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Abstract

More frequent and severe weather events are projected with climate change. The U.S. Federal Government offers programs to help producers mitigate the financial impacts of these adverse events, the largest of which is the USDA, Federal Crop Insurance Program (FCIP). The potential impacts on FCIP outlays under future climate scenarios have been explored but most analyses have focused on impacts on field crops. A changing climate could also affect forage commodities and livestock producers. The Pasture, Rangeland, and Forage (PRF) insurance plan was designed to help producers mitigate financial losses associated with a lack of precipitation. Payments are triggered if precipitation is below a historical index. Payment amounts are determined by the decrease in precipitation, changes in biomass value, and participation in the program. This report provides projected changes to precipitation (using climate estimates), biomass (using a livestock rangeland model), and future participation in the program. Results show that net payments (defined as indemnities, plus premium subsidies, minus total premiums) are projected to range from an annual average of approximately $495 million per year to $2.63 billion per year between 2024 and 2050 compared to the average net payments of $603 million per year (in 2024 terms) observed in 2020–23.

About the Authors

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Potential Budgetary Impacts of Climate Change on the Pasture, Rangeland, and Forage Insurance Plan

Introduction

More frequent and severe climate events are projected as the climate changes, with implications for U.S. agricultural production and producer incomes (Bolster et al., 2023). The Federal Government offers a variety of programs to help producers mitigate the financial impacts of adverse events (Tsiboe & Turner, 2023; Turner et al., 2023), the largest of which is the USDA, Federal Crop Insurance Program (FCIP) (see box, "Federal Crop Insurance Program (FCIP), a Public/Private Partnership"). While various analyses of the potential impacts on FCIP outlays under future climate scenarios have been reported, most have focused on the potential impacts on field crops (e.g., Beckman et al., 2024; Tack et al., 2018). However, a changing climate could also affect forage crops and livestock producers under scenarios with declining precipitation. Previous work from Hrozencik et al. (2024) projected how increased drought incidence under climate change would affect producer payments under the Livestock Forage Disaster Program, which is not under the FCIP. The FCIP Pasture, Rangeland, and Forage (PRF) insurance plan is another risk management tool for livestock producers that may help mitigate financial losses from a decline in forage production when rainfall falls below historical levels. To date, however, the financial risk to the Federal Government of this program is unknown.

Federal Crop Insurance Program (FCIP), a Public/Private Partnership

Operated as a public/private partnership between the Federal Government and private insurance companies known as Approved Insurance Providers (AIPs), FCIP is administered by the USDA, Risk Management Agency (RMA), while policies are sold and serviced by AIPs. The Government also supports FCIP by subsidizing both a portion of producer policy premiums (i.e., the cost of the insurance plan) and AIP administrative and operating costs. The Government may also share underwriting losses with the AIP.

Crop insurance premium subsidies represent the largest budgetary outlay among Farm Bill producer support programs, averaging $9 billion annually over fiscal years 2020 to 2022. In fiscal year 2022, subsidies for crop insurance policies accounted for nearly one-third of the total Government budgetary expenditures for producer support (data on program expenditures are sourced from USDA, Office of Budget and Program Analysis (OBPA) and USDA, Farm Production and Conservation Business Center (FPAC), accessed through the Organization for Economic Co-operation and Development's Producer Support Estimates database).

For most of the FCIP's existence, options for insuring pasture, rangeland, and forage production were limited to the plans focused on annual forage crops (often hay) that have a defined planting and harvesting window. Pasture, Rangeland, and Forage insurance (PRF) was introduced as a pilot product for the 2007 crop year to address some challenges associated with applying traditional crop insurance plans to perennial forage crops. For example, the same pasture or rangeland can be continuously grazed throughout the year, making it difficult to measure the productivity of the acreage for purposes of setting an insurance guarantee (as is needed for field crops under the FCIP). Moreover, traditional policies provide financial protection for the entire crop year, whereas ranchers may have only small windows during the year when livestock are grazing, after which insurance is not necessary. PRF provides protection for producers when a loss of forage is experienced due to a single peril—a lack of precipitation (see box, "How the Pasture, Rangeland, and Forage Insurance Plan Works"). Because PRF utilizes a rainfall index for purposes of calculating losses, a measure of actual on farm production or loss of production is not required.

How the Pasture, Rangeland, and Forage Insurance Plan (PRF) Works

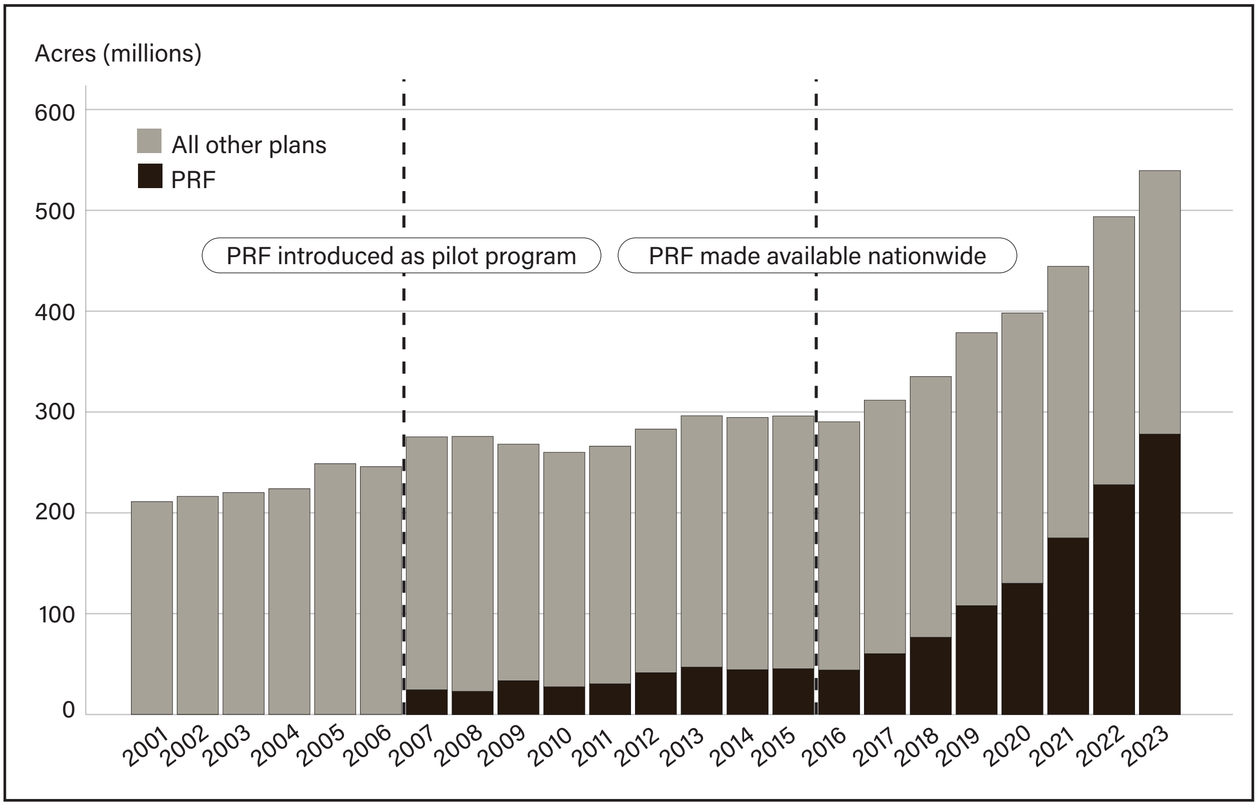
PRF utilizes a rainfall index to determine precipitation for coverage purposes. The rainfall index is normalized such that 100 is approximately equal to the historical average of rainfall from 1948 to the past year. The total number of years of historic rainfall used to construct the index increases by 1 each year. Since years are never removed from the index, the relative influence of each additional year on the index declines over time. Another feature of the PRF program is the use of a grid system rather than a county boundary. The index is based on National Oceanic and Atmospheric Administration Climate Prediction Center (NOAA, CPC) data, with grids of 0.25 degrees latitude by 0.25 degrees longitude (approximately 17 miles by 17 miles at the equator). Coverage is based on the experience of the entire grid and not on specific farms/ranches or an individual weather station in the specific area. Producers who insure production under PRF make three primary choices: (1) a coverage level from 70 to 90 percent (representing a percentage of the county base value) for the county, crop, intended use, and production practice (e.g., organic and irrigation); (2) at least two (and up to six) index intervals representing nonoverlapping 2-month periods. This choice allows producers to insure the periods when precipitation is most important to their operation; and (3) one productivity factor from 60 percent through 150 percent to match the amount of protection to the productive capacity of the producer's acres. Producers can insure some or all of their insurable acres. If the final grid index falls below the policy's "trigger grid index" (i.e., the expected grid index (100) times the coverage level), the producer may receive payment. Indemnities (i.e., the compensation paid out for qualifying losses under PRF) and premium rates are determined by using actual NOAA, CPC data for the grid(s), coverage level, and index intervals that were insured.

The report authors used projected precipitation estimates and estimates of biomass change to calculate potential future PRF net payments (indemnities, plus premium subsidies, minus total premiums). Depending on assumptions made on future PRF participation, net payments are projected to average between $495 million and $2.63 billion per year between 2024 and 2050. For reference, net payments have averaged approximately $603 million per year from 2020 to 2023, all in 2024 monetary terms.

The Pasture, Rangeland, and Forage Insurance Plan (PRF)

The PRF plan was introduced in 2007 as a pilot program in six States (Pennsylvania, South Carolina, Texas, Colorado, North Dakota, and Idaho) and made available to all 48 contiguous U.S. States by 2016. Since then, participation in PRF has increased (figure 1). Total insured FCIP acreage for the 2016 crop year was just under 300 million acres, of which 44 million acres were insured under PRF (approximately 15 percent of insured acreage, both grassland and cropland). Total insured acreage has grown each year since 2016, with the relative share of PRF increasing as well. For the 2023 crop year, total insured FCIP acreage reached 538 million acres, with 278 million of those acres (approximately 52 percent) insured under PRF. The 2023 crop year was the first time acres insured under PRF represented the majority of total FCIP insured acres[1] [2] (see box, "Increases in PRF Enrollment").

Figure 1
Federal Crop Insurance Program insured acres



PRF = Pasture, Rangeland, and Forage insurance plan.

Note: Data in the chart represent USDA, Risk Management Agency's (RMA) Summary of Business files as of April 16, 2024.

Source: USDA, Economic Research Service using data from USDA, Risk Management Agency.

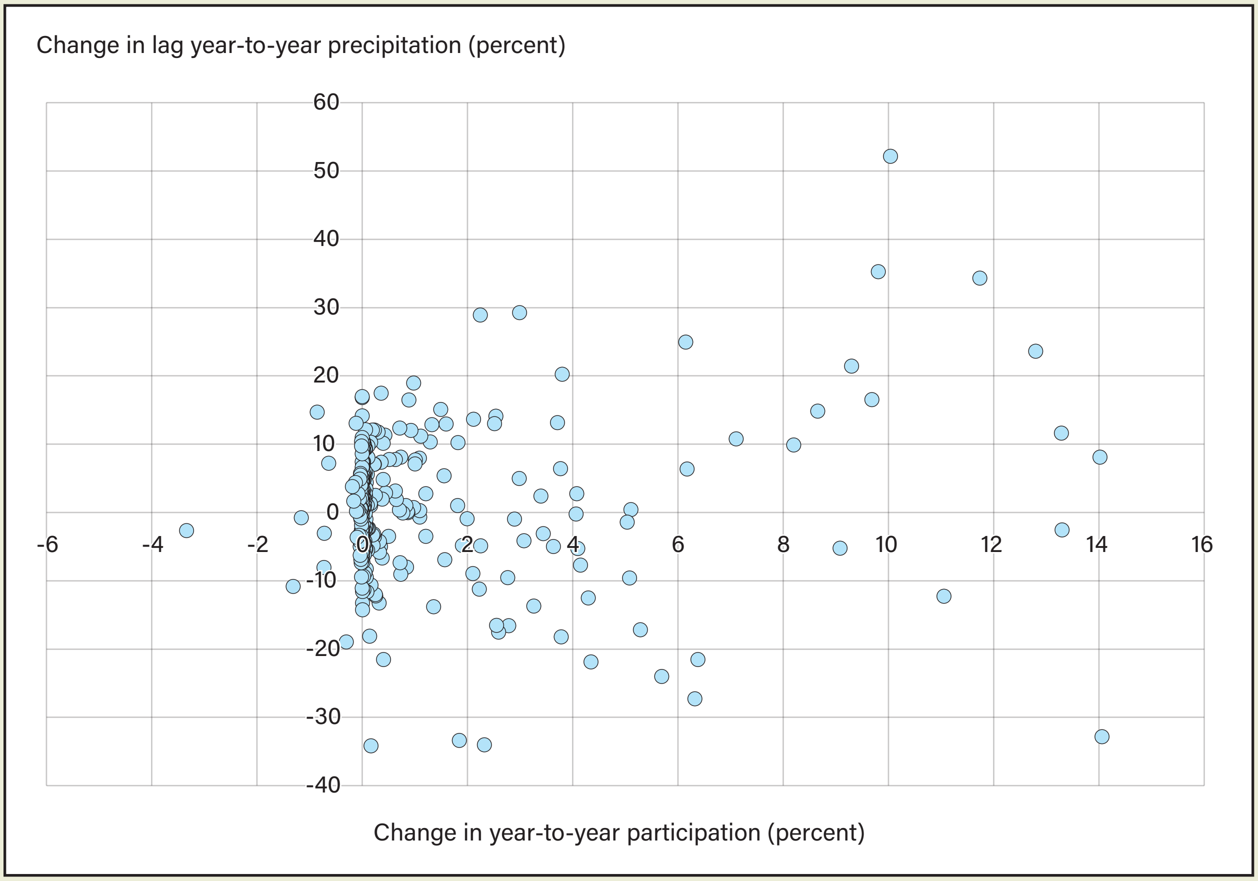
[1] Although several other insurance options have remained available for forages, about 95 percent of all insured acreage for forage crops from 2016 to 2021 was enrolled in the PRF plan.

[2] The authors estimated that 21 percent of all land that could be used for pasture, rangeland, and forage in the contiguous United States is enrolled in PRF.

Increases in Pasture, Rangeland, and Forage Insurance Plan (PRF) Enrollment

Since 2016, participation in PRF has increased steadily, but it is difficult to directly identify determinants of enrollment. When first introduced, an initial surge in demand occurred associated with program availability. However, observed correlations between enrollment and other factors, like precipitation, may be spurious and simply attributable to producers' awareness of the program. Since 2016, there have been increases in State-level year-to-year enrollment in 76 percent of the occurrences (that is, there are 287 possible occurrences—the number of years for how many States had PRF, summed across all States, and State enrollment increased in 218 of those occurrences), yet precipitation decreased in only 127 of the instances. PRF payments are made based on decreases in precipitation along with the other parts of the calculations. However, the correlation between the change in year-to-year enrollment and the change in precipitation (2 years ago versus last year—referred to as lag year-to-year precipitation) is only 0.12. Because of the pilot/new nature of the program, the report authors advise caution when interpreting the correlation coefficients. Examining if the largest increases in year-to-year enrollment can be linked to decreases in precipitation is also difficult. Figure 2 shows the change in year-to-year program participation along with the corresponding change in lag year-to-year precipitation. The largest enrollment increase by a State in a given year was in Nevada in 2022 (an increase of 14.06 percent from 2021). This increase came after precipitation decreased by 32.86 percent from 2020 to 2021. However, the next largest increase in enrollment participation was in Utah in 2021 (14.02 percent), which came after an 8 percent increase in precipitation from 2019 to 2020.

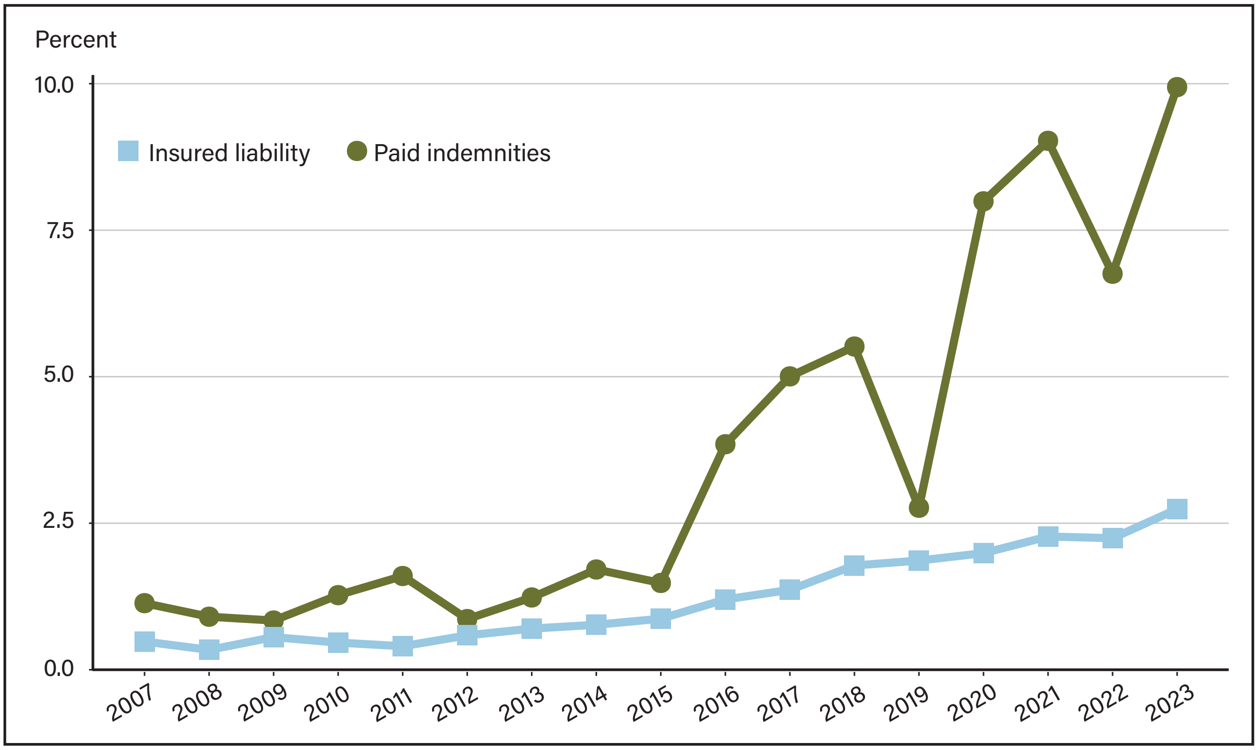
Figure 2
Pasture, Range, and Forage insurance plan (PRF) participation and changes in precipitation



Source: USDA, Economic Research Service using precipitation data from the National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP). Participation data come from USDA, Economic Research Service using data from USDA, Risk Management Agency.

Although PRF represents the majority of insured FCIP acres, the economic significance of PRF is generally small compared to other FCIP insurance plans. At the national level, PRF represented 2.7 percent of insured liability (i.e., the total amount of insurance measured by value) for the 2023 crop year (figure 3). The difference between PRF representing the majority of FCIP insured acreage and a small share of liability is because forage crops are typically of a much lower value than major field crops or specialty crops. The share of total indemnities attributable to PRF was generally commensurate with PRF's share of total liabilities until 2015. From 2016 to 2023, relative indemnities began to rise (coinciding with decreased precipitation in the western States), reaching a peak of 10 percent of paid indemnities for crop year 2023. This period also coincided with the program's expansion to the contiguous 48 States.

Figure 3
PRF liabilities and indemnities as a share of total FCIP liabilities and indemnities



PRF = Pasture, Rangeland, and Forage insurance plan. FCIP = Federal Crop Insurance Program.

Note: Data in the chart represent USDA, Risk Management Agency's (RMA) Summary of Business files as of April 16, 2024.

Source: USDA, Economic Research Service using data from USDA, Risk Management Agency.

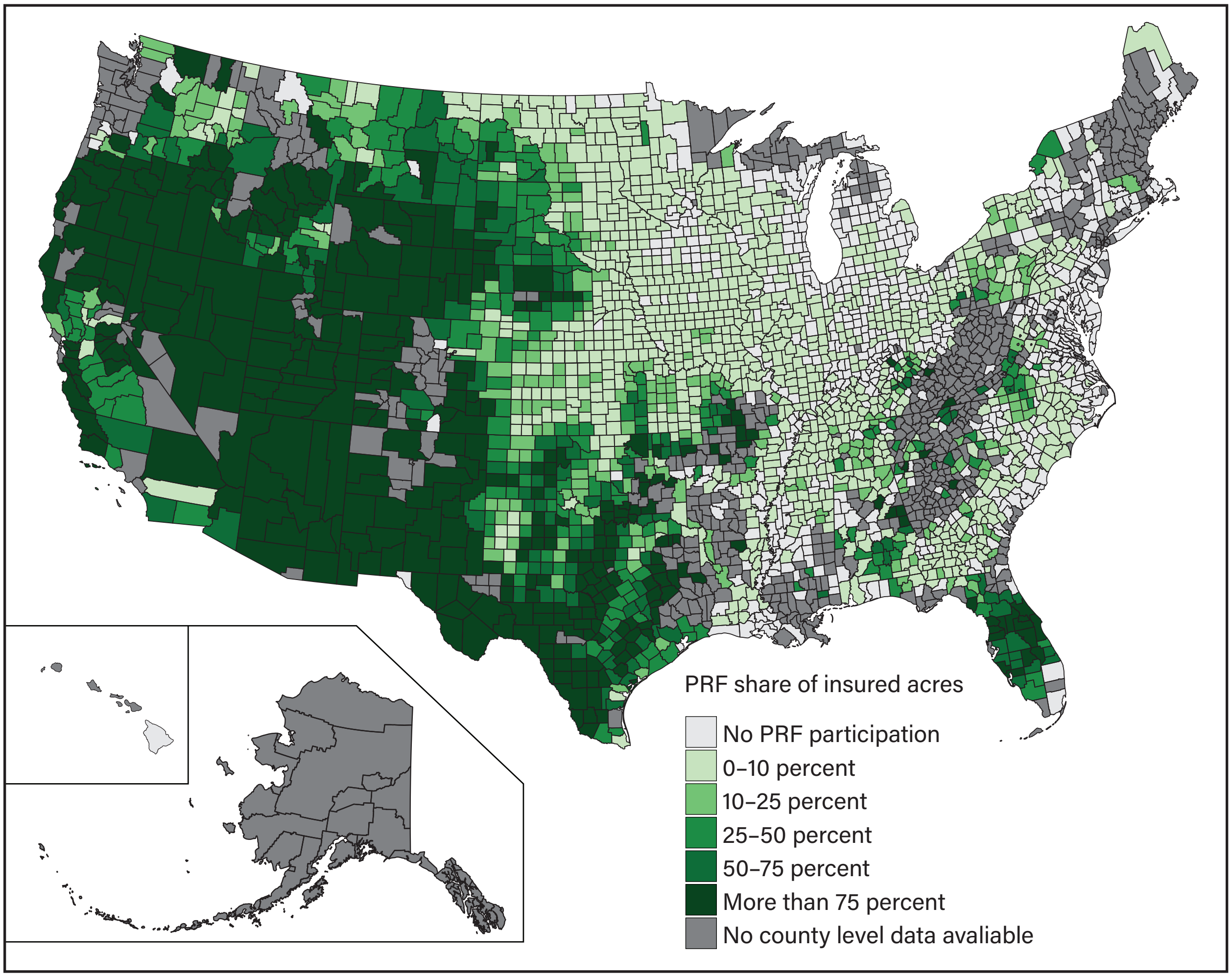
Although the economic significance of PRF is relatively small at the national level, for some portions of the United States, the insurance plan covers the majority of FCIP acreage. Figure 4 shows the average share of insured acres associated with the PRF insurance plan relative to all insured acreage in each county in 2016–23. For many counties in the western and southern United States, PRF represents more than 75 percent of the insured acreage (see box, "Literature on Pasture, Rangeland, and Forage Insurance").

Literature on Pasture, Rangeland, and Forage Insurance Plan (PRF)

Given PRF's expansion to the 48 contiguous States and the recent growth in participation, limited literature has explored PRF's design and enrollment. Davidson and Goodrich (2023) noted that low enrollment could be due to the complex design of the program. As of 2021, PRF enrollment was estimated at 33 percent of eligible acreage participated. Goodrich et al. (2020) showed that producers tended to insure in 2-month intervals that were outside the typical growing season and did not have a significant impact on forage growth.[1] Belasco and Hungerford (2018) similarly noted that producer interval selections were spread throughout the year, including during the winter months, although snowpack has not been shown to greatly impact forage.

[1] The authors note that because the subsidy rates for PRF coverage are set as a fixed proportion of the total premium and total premiums are higher for index intervals in the nongrowing season, then allocating insured liability into index intervals outside the growing season maximizes a producer's expected return on purchasing PRF coverage.

Figure 4
Average PRF insured acreage as a share of total insured acreage, 2016–23



PRF=Federal Pasture, Rangeland and Forage insurance plan.

Note: "No county level data are available" indicates that there was either no crop insurance participation or data were not disaggregated at the county level. "No PRF participation" indicates that some acreage in the county was enrolled in a Federal Crop Insurance Program (FCIP) policy, but no acreage was enrolled in PRF. PRF is not offered in Alaska, Puerto Rico, Guam, or the U.S. Virgin Islands. PRF was expanded to Hawaii in 2024.

Source: USDA, Economic Research Service using data from USDA, Risk Management Agency's Summary of Business files as of April 16, 2024.

Estimating Future Payments

Estimation of future PRF payments requires three pieces of data:

(1) Precipitation: Grid-level estimates of future precipitation are required to calculate the grid-level precipitation indices and track when precipitation is projected to decline below the threshold necessary to trigger a PRF payment. (2) Biomass: Grid-level estimates of future biomass availability are needed to calculate the value of the available forage in each grid. Available biomass directly influences the insured liability of a PRF policy and affects the magnitude of future payments when a payment is triggered by low precipitation. (3) Participation: County-level estimates of future participation are required to track the level and spatial distribution of insured forage under PRF so that the relevant precipitation and biomass values can be applied.

Future Precipitation

To estimate future precipitation and its impact on PRF payments, the authors used the National Aeronautics and Space Administration's (NASA) global climate projections, specifically, SSP5-RCP-8.5 (see box, "Understanding NASA's Global Climate Projections"). This climate scenario represents the highest emission scenario of all Representative Concentration Pathways (RCPs) and has been the focus of recent USDA, ERS reports (Beckman et al., 2024; Vaiknoras et al., 2024). The authors collected and processed climate change data from the NEX-GDDP database based on the SSP585. The database is formed of different simulation experiments performed by various scientific groups around the world using global circulation models (GCMs). The authors used the following: (1) Canadian Earth System Model version 5, (2) Taiwan Earth System Model version 1, (3) Model for Interdisciplinary Research on Climate version 6, and (4) Australian Community Climate and Earth System Simulator Coupled Model version 2. Thrasher et al. (2022) described the simulation methodologies and database.[3]

Understanding NASA's Global Climate Projections

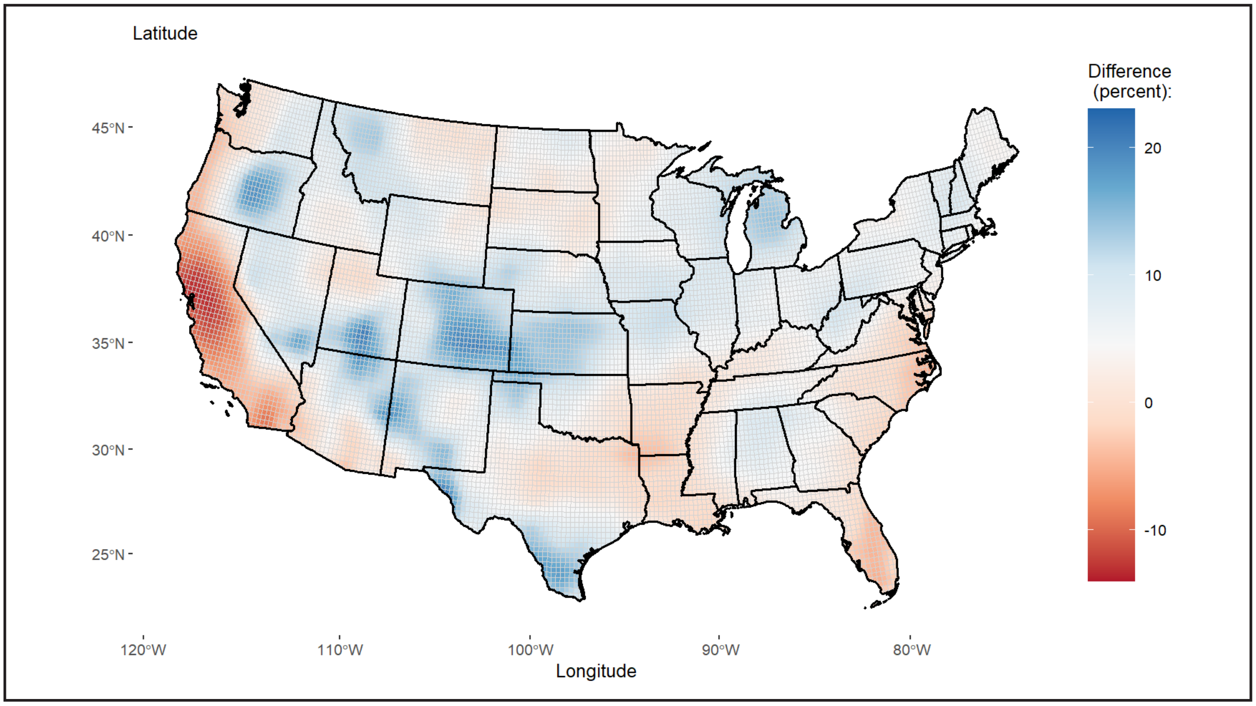
Climate projection models are built and classified using a two-step approach that considers factors such as economic and population growth and mitigation strategies. In the first step, Shared Socioeconomic Pathways (SSPs) account for energy, land use, and some economic determinants that subsequently affect the amount of greenhouse gas emitted. SSPs are categorized by different degrees of challenges to mitigation and adaptation. SSP5, used in this research, is often referred to as fossil-fueled development, with high challenges to mitigation and low challenges to adaptation. Next, Representative Concentration Pathways (RCPs) measure the change in the energy concentrated in the atmosphere caused by natural or anthropogenic forces (those caused by human activities). The RCP used here assumes greenhouse gas emissions will keep rising toward the end of the century (Riahi et al., 2007).

Figure 5 describes the geographical and temporal patterns of precipitation, respectively, in the contiguous United States based on the modeling scenario described above. The geographical pattern described in figure 5 indicates that certain areas in the contiguous United States will experience increases in precipitation as high as 22.51 percent and declines of up to -13.15 percent by 2050. While such changes are scattered throughout

[3] Climate change is also projected to change the intensity and variability of precipitation, implying an increase in the probability of extreme events such as droughts and floods. Further examination of these dynamics is beyond the scope of this report.

the country, differences in a few locations are worth highlighting. Particularly, some western regions of the United States will experience higher levels of precipitation by the middle of the century, which appear as blue clusters on the map. Some of these States (e.g., Nevada, Utah, Colorado, and Wyoming) also have the largest shares of pasture, rangeland, and forage lands in the United States. The Corn Belt, where most of the corn and soybean production occurs, is expected to experience higher precipitation toward the middle of the century. This region, however, has the lowest share of pasture, rangeland, and forage land in the country (as shown in figure 4). Future precipitation projections also indicated several isolated areas of decreasing precipitation, primarily located along the West and East coasts.

Figure 5
Difference in projected annual precipitation in the contiguous United States, 2020–50



Note: Projected precipitation is measured in cumulative cubic centimeters each year. The values for 2020 and 2050 are obtained by averaging the previous 5 years for robustness. Alaska and Hawaii were not included in the study as the Pasture, Rangeland, and Forage insurance plan (PRF) was not available in those States in the past. Coverage was expanded to Hawaii in 2024.

Source: USDA, Economic Research Service using data from the National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP).

Future Biomass

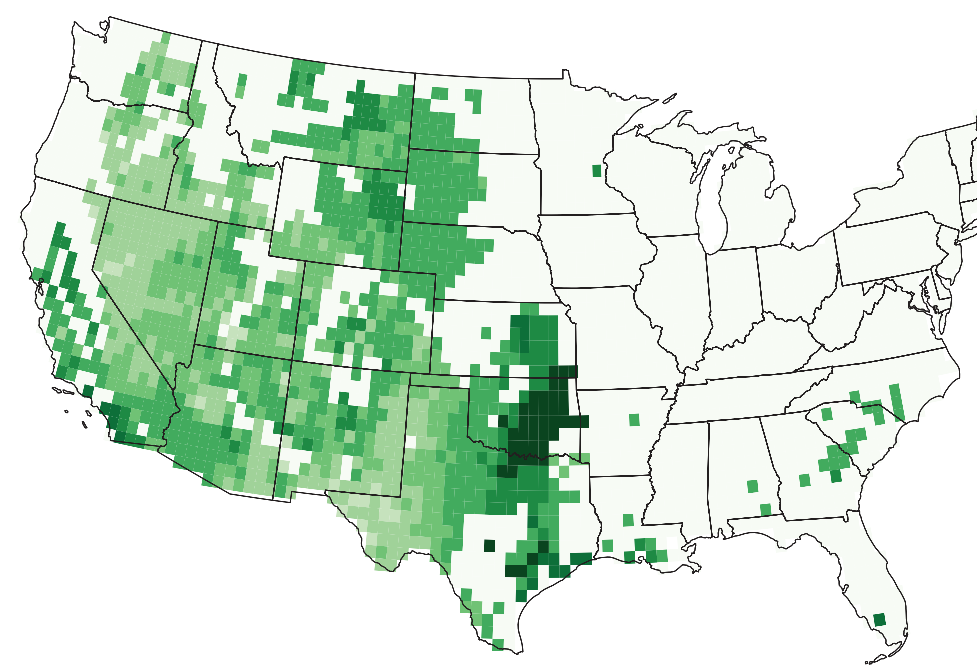
Estimates of future quantities of available herbaceous biomass are obtained using a simulation program called G-Range, a global, gridded ecosystem model of rangelands. Projected climate data from seven GCMs[4] on monthly precipitation and temperatures (maximum and minimum) are input into G-Range to simulate changes to biomass on rangelands around the globe due to climate change (although the authors used only

[4] Following Boone et al. (2018), the included models are BCC-CMS 1.1 (Wu, 2012); CSIRO-Mk3.6.0 (Collier et al., 2011); GFDL-CM3 (Donner et al., 2011); GISS-E2-R (Schmidt et al., 2006); HadGEM2.ES (Collins et al., 2011); IPSL-CM5A-LR (Dufresne et al., 2013); and MIR-CGCM3 (Yukimoto et al., 2012). Note that the GCMs are not the same across the G-Range work and the precipitation projections, but all GCMs simulate changes in climate, hence their outputs should be similar.

the U.S. results in this report). The model includes parameters such as soil properties from the Harmonized World Soil Database (United Nations Food and Agriculture Organization (FAO), International Institute for Applied Systems Analysis (IIASA), ISRIC-World Soil Information, Institute of Soil Science, Chinese Academy of Sciences (ISSCAS), and Joint Research Centre of the European Commission (JRC), 2012), and the proportional cover of herbaceous, shrub, and trees (DeFries et al., 2000; Loveland et al., 2000). For each grid cell, plant growth and death, soil carbon levels, nutrient cycling, and more were simulated by month based on changing precipitation and temperatures and the characteristics of the grid cell.[5]

Because G-Range simulates only rangeland areas as defined by land cover type, some portions of the United States were not included.[6] Figure 6 shows the location of rangelands in the United States and the quantity of herbaceous biomass by grid square, as estimated by the model in 2024. Most rangelands are in the western half of the United States, along with small areas of the southeastern United States.

Figure 6
Herbaceous biomass in the contiguous United States, 2024



Note: Alaska and Hawaii were not included in the study as the Pasture, Rangeland, and Forage insurance plan (PRF) was not available in the past. Coverage was expanded to Hawaii in 2024.

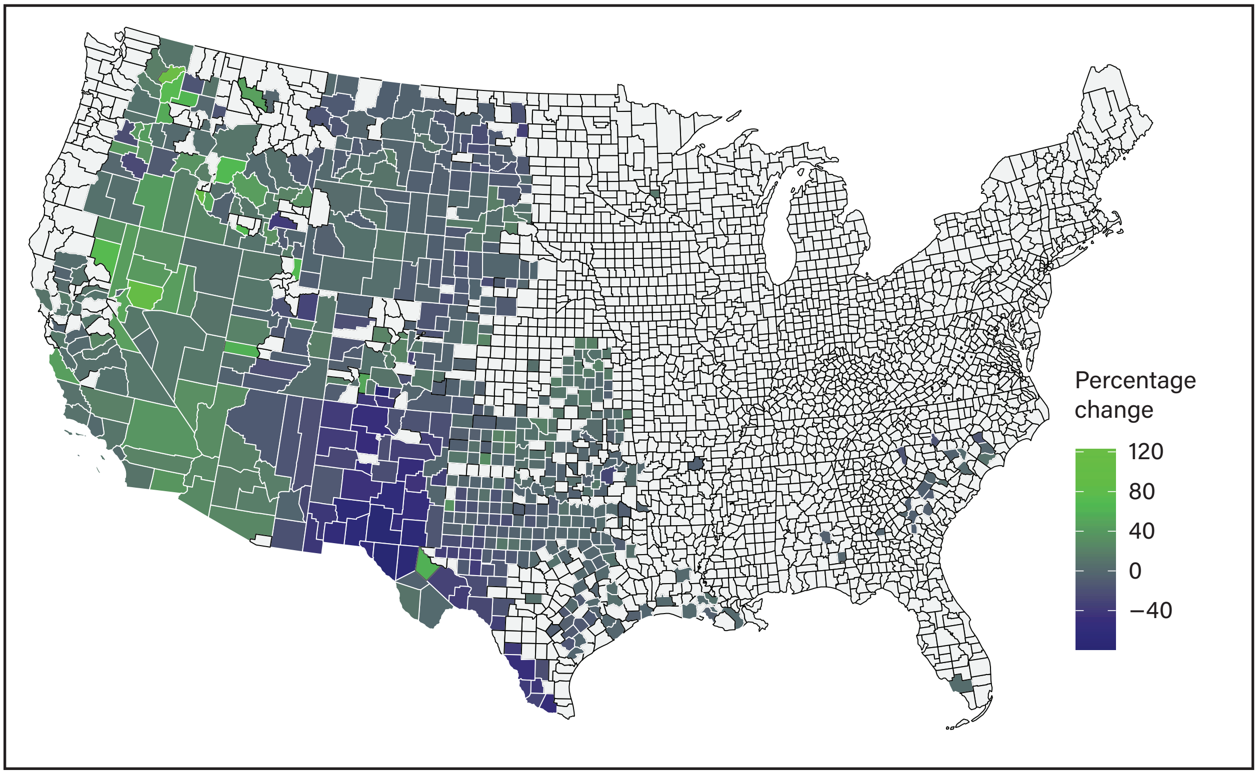
Source: USDA, Economic Research Service using the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

[5] Boone et al. (2018) provided more detailed information about G-Range, including its development and validation. G-Range has been used in literature, including Godde et al. (2020) and Vaiknoras et al. (2024).

[6] The authors determined potential areas for PRF adoption based on two sources of data. The first source is Rangelands grided data from USDA, Forest Service, where they overlaid the PRF grid surface with it to determine the share of each PRF grid that can be potentially enrolled in PRF. They supplemented this with cropland data layer (CDL) grid data from 2008 to 2023, where they developed an indicator grid where this grid takes on the value of unity if the grid had alfalfa or pasture at least once over this period. Again, they overlaid the PRF grid surface with this indicator surface to identify extra areas missed by rangelands. For the counties that have PRF land but are not in G-Range, they assumed that the growth in forage is zero. However, note that the granular data from the G-Range model are particularly useful for the micro-level shocks, which were used for the macro-level projections at either the State or the national level. Practically, this finding means that they put more weights on the areas with G-Range model outcomes. The authors' estimate of land available for PRF is 1.3 billion acres, which is approximately 55 percent of all U.S. land, as noted by RMA (2024).

Between 2024 and 2050, it is estimated that the contiguous United States will have a 1-percent gain in herbaceous biomass. However, results vary by county and State (figure 7). Some counties are predicted to lose more than 50 percent of their herbaceous biomass by 2050; these counties are in Texas, New Mexico, and Colorado. New Mexico is projected to experience the largest percentage loss (35 percent) of any State, and all but one of its 30 rangeland counties are projected to lose herbaceous biomass. The second greatest projected herbaceous biomass loss at the State level is North Dakota, with a projected 13-percent decline. By contrast, some counties are forecast to gain more than 50 percent herbaceous biomass; these counties are in Washington, Idaho, Nevada, California, Utah, and Colorado. At the State level, Washington is forecast to have the greatest percentage increase (32 percent), followed by Nevada (22 percent).

Figure 7
Percent change in herbaceous biomass, 2024 to 2050

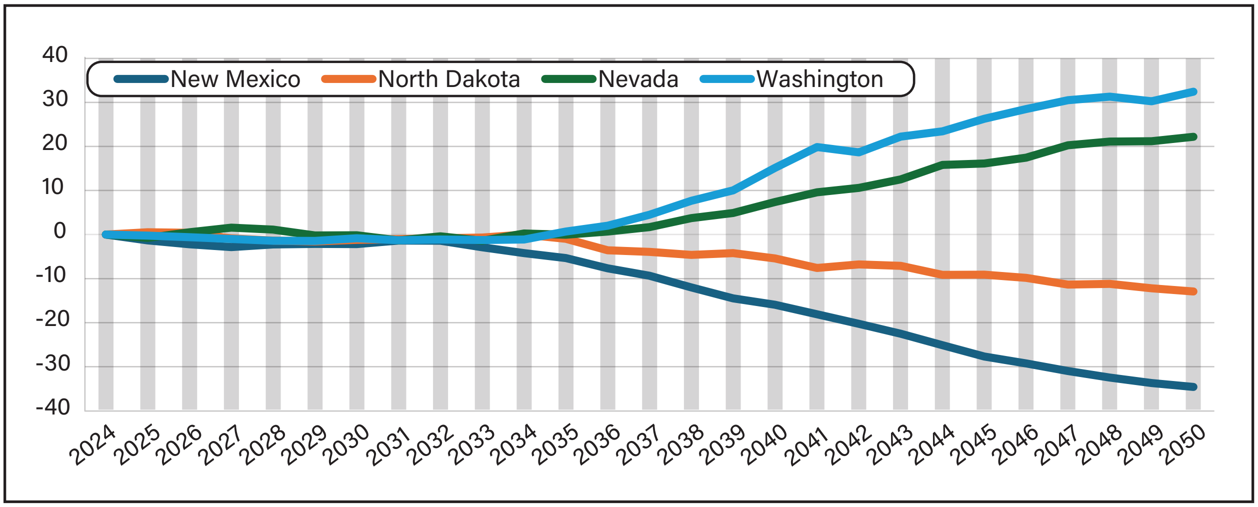


Note: Alaska and Hawaii were not included in the study as the Pasture, Rangeland, and Forage insurance plan (PRF) was not available in those States in the past. Coverage was expanded to Hawaii in 2024.

Source: USDA, Economic Research Service using the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

In Washington and Nevada, the States with the greatest percentage growth in herbaceous biomass, most growth is projected to occur after 2035 (figure 8). North Dakota, the State projected to lose the second most biomass (13 percent decrease), will begin losing biomass around 2035. For New Mexico, the State with the greatest projected losses (35 percent), losses begin a few years earlier, around 2032.

Figure 8
Percentage change in herbaceous biomass, 2024 to 2050, for U.S. States with the largest projected change



Note: Includes the States with the greatest percentage growth (Washington and Nevada) and loss (New Mexico and North Dakota) from 2024 to 2050.

Source: Source: USDA, Economic Research Service using the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

Future Participation

USDA, ERS generates estimates of future PRF participation using four distinct scenarios.[7]

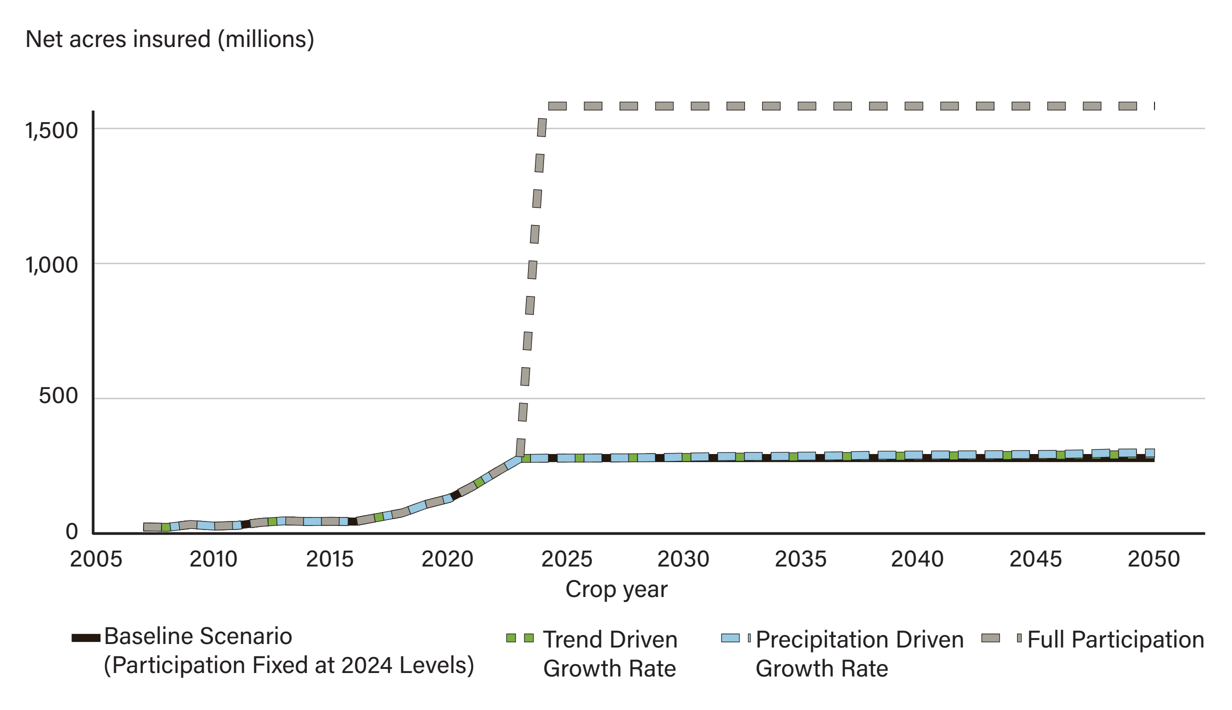
- A baseline scenario, in which insured acreage is held fixed at 2024 levels throughout the analysis.
- A nonnegative trend-based growth scenario, in which future county-level PRF acreage is estimated by regressing past county-level PRF acreage on a trend variable, using data from 2020 to 2023.
- A variable precipitation-driven growth scenario, in which county-level PRF participation is modeled as a function of historical monthly precipitation levels. Specifically, for each observation (defined by the unique combination of county, PRF coverage level, and index interval), month-specific measures of precipitation were constructed based on the 4-year moving average of grid-level precipitation for all grids in the county.[8] PRF acreage was then regressed on these measures of precipitation, along with an annual trend variable, indicators for Farm Bill periods (to control for distinct policy environments), and interactors between the annual trend and Farm Bill indicators. These regression results were then combined with projected changes in precipitation to get predicted rates of PRF enrollment for each year in the projection period.
- A full participation scenario, where all acreage that could potentially be used for rangeland, pasture, and forage is enrolled in the program.

[7] Similar to Hrozencik et al. (2024), this analysis assumed that livestock producers do not adapt to evolving climatic conditions. However, livestock producers may adapt to changing climate conditions by altering their herd sizes, production practices, and/or the location where they choose to operate.

[8] Grid-level measures of precipitation were aggregated to the county level by weighting each grid's precipitation by the share of potential PRF acreage that is in the grid.

Figure 9 depicts actual (through 2024) and projected (2024–50) insured acreage under each of the four scenarios. Enrolled acreage under the baseline scenario and full participation scenario remain constant for the entire projection period at 279.5 million acres and 1.582 billion acres, respectively. Enrolled acreage under the trend-driven growth rate and precipitation-driven growth rate both rise steadily over the projection period, reaching 292.5 million acres and 298.5 million acres, respectively, by 2050.

Figure 9
Pasture, Rangeland, Forage insurance plan projected insured acreage, 2007–50



Source: USDA, Economic Research Service analysis of data from USDA, Risk Management Agency, National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), and the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

Estimations of future participation were combined with precipitation and biomass estimates to calculate insured liabilities. Projections for liability were based on anticipated changes in county-base value (i.e., expected per acre value for PRF) and insured acreage. The county-base value was projected at the county level based on externally determined changes in biomass. Finally, the base rate (used for premium calculation) and payment factors (used for indemnity calculations) for PRF were projected by applying RMA actuarial methodology (Coble et al., 2020; Tsiboe et al., 2023) at the grid level, based on estimated changes in precipitation (see box, "PRF Premium and Indemnity Calculation"). These numbers were then aggregated to the county level, based on observed PRF participation patterns from 2018 to 2023 and over counties with rangeland or pasture and forage coverage. The premium subsidy percentages were fixed at the levels established by Federal legislation in 2024. The projection of total future net payments was then calculated as the sum of total indemnity and premium subsidy minus total premium.[9]

[9] The overall cost to the Government is conditional on variations in: (A) total premiums, (B) premium subsidies provided to producers, (C) indemnities, (D) program delivery cost and subsidies, and (E) reinsurance (underwriting losses minus underwriting gains). Given the above items, the total cost is calculated as (A-B)-C-D+E. In this exercise, the authors only captured (A-B)-C.

Pasture, Rangeland, and Forage Insurance Plan (PRF) Premium and Indemnity Calculation

Premium Calculation:

Step 1: Calculating the Dollar Amount of Insurance Per Acre

The dollar amount of insurance per acre is the product of the county-base value, which is calculated by USDA, Risk Management Agency (RMA), based on the available quantity of forage per acre (i.e., biomass, which authors used from the G-Range model (Boone et al., 2018; Vaiknoras et al., 2024), and current market prices), the chosen coverage level, and chosen productivity factor.

Dollar Amount of Insurance Per Acre = County-Base Value * Coverage-Level Percent * Productivity Factor

Step 2: Calculating Insured Liability

The total guaranteed liability amount is the product of the dollar amount of insurance per acre, the total amount of acreage being insured, and the percent of value that determines how the insurance coverage is allocated across the multiple index intervals selected by the producer (i.e., two index intervals with percent of value equal to 50 percent would apply equal weighting to each index interval).

Total Guarantee Amount = Dollar Amount of Insurance Per Acre * Total Insured Acreage * Percent of Value

The insured liability was then calculated by multiplying the total guarantee amount by the insured share percent that reflects the producer's ownership share of the ranching operation.[1]

Liability Amount = Total Guarantee Amount * Insured Share Percent

Step 3: Total Premium, Subsidy, and Producer Premium Calculation

The total premium was then calculated by multiplying the liability amount by a base premium rate set by USDA, RMA (using RMA methods, this rate was dynamically calculated in the simulations as precipitation was projected out). The subsidy amount was a product of the total premium and the subsidy percent.[2] The producer's out of pocket expenditure for the insurance coverage (i.e., the producer premium amount) was equal to the total premium amount net of the subsidy amount.

Total Premium Amount = Liability Amount * Base Premium Rate

Subsidy Amount = Total Premium Amount * Subsidy Percent

Producer-Premium Amount = Total Premium Amount - Subsidy Amount

[1] In cases where the insured does not have a 100-percent ownership stake (for example, co-ownership or crop share agreement), the insured liability is scaled based on the insured's share of production. The insured share is fixed based on the ownership structure of the operation.

[2] The standard subsidy percentage ranges from 51 percent to 59 percent, depending on the chosen coverage level. Producers who qualify as beginning or veteran farmers or ranchers have their subsidy percent increased by 10 percentage points.

Continued on next page 14

Continued from page 13

Indemnity Calculation:

When the rainfall index for a particular grid falls below the normalized trigger level (i.e., any value below 100) during a producer's selected index interval, a producer receives an indemnity equivalent to the liability amount multiplied by the difference between 100 and the index value (i.e., the payment factor).

Indemnity Amount = Liability Amount * Payment Factor

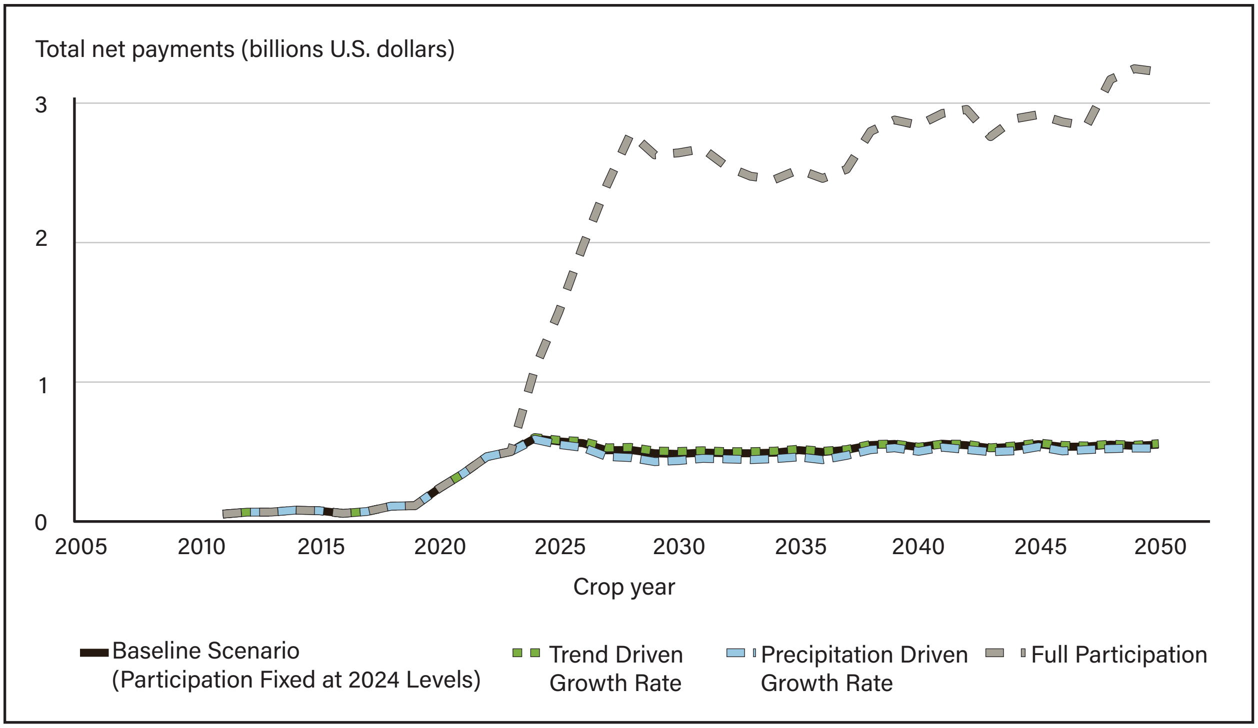
Assumptions: Note that the authors made several assumptions in this report, such as (A) fixed time periods of enrollment in PRF, (B) the coverage level, and (C) the productivity factor (all of which are based on the average observed levels from 2018 to 2023). Climate change may indirectly affect each of these aspects. For example, as the climate warms, some States (Montana) will have longer grazing seasons, so producers may start insuring 4 months of the year rather than 2; or the increases in precipitation will likely make some land more productive, so producers may change their productivity factor.

Simulation Results

The report authors used the results from the precipitation and biomass models, along with estimates of future participation, to project 5-year moving averages of total net payments attributable to the PRF plan out to 2050. Payments are equivalent to the sum of indemnity payments and disbursed subsidies net of total premiums, as depicted in figure 10 (all results are in 2024 dollars).

- Under the baseline scenario (participation fixed at 2024 levels), total net payments were projected to average $530 million per year between 2024 and 2050.
- Under a nonnegative trend-based growth scenario, total net payments were projected to average $538 million per year between 2024 and 2050.
- Under the scenario allowing for a variable, precipitation-driven growth rate in PRF participation, total net payments were projected to average $495 million per year.
- Finally, under the full participation scenario, total net payments were projected to average $2.63 billion per year between 2024 and 2050.

Figure 10
Pasture, Rangeland, Forage insurance plan 5-year moving average projected total net payments, 2011–50



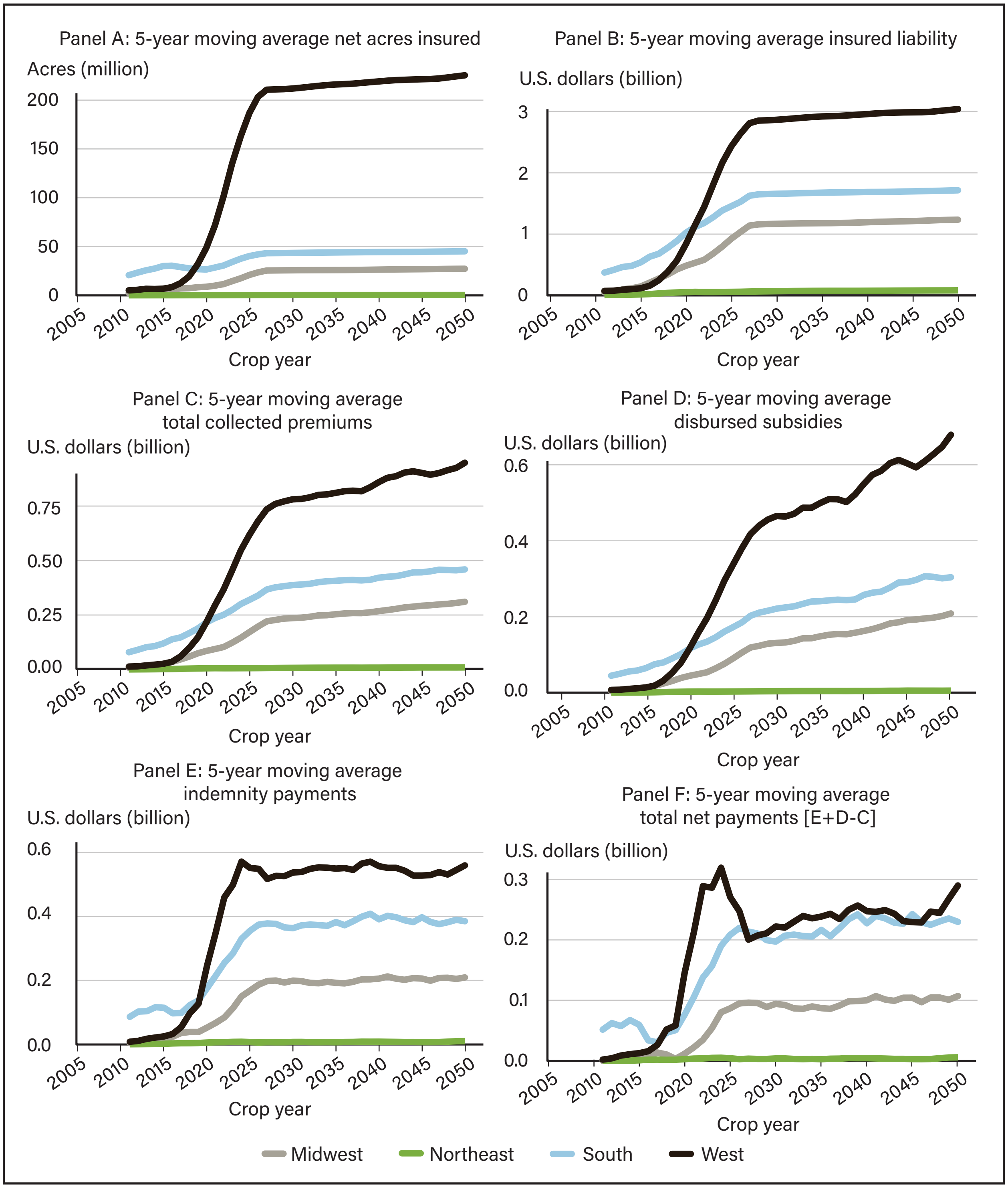
Note: All monetary values are in real 2024 dollars.

Source: USDA, Economic Research Service analysis of data from USDA, Risk Management Agency, National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), and the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

The results also highlight that variation in payments can be significant even when holding participation fixed (either at 2024 levels or fixed at "full participation"). The change in payments at various points in time is driven by climatic variables, such as changes in precipitation and biomass. A decline in precipitation (relative to the rainfall index) is what triggers PRF program payments, but the magnitude of the payments is based on precipitation and biomass. It is difficult to directly attribute a change in a given year to one of those variables because the analysis is done on a grid level, but the authors note that biomass exhibits relatively little variation year to year (see figure 8, for example, which shows longer term trends in changes), whereas precipitation is highly stochastic (random) (see figure 5).

In practice, associating precipitation with participation (as was done with the "precipitation-driven growth rate" assumption) is useful for illustrating growth rates that are dynamic across U.S. regions with different precipitation levels under that participation assumption. Figure 11 depicts program outcomes separately estimated for four U.S. regions. Panel A shows that the majority of the recently observed growth in insured acres under PRF has been in the western United States.

Figure 11
Pasture, Rangeland, Forage insurance plan by region using precipitation-driven growth rate, 2011–50



Note: Midwest includes Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, Ohio, North Dakota, South Dakota, and Wisconsin. Northeast includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. South includes Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. West includes Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming.

Source: USDA, Economic Research Service based on analysis of data from USDA, Risk Management Agency, National Aeronautics and Space Administration (NASA) Earth Exchange Global Daily Downscaled Projections (NEX-GDDP), and the G-Range simulation model with results averaged across seven general circulation models: HadGEM2.ES (Collins et al., 2011), IPSL-CM5A-LR (Dufresne et al., 2013), CSIRO-Mk3.6.0 (Collier et al., 2011), BCCCMS 1.1 (Wu, 2012), GFDL-CM3 (Donner et al., 2011), GISS-E2-R (Schmidt et al., 2006), and MIR-CGCM3 (Yukimoto et al., 2012).

Based on 5-year moving averages, growth in insured acreage in the West was estimated to increase by 38.3 percent, from 163 million acres in 2024 (average insured acreage from 2020 to 2024) to 225 million acres by 2050 (average insured acreage from 2046 to 2050) using results from the precipitation-driven growth rate scenario. Percentage changes in enrolled acres were similarly estimated for the Midwest (56.1 percent), South (20.3 percent), and Northeast (52.3 percent). Other estimated outcomes (panels B–F of figure 11) show a consistent relative ordering across regions with the West (having the highest values), followed by the South, Midwest, and Northeast. One exception is that estimated total net payments (panel F) for the South and West were comparable across the projection period despite the West having approximately five times the enrolled acreage. This finding is mostly explained by the higher productivity of acreage in the South, which results in relatively higher insured liabilities (panel B). For example, despite the West having approximately five times the enrolled acreage, insured liabilities are only about 1.75 times the liabilities of the South. Average annual net total payments for the four regions depicted in figure 11 were $243 million (West), $220 million (South), $3.5 million (Northeast), and $96 million (Midwest).

It is important to note when interpreting the results depicted in figure 11 that an implicit assumption is that the correlations observed between precipitation and PRF enrollment trends to date will hold in the future. This result may not be the case due to the number of factors that influence participation besides rainfall, in addition to currently observed enrollment trends being heavily influenced by initial availability.[10]

[10] Since PRF is a relatively new insurance product, much of the observed increases in demand to date are a result of the insurance product that is available for the first time in a producer's county. Thus, correlations between precipitation and changes in participation over this period may not necessarily indicate a causal relationship.

Conclusion

Research shows that climate change is likely to affect agriculture. Beckman et al. (2023, 2024) found that corn and soybean production could be affected by higher temperatures in the United States. In addition, Hrozencik et al. (2024) provided evidence that more greenhouse gas emissions could produce more drought—leading to more Government payments in the Livestock Forage Disaster Program. Climate change may also affect another program available to livestock producers—the Pasture, Rangeland, and Forage (PRF) insurance program. PRF was introduced as a pilot program in the 2007 crop year to provide producers protection when a loss of forage is experienced due to a lack of precipitation. Since its 2016 expansion, PRF participation has steadily increased from 44 million acres in 2016 to 278 million in 2023. The authors use projected precipitation estimates, along with estimates of biomass change, to calculate potential future PRF net payments.

They find that grid-level estimates suggest increases in precipitation and biomass between 2024 and 2050, which result in total net PRF payments comparable to payment levels in recent years. Holding participation fixed at 2024 levels (i.e., the baseline scenario), estimating a trend-based growth rate, and estimating a precipitation-based growth rate all produce annual net payments that range from $429 million to $602 million.

These estimates are in a comparable range to the average annual net payments of $603 million per year observed from 2020 to 2023. However, upper bound estimates (assuming that enrollment rises to 100 percent of eligible acres) project that net payments would reach an average of $2.63 billion per year (with annual extremes of between $1.09 billion and $3.25 billion) over the projection period if all PRF eligible acreage was enrolled.

The authors also find that variation in payments over time can be significant even when holding the participation rate fixed (either at 2024 levels or fixed at “full participation”). This finding indicates that a significant portion of the variance in program outcomes is driven by climatic variables, such as changes in precipitation and biomass. Although volatility in net payments is higher in absolute dollar terms under the full participation scenario, this result is partially an artifact of scale. The coefficient of variation, which provides a measure of volatility that is normalized by the mean, in net payments across the projection period, were between 0.05 and 0.18 for all four scenarios.

It is important to note that when disentangling how precipitation and biomass relate to net payments, one must consider the design of PRF. By program design, precipitation has an immediate (same year) effect on gross payments (indemnities) and a 2-year lagged effect on gross cost (premiums) to producers. Thus, depending on their magnitudes and distribution of acres across different levels of indemnification, this result may lead to a modest change in net payments (indemnities + subsidy – premiums). While precipitation also has a direct effect on biomass, this effect is generally negligible because of the way forage yields and prices interact within the program (declining yields could lead to higher prices, for example). The county-base value, which is essentially a per acre value (price * yield) of PRF, acts as a scaling factor to convert the costs and benefits of the program into monetary terms. The monetary terms then do not affect the premium per dollar of liability (premium/liability) or the lost cost ratio (indemnity/liability) of the program since the terms affect premiums, liabilities, subsidy, and indemnity proportionally. The fact is that precipitation and biomass have unique, and sometimes independent, effects on net program payments that are not straightforward to disentangle.

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