Service. For State, local, and private lands, State agencies are responsible for wildland fire suppression. However, there is coordination among the States and Federal agencies through the National Multi-Agency Coordination Group housed at the National Interagency Fire Center in Boise, Idaho.

[94] The 10-year average is the for 2020 includes the years 2011-2020, and the 10-year average for 1994 includes the years 1985-1994.

[95] National Interagency Fire Center. (2021). Statistics. *https://www.nifc.gov/fire-information/statistics*

Chart 21-1. Wildland Fire Suppression Spending by USDA Forest Service and the Department of the Interior, 1994-2020 (2020$)



Source: National Interagency Fire Center (2021); Office of Management and Budget for the GDP-chain deflator from Table 10.1 of the President's Budget (2021)

2018, in which wildland fire suppression expenditures averaged $2.0 billion (2020$).[96]

Wildland fire suppression expenditures of FS and DOI are anticipated to increase due to climate change. For the midcentury period, the moderate emissions scenario is anticipated to increase outlays by $0.83 billion annually, while the higher emissions scenario projects an increase in outlays by $2.32 billion per year. The median projected increase (across all GCMs and emission scenarios) for expenditures by mid-century is $1.67 billion annually. For the late century period, the moderate emissions scenario is anticipated to increase outlays by $1.55 billion annually, while the higher emissions scenario is projected to increase outlays by as much as $9.60 billion annually. The median projected increase (across all GCMs and emission scenarios) for expenditures in the late century is $3.71 billion annually.[97]

Given these high costs and very troubling trends, the Federal Government is devoting significantly more attention in increasing the resilience of forests and rangelands to wildfire events by investing in landscape scale and strategically placed fuels treatments, prioritizing the areas as highest risk of wildfire. Deploying science-based thinning and prescribed fire across the landscape can be an effective and cost-efficient way to maintain fire-adapted ecosystems, making them more resilient to fire. The FS recently developed a 10-year wildfire mitigation strategy, in coordination with the Interior Department, that describes these types of pre- and post-fire mitigation and rehabilitation investments.[98] IIJA[99] has substantially increased the budgets of both the Interior Department and the USDA to engage in wildfire mitigation activities. IIJA also has established a new Wildland Fire Mitigation and Management Commission. It will work closely with the Wildfire Resilience Interagency Working Group that is co-led by the USDA, DOI, and OMB.

Other Direct and Indirect Costs

The total costs of climate change to the Federal Government are expected to be larger than those which are quantified through individual assessments. The projected expenditures in this chapter highlight examples of the impact of climate change on Federal programs and taxpayers. There are several anticipated impacts of climate change on the Federal budget that are not modeled in this assessment. For example, Federal healthcare expenditures linked to several health-related outcomes like extreme heat exposure or mental health impacts are not modeled, nor is emergency Federal assistance for tornadoes, hail, and blizzards. Congressional supplemental assistance for agriculture is not included, which has notably increased in recent years. As research advances, additional Federal programs may be incorporated into future analysis of climate-related fiscal risks. The Federal

[96] OMB, 2022. Climate Risk Exposure: An Assessment of the Federal Government's Financial Risks to Climate Change. Office of Management and Budget (forthcoming).

[97] OMB, 2022. Climate Risk Exposure: An Assessment of the Federal Government's Financial Risks to Climate Change. Office of Management and Budget (forthcoming).

[98] Forest Service, U.S. Department of Agriculture. (2022).Wildfire Crisis Strategy. FS-1187a. *https://www.fs.usda.gov/sites/default/files/Confronting-Wildfire-Crisis.pdf*

[99] Infrastructure Investment and Jobs Act (Pub. L. 117-58).

Government will also likely incur additional direct and indirect costs attributed to infrastructure, national security, and species recovery efforts as a result of climate-driven changes across sectors of the economy. However, for some of these topics, it is inherently difficult to quantify risks and expenditures that are related to climatic factors such as extreme weather and rising temperatures. A summary of the qualitative impacts of select risks is provided below.

Infrastructure Risks

Climate change poses challenges to infrastructure by potentially causing damage and disruptions in infrastructure services through climate-related events, as described in the NCA4.[100] Infrastructure built to withstand historical climate-related hazards may not be capable of enduring the more severe conditions projected for the future. Given the necessity of infrastructure for a functioning economy, service interruptions caused by weakened or damaged infrastructure could have notable impacts on the economy at large.

Climate change has both immediate and long-term effects on infrastructure. The immediate impacts could include delays on rail systems due to extreme heat causing the expansion and weakening of rail tracks as well as air travel delays because of the need for longer takeoff distances, in order to facilitate lift-off.[101] The longer-term impacts could include damage to roadways from high temperatures causing asphalt to buckle and need more frequent repairs;[102] impacts to water infrastructure due to drought and high temperatures which not only worsen ground water depletion but can also weaken earthen dams and levees;[103] negative impacts on thermoelectric power generation which requires surface water for cooling; and declines in snowpack and changes in snowmelt timing in the western United States which could affect availability of hydropower generation.[104]

Drought and high temperature are not the only climate-related threats to infrastructure. Rising frequency of heavy precipitation and strong winds presents perils for infrastructure, both in coastal and inland regions. Intense rainfall has the potential to wash away bridges and roads, cause tunnels for utilities and transportation to become inoperable, and delay air travel. Flooding can also lead to disruptions at ports due to delays of cargo on trucking and rail systems.[105] Severe flooding has the potential to deteriorate or cause breaches in dams or levees.[106] More frequent flooding and other extreme weather events including severe cold snaps such as the one that hit Texas in 2021 also can damage energy infrastructure, causing more frequent and longer power outages.[107] While the above outlines multiple severe impacts of climate change on infrastructure, this summary is by no means comprehensive of all the possible impacts. For example, sea-level rise presents additional severe risks to coastal infrastructure, due to increased risk of coastal flooding, as discussed in other sections of this chapter. Also noting climate change's impacts on infrastructure do overlap with other sections of this chapter, including the sections on coastal disasters and flooding of Federal facilities.

Climate change could impact Federal expenditures relating to infrastructure in multiple ways. For example, the Army Corps of Engineers, the Bureau of Reclamation, and the Tennessee Valley Authority maintain and repair the water resources infrastructure that they own, while the Power Marketing Administrations and the Tennessee Valley Authority maintain and repair the transmission lines that they own. A large flood can damage some of these assets, or otherwise affect the ability of these agencies to make water and power available to their customers. Similarly, a drought can increase the cost that the Bureau of Reclamation incurs in those watersheds where it purchases water for fish and wildlife. Thus, in those parts of the country where the incidence of large floods or other extreme weather events due to climate change will increase, Federal expenditures for these agencies may also increase. Additionally, State Departments of Transportation, who are the largest recipients of Federal highway formula funding, may need to use a larger amount of their fed-

[100] USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. *https://doi.org/10.7930/NCA4.2018*

[101] Jacobs, J.M., M. Culp, L. Cattaneo, P. Chinowsky, A. Choate, S. DesRoches, S. Douglass, and R. Miller. (2018). Transportation. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 479–511. *https://doi.org/10.7930/NCA4.2018.CH12*

[102] Ibid.

[103] Lall, U., T. Johnson, P. Colohan, A. Aghakouchak, C. Brown, G. McCabe, R. Pulwarty, and A. Sankarasubramanian, 2018: Water. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 145–173. *https://doi.org/10.7930/NCA4.2018.CH3*

[104] Zamuda, C., D.E. Bilello, G. Conzelmann, E. Mecray, A. Satsangi, V. Tidwell, and B.J. Walker. (2018): Energy Supply, Delivery, and Demand. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 174–201. *https://doi.org/10.7930/NCA4.2018.CH4*

[105] Jacobs, J.M., M. Culp, L. Cattaneo, P. Chinowsky, A. Choate, S. DesRoches, S. Douglass, and R. Miller. (2018). Transportation. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 479–511. *https://doi.org/10.7930/NCA4.2018.CH12*

[106] Lall, U., T. Johnson, P. Colohan, A. Aghakouchak, C. Brown, G. McCabe, R. Pulwarty, and A. Sankarasubramanian, 2018: Water. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 145–173. *https://doi.org/10.7930/NCA4.2018.CH3*

[107] Zamuda, C., D.E. Bilello, G. Conzelmann, E. Mecray, A. Satsangi, V. Tidwell, and B.J. Walker. (2018): Energy Supply, Delivery, and Demand. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 174–201. *https://doi.org/10.7930/NCA4.2018.CH4*

eral funding to make projects resilient to climate change. This, in turn, reduces the amount of federal funding available for additional transportation projects. In addition, climate change impacts from flooding and other events may increase the number of projects eligible for the Federal Highway Administration's Emergency Relief (ER) Program, which helps States repair or reconstruct highways damaged by natural disasters or catastrophic failures. Supplementals are periodically enacted to fill in the gap between the cost of eligible ER program projects and the amount of available ER program funding, with the most recent supplemental providing $2.6 billion for the ER program. Finally, climate change presents a budgetary risk to transportation infrastructure owned by the Federal Government, such as roads on Federal lands and large equipment at airports. The Federal Government may need to provide additional expenditures to repair or reconstruct these assets when they are damaged by climate change consequences, or make them more resilient when they are originally built or purchased.

National Security

Increasing temperatures, changing precipitation patterns, and more frequent, intense, and unpredictable extreme weather conditions caused by climate change are exacerbating existing risks and creating new challenges for Department of Defense (DOD) missions, plans, and installations. Climate change is also shaping the strategic environment in which the DOD operates. Climate change impacts, when combined with other stressors, are likely to contribute to political, economic and social instability.

Responding to the Administration's *Executive Order Tackling the Climate Crisis at Home and Abroad*, DOD has elevated climate considerations to be an essential element of U.S. national security. For instance, DOD recently released the following documents to begin adapting Departmental plans, policies, and procedures to the climate challenge:

- The DOD Climate Adaptation Plan (CAP) provides a roadmap to ensuring the Department maintains the ability to operate under changing climate conditions while preserving operational capabilities and protecting systems essential to our success.
- The DOD Climate Risk Analysis (DCRA) focuses on the geo-strategic and mission implications of climate change. It is the framework for shared Department-wide understanding of climate change and its effects.
- Additionally, utilizing the Defense Climate Assessment Tool (DCAT), DOD has analyzed the exposure of military installations to a range of climate hazards and reflected outcomes in the "DOD Installation Exposure to Climate Change at Home and Abroad" report.

With the CAP and the DCRA as a foundation, DOD is integrating climate change considerations across strategic guidance and planning documents, including the National Defense Strategy. The 2023 Budget aligns investments to improve the resilience of military installations and the mission critical capabilities they support. These investments will strengthen the ability of installations to operate under adverse conditions and to rapidly recover from disruptions, whether natural or man-made. Additionally, this budget invests in initiatives to improve the energy efficiency and capability of current and future combat systems, helping to ensure their supportability and effectiveness in contested environments.

Ecosystem Services and Biodiversity

All Americans depend on the services that ecosystems provide, including clean air and water, food and resources, and support for cultural heritage and livelihoods. A large body of evidence, summarized in the Fourth National Climate Assessment, shows that climate change is impacting ecosystems in multiple ways, including: losing the capacity to buffer impacts of extreme events, altering the plant and animal life that inhabit regions of the United States, changing the timing of biological events, and reducing the ability to regulate water and air quality. These impacts are closely tied to how plant and animal species are responding to climate change—many species are unable to cope with these disturbances leading to permanent extinctions unless significant emissions of GHGs are avoided. Climate impacts, for instance, affect forest ecosystems, which in turn can affect the timber supply and the Federal Government's financial management of those resources. In addition, many ecosystems provide important resilience functions for communities. For example, healthy, intact salt marshes can buffer coastal communities from inundation. Harnessing natural and nature-based infrastructure can be an important strategy for increasing climate resilience, while providing additional benefits from ecosystems.

Financial risks to the Federal Government for programs that help support ecosystem services and species protections are very broad and difficult to monetize. In addition to financial risks caused by increased wildland fire discussed above, climate change also impacts the health and functionality of the Nation's watersheds, causing significant changes in water quantity and quality across the country. For example, the DOI, which is the largest distributor of water in the country, must increasingly alter water management to account for decreased snowpack and differences in the timing and volume of spring runoff to support wildlife, as well as water customers. Climate change is also shifting and often exacerbating the range of invasive species, which creates additional cost for land management agencies seeking to maintain native biodiversity and healthy ecosystems.

Both mitigation and adaptation actions by the Federal Government, along with State, local, tribal governments, and private organizations will be needed to curb the worst effects of climate change on ecosystems within the United States. The NCA4 notes that many adaptation initiatives generate benefits that exceed their investment costs by more than half, and benefits can exist in the near- and long-term. Some Federal programs currently promote nature-based solutions, such as the U.S. Army Corps of Engineers' Engineering with Nature Initiative or FEMA

Public Assistance grants that consider natural features for being improved,[108] but more efforts are needed to leverage the full potential of nature-based solutions. The United States needs to act quickly to continue to experience the same benefits from America's ecosystems as have been afforded to date.

Lost Revenue

Climate change is projected to reduce economic output and, in turn, revenue for the Federal Government, adding hundreds of billions of dollars to the Federal deficit. Projections by the International Panel of Climate Change (IPCC) include a warming range of about 3.3 to 5.7 degrees Celsius (5.9 to 10.3 degrees Fahrenheit) over preindustrial levels by 2100 if recent global emissions are allowed to continue along IPCC's high-end scenario.[109] Available economic assessments of warming of the low-end of this range indicate economic damages that could range from 3 to 10 percent of U.S. GDP each year by 2100.[110] In addition, there is significant variation across current models stemming from whether economic damages accrue to the level of GDP or the growth rate of GDP over time. A small change in the growth rate can accumulate into large annual damages over a longer horizon, increasing the economic impact on GDP.[111]

Estimates of GDP impacts do not tell the whole story. For example, researchers have yet to determine the economic impact of climate change on important goods and services that are more difficult to quantify and monetize, but which the Federal Government has obligations to safeguard, limit or protect, such as biodiversity loss, increased ocean acidification, and catastrophic events. The economic cost of each must be determined in light of the irreversibility of climate change impacts, tipping points leading to non-linear changes to the climate, and heightened political instability as a result of climate impacts. In an effort to capture these risks, the Federal Government has initiated an Interagency Working Group to develop the capability to measure the economic impacts of a wider range of physical risks.

The uncertainty of economic loss projections is compounded when attempting to estimate the associated potential for lost Federal revenue in the United States. Assuming the underlying economic loss projection is accurate, lost revenue could be as high as 1.9 percent of U.S. real GDP in 2100.[112] In today's dollars, a 2100 tax revenue loss of that magnitude equals $2 trillion in lost tax revenue. It should be noted that this example does not take into account the fact that a portion of the projected economic losses include non-market losses that harm American society, but may not directly translate into lost revenue.

The Need for Action

The United States and the rest of the world has a narrow moment to pursue actions to avoid the most catastrophic impacts of the climate crisis. By reducing GHG pollution from 2005 levels by 50-52% in 2030 and reaching net-zero emissions economy-wide by no later than 2050, we can do our part to avoid the worst and irreversible impacts of climate change.[113] The Administration is taking a whole-of-government approach to reduce emissions in every sector of the economy; increase resilience to the impacts of climate change; protect public health; conserve our lands, waters, and biodiversity; deliver environmental justice; and spur well-paying union jobs and economic growth, especially through innovation, commercialization, and deployment of clean energy technologies and infrastructure. With that approach is a need to advance consistent, clear, intelligible, comparable, and accurate disclosure of climate-related financial risk while taking near-term actions to reduce exposure to those risks.

Through the Bipartisan Infrastructure Law, the Administration also secured the largest investments ever in our Nation's water infrastructure, power grid, public transit, and resilience. It will make our communities safer and our infrastructure more resilient to the impacts of climate change, with an investment of over $50 billion to protect against droughts, heat, floods and wildfires, in addition to a major investment in weatherization. It invests more than $65 billion through the Department of Energy to upgrade our power infrastructure, facilitate the expansion of renewables and clean energy, and fund new programs to support the development, demonstration, and deployment of cutting-edge clean energy technologies to accelerate our transition to a zero-emission economy. And it will build out a nationwide network of electric vehicle charging stations, deliver thousands of electric school buses, and reduce emissions near ports and airports.

The *2023 Budget* highlights several near-term budgetary needs that will both help reduce the Federal Government's long-term fiscal exposure to climate-related financial risk and reduce future climate risks for all Americans. In total, the Budget invests a historic $44.9 billion in discretionary funding to tackle the climate cri-

[108] Public Assistance grants that help improve or maintain a natural feature must meet several conditions, such as improvement to natural characteristics and enhanced function of the feature.

[109] Very likely range for changes in global surface temperature under scenario SSP5-8.5 in the long term, 2081-2100. IPCC. (2021). Climate Change 2021: Summary for Policymakers. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, V. Masson-Delmotte and P. Zhai (eds.)]. IPCC, Geneva, Switzerland, 40. *https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf*

[110] NGFS. (2021). NGFS Climate Scenarios for central banks and supervisors. *https://www.ngfs.net/sites/default/files/media/2021/08/27/ngfs_climate_scenarios_phase2_june2021.pdf*.

[111] Burke, M., H. Solomon, and E. Miguel. (2015). Global Non-Linear Effect of Temperature on Economic Production. Nature. 527: 235-9. *https://doi.org/10.1038/nature15725*

[112] This result uses a 10 percent impact on U.S. GDP, which represents the 95th percentile of estimated economic damages under the NGFS 'Current Policy' scenario.

[113] White House Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies. April 22, 2021. Received from *https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/*

sis, a nearly 60 percent increase over 2021. This includes more than $15 billion to increase clean energy innovation and deployment, and further U.S. competitiveness through innovative technologies that accelerate the transition to a clean energy economy. This also includes more than $18.1 billion to strengthen climate resilience and adaptation efforts across the Federal Government—including investments to increase the resilience of ecosystems and communities to wildfires, flooding, and drought and better incorporate climate impacts into pre-disaster planning and infrastructure development to ensure that the Nation is rebuilding smarter and safer for the future.

The Administration has not only taken bold action to confront the financial risks created by the climate crisis, but turned it into an opportunity to advance environmental justice. Severe harms from climate change fall disproportionally upon socially vulnerable populations, and racial and ethnic minority communities are particularly vulnerable to climate impacts. The Budget supports communities that have been left behind by targeting investments to ensure that 40 percent of the benefits from tackling the climate crisis are directed toward addressing the disproportionately high cumulative impacts on disadvantaged communities.

Near-term Federal investments to both mitigate GHG emissions and adapt to future climate scenarios can help reduce future financial burdens, but will rely on both Congressional appropriations and Federal implementation to reduce those risks. While the Federal programs and activities mentioned in this chapter are expected to reduce the Federal Government's exposure to future climate-related financial risks, more work is needed to identify and quantify the impact of factors that can mitigate or compound climate change fiscal risk. Investments in adaptation, for instance, can significantly reduce future risk exposure. Higher up-front adaptation costs will save taxpayers and the Federal Government in the long-term. On the other hand, business as usual investments could further exacerbate future climate risks. Better understanding and analysis to quantify factors like these as they relate to Federal budget formulation is important for taking steps to mitigate the broad and urgent financial crises the Federal Government could face.