Description of document: Report: Climate Change Impacts on Crop Insurance, prepared under contract by Research Triangle Institute for the Department of Agriculture (USDA) Risk Management Agency (RMA), May 2010

Requested date: 13-September-2013

Released date: 16-September-2013

Posted date: 17-March-2014

Source of document: FOIA Officer
USDA-RMA-PSS
Stop 0821
1400 Independence Ave SW
Washington, D.C. 20250
Fax: 202-720-1162

USDA

United States Department of Agriculture

Farm and Foreign Agricultural Services

Risk Management Agency

1400 Independence Avenue, SW
Stop 0801
Washington, DC 20250-0801

September 16, 2013

Sent via email

Re: Freedom of Information Act Request 2013-RMA-05382-F

This will acknowledge receipt of your request received in our office September 13, 2013. Your FOIA request was referred to us by the Farm Service Agency. Your request for information was processed under the Freedom of Information Act (FOIA) and Privacy Act. Your request has been assigned FOIA tracking number: 2013-RMA-05382-F. Please refer to this number in future communications regarding this request.

You requested a copy of the final report and final presentation materials from the contract on Climate Change performed for FSA by Research Triangle Institute under contracts AG645SC080024 and AG645SC080025.

The Risk Management Agency has searched for the documents you requested. Enclosed is the 215 page report on Climate Change Impacts on Crop Insurance, prepared under Contract AG-645S-C-08-0025 (0025). Contract AG-645S-C-08-0024 was cancelled and replaced by 0025. There were no final presentation materials.

This is a full release of all requested information.

If you disagree with this decision, you may appeal in writing to the Administrator, Risk Management Agency, 1400 Independence Avenue, SW, Room 6092-S, Stop Code 0801, Washington, DC 20250-0801, within 45 days from the date of this letter. The phrase 'FOIA APPEAL' should appear on the letter and the outside of the envelope containing the appeal.

If you have any further questions, please contact me at 202.720.9507.

Best regards,

Bill Crews
RMA FOIA Officer
Executive Planning & Administrative
Support Branch
bill.crews@rma.usda.gov

Enclosure

May 2010

Climate Change Impacts on Crop Insurance

Contract AG-645S-C-08-0025

Final Report

Prepared for

Terrence Katzer
USDA Risk Management Agency
6501 Beacon Drive
P.O. Box 419205, Stop 0813
Kansas City, MO 64141-6205

Prepared by

Robert H. Beach
Chen Zhen
Allison Thomson (JGCRI)
Roderick M. Rejesus (NCSU)
Paramita Sinha
Anthony W. Lentz
Dmitry V. Vedenov (TAMU)
Bruce A. McCarl (TAMU)
RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

RTI Project Number 0211911

RTI Project Number
0211911

Climate Change Impacts on Crop Insurance

Contract AG-645S-C-08-0025

May 2010

Final Report

Prepared for

Terrence Katzer
USDA Risk Management Agency
6501 Beacon Drive
P.O. Box 419205, Stop 0813
Kansas City, MO 64141-6205

Prepared by

Robert H. Beach
Chen Zhen
Allison Thomson (JGCRI)
Roderick M. Rejesus (NCSU)
Paramita Sinha
Anthony W. Lentz
Dmitry V. Vedenov (TAMU)
Bruce A. McCarl (TAMU)

RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

Table of Contents

Chapter **Page**

Appendixes

List of Figures

Number **Page**

List of Tables

Number **Page**

Executive Summary

There is general consensus in the scientific literature that human-induced climate change has taken place and will continue to do so over the next century. The Fourth Assessment Report (AR4) of the Intergovernmental Plan on Climate Change (IPCC) concludes with "very high confidence" that anthropogenic activities such as fossil fuel burning and deforestation have affected the global climate. The AR4 also indicates that global average temperatures are expected to increase by another 1.1°C to 5.4°C by 2100, depending on the increase in atmospheric concentrations of greenhouse gases (GHGs) that takes place during this time. The projected effects of this increase in temperature are further reductions in global snow and ice cover and increases in sea level and total global precipitation over land. However, there is projected to be considerable variation in the level of warming by region as well as by time of day and time of year. In addition, models used for the IPCC projections forecast substantial changes in the temporal and spatial distribution of precipitation.

As discussed in the U.S. Climate Change Science Program's recent report on the impacts of climate change on U.S. agriculture and natural resources, the U.S. also warmed and became wetter overall during the last century but these changes varied across regions (CCSP, 2008). The CCSP assessment finds that increasing atmospheric carbon dioxide (CO_2) levels, temperature increases, altered precipitation patterns and other factors influenced by climate are leading to increases in forest fires and insect outbreaks in the interior West, Southwest, and Alaska; increasing total precipitation over most of the continental U.S. but drying in some areas; reduced snowpack and earlier runoff in the Western U.S.; higher growth rates for many crops and weeds; and migration of plant and animal species. The CCSP report concludes that climate change will continue to have significant effects on U.S. agriculture, water resources, land resources, and biodiversity in the 21st century as temperature extremes begin exceeding thresholds that harm crop growth more frequently and precipitation and runoff patterns continue to change. In addition to changes induced by climate, there are numerous other stressors and disturbances that affect these resources, all of which interact with one another and greatly complicate the assessment of the impacts of a changing climate.

In this report, we provide an assessment of the potential long-term implications of climate change on the U.S. crop insurance portfolio. Agricultural producers have always faced numerous production and price risks, but forecasts of more rapid changes in climatic conditions in the future have raised concerns that these risks will increase in the future relative to historical conditions. In addition to implications for landowner decisions regarding land use, crop mix, and production practices, changing agricultural risks could potentially affect the performance of the crop insurance program. Thus, we assess the potential implications of climate change on the financial returns to both the public Federal Crop Insurance Corporation (FCIC) and the private approved insurance providers (AIPs) under the current Standard Reinsurance Agreement (SRA) and identify potential considerations for the specification of the SRA and other aspects of the crop insurance program that may help to mitigate financial impacts.

To conduct these analyses, we developed a program impact model that combines updated versions of several different existing models and methodologies to generate estimates of the financial impacts under alternative climate scenarios considered relative to a baseline without climate change based on the 2006 FCIC book of business. The model makes use of existing publicly available data on simulated changes in future temperatures, precipitation, and CO_2 concentrations generated by Global Circulation Models (GCMs) as part of the IPCC AR4 process. GCMs use assumptions regarding future emissions and atmospheric concentrations of GHGs as model inputs to simulate impacts on the future spatial distribution of temperature and precipitation across the globe. These inputs have been defined for multiple IPCC climate scenarios. In this analysis, we use results from the A1B scenario, which assumes a future of rapid economic growth, increasing globalization and convergence among regions, rapid technological improvements, and balanced growth in energy use across alternative energy sources. This scenario is the most frequently used in the literature and has emissions projections closest to those that have been experienced in recent years. Given the inherent uncertainty in such projections and differences among GCMs, it is common practice in climate change analyses to use multiple GCM projections. Thus, we used the future climate projections of multiple GCMs used in IPCC AR4 to provide a range of potential impacts, focusing on the model outputs of four GCMs for the 2045-2055 time period.

The outputs of the GCMs were incorporated into the Environmental Policy Integrated Climate (EPIC) model to estimate impacts of alternative climate scenarios on crop yields. EPIC was jointly developed in the early 1980s by USDA and the Texas Agricultural Experiment Station. There have been numerous enhancements to the model over time as well as an expansion in the focus of the model and the model is widely used across numerous organizations. Crop growth is simulated by calculating the potential daily photosynthetic production of biomass. Daily potential growth is decreased by stresses caused by shortages of radiation, water, and nutrients, by temperature extremes and by inadequate soil aeration. Thus, EPIC can account for the effects of climate-induced changes in temperature, precipitation, and other variables, including episodic events affecting agriculture, on potential yields. The model also includes a nonlinear equation accounting for plant response to CO_2 concentration and has been applied in several previous studies of climate change impacts. In this application, we simulated yields for barley, corn, cotton, hay, potatoes, rice, sorghum, soybeans, and wheat under each climate scenario considered.

These crop yields were then used as inputs into the stochastic version of the Forest and Agricultural Sector Optimization Model (FASOM) to assess market outcomes given climate-induced shifts in yields that vary by crop and region. FASOM and related models have been used extensively for forest and agricultural policy applications, including a large number of climate change-related studies for IPCC, CCSP, USDA, Department of Energy (DOE), Environmental Protection Agency (EPA), and others. The stochastic version of the model is used to model crop allocation decisions by crop and management categories based on the relative returns and risk associated with alternative cropping patterns under each of the modeled scenarios. This enables exploration of potential shifts in cropping patterns within and across regions in response to changing yield distributions.

Next, we used the changes in yield distributions simulated using EPIC and the simulated changes in equilibrium price distributions from FASOM in actuarial models representing the major crop insurance products to assess the probability of losses exceeding a given coverage level and simulated indemnities.

Parametric yield distributions were estimated using historical crop reporting district-level yield data and price distributions were estimated from historical futures price data. These data are used to simulate baseline loss costs for the yield and revenue insurance products in this study. Changes in the distribution of yields and prices from the EPIC and FASOM models resulting from changes in climate conditions are then used to estimate the changes in loss cost distributions for each climate scenario.

Finally, we used the results from the EPIC, FASOM, and actuarial models as inputs into the Standard Reinsurance Agreement (SRA) model. The SRA model was originally developed for RMA in the late 1990s and has been used in several previous analyses of the impacts of alternative SRA specifications. This model provides simulated distributions of rates of return from underwriting crop insurance. Pre-SRA rates are driven by gross underwriting gains or losses defined for modeling purposes as the difference between premiums collected and indemnities paid. The post-SRA rates of return are determined in the model by particular realization of companies' loss ratios at the state level and SRA parameters (retention rates, breakpoints, and shares). Thus, to analyze the effect of the SRA on rates of return, we model the distribution of loss ratios by state and reinsurance fund for each participating organization reinsured by the FCIC. This is done by combining the simulated distributions of loss cost ratios for each district, crop, and insurance product generated using the crop insurance actuarial models with data provided by RMA on liabilities, premium rates, and retention rates for the base year (2006) and aggregating to derive distributions of loss ratios for each company by state and reinsurance fund for the period 1972-2007. The distributions of the loss ratios are then used along with the SRA parameters to compute simulated net gains to AIPs as a percentage of retained premiums and standard deviations of the net gains by company, state, and reinsurance fund.

Applying the modeling system described above, we find large effects on crop yields under the climate change scenarios modeled, both positive and negative. In general, yields increase in northern areas relative to southern areas for major crops other than wheat, but the patterns of simulated yield changes for a given climate scenario are complex and depend heavily on the individual crop, irrigation status, interactions with changes in precipitation that affect water availability, regional soils, and many other factors. There are also considerable differences in the yield change patterns between GCM scenarios. While each of the GCMs considered projected increases in average national maximum and minimum daily temperatures, they differ in the magnitude of these effects. Also, consistent with the greater uncertainties associated with projecting precipitation than temperature using GCMs, the precipitation patterns differ across models not only in magnitude but in direction of the change in precipitation for the U.S. overall as well as for key production regions.

As a result of these changing yields, equilibrium crop acreage allocation and production patterns change as producers switch crops in response to changes in relative expected profitability and risk. There are also changes in the simulated loss cost ratios due to changes in the yield and price distributions. However, even without allowing for any reallocation of liabilities and premiums in response to changing conditions, the changes in simulated net gains and standard deviation of net gains for AIPs under the climate change scenarios simulated using the SRA model are relatively small at the national level. This is partially due to the readjustment of yield guarantees as projected yields change under different climate conditions. It also reflects the diverse impacts across scenarios, crops, and regions, where there are numerous cases where production of a given crop within a region may become less risky due, for instance, to increased precipitation. Thus, while there are reductions in simulated net gains in some regions, there are also increases in other regions that largely offset at the national level. This is consistent with previous studies finding that agricultural impacts of climate change in the U.S. may be relatively small at the national level, but that this obscures the potential distributional effects within the U.S. However, it is also reflective of the risk protection provided to the AIPs by the SRA. The climate change scenarios have substantially larger impacts on the simulated net gains and standard deviation of gains to the FCIC than the AIPs, again holding the distribution of liabilities and premiums constant at base levels. Simulated average net gains for AIPs aggregated to the national level vary only from 3.1 percentage points below to 1.2 percentage points above the base simulated post-SRA return of 23.5%. Simulated average net gains to the FCIC, on the other hand, vary from 26.8 percentage points below to 14.4 percentage points above the base simulated return of 12.7% across the climate scenarios examined.

While the changes in simulated net gains to AIPs at the national level are relatively small, there are far greater deviations in the changes in simulated net gains to AIPs across individual states. Averaging across the four primary GCM scenarios analyzed, the change in simulated expected returns ranges from an increase of 20 percentage points to a reduction of 14 percentage points. In general, simulated net gains tend to be increasing in Northeastern and West Coast states and decreasing in most of the interior states of the U.S. as well as the Southcentral region. The largest percentage point declines in net gains are found in a band of states in the Southcentral and Southeast regions (Alabama, Arkansas, Georgia, Louisiana, Mississippi, and North Carolina) where there are large increases in temperature extremes, precipitation tends to be declining in the GCMs, and there is little irrigation. It is very important to recognize the uncertainties associated with climate modeling, however, particularly in downscaling climate model results to the regional level, due to the highly complex nature of the climate system and the evolving scientific understanding of interconnections between climate and terrestrial systems.

Based on the existing literature on potential climate change and GCM projections, catastrophic modeling is likely to become increasingly important over time as temperature thresholds for crop germination, growth, and winter chill are exceeded more frequently; water availability increasing becomes a constraint limiting yields for certain crop/region combinations; and catastrophic events may occur more frequently. Relying on historical data implicitly assumes low-frequency high-loss events are reflected in the data. However, data series for some crops/regions may not be long enough to capture these events and the probability of these extreme events may change in the future given projected changes in climate. EPIC simulates the effects of temperature thresholds and extreme events to the extent that they are present in the GCM outputs, but changes in extreme events are highly uncertain and are not necessarily well-captured in available GCMs. There is also little existing information in the literature quantifying potential changes in extreme events that could be utilized in our modeling system. Thus, as a simple sensitivity analysis we explored the effects on simulated net gains of making the probability of experiencing years like the two years in our dataset with the lowest simulated returns out of the 36 historical years included in the simulations (1988 and 1993) occur about twice as frequently. As expected, this decreases simulated average net gains for both AIPs and the FCIC, with a 1.5 percentage point reduction in average net gain to AIPs (6.5% reduction) and a 2.7 percentage point reduction in average net gain to the FCIC (21.3% reduction).

Although this modeling system builds on existing models that have been used for climate change assessments and reflects what we consider reasonable and appropriate assumptions, it is very important to recognize the considerable uncertainties surrounding the results of this study or any study assessing the potential impacts of climate change on agricultural production. First, there are numerous uncertainties underlying the IPCC projections of population, economic growth, energy use, and other factors that drive emissions projections. There are also currently a number of local, state, national, and international efforts to reduce GHG emissions that may significantly affect the future emissions path if adopted. Second, there is considerable variation in the publicly available climate projections data between GCMs, including both differences in the magnitude of temperature changes as well as in the magnitude and direction of changes in precipitation for regions of the U.S. These differences in projected climate conditions lead to differences in simulated changes in crop yields, with many cases where crop yields and yield variability simulated by EPIC for a given crop/region combination may be increasing or decreasing depending on the GCM used. We selected the GCMs used in this study based on data availability and model performance as well as their ability to provide a range of potential outcomes representative of the range of climate projections developed for the IPCC, but there are a number of other GCMs that have been used for climate projections, each of which would provide a somewhat different picture of future climate conditions across the U.S. Third, while we are building upon existing models that have been used extensively in the climate change literature, there are numerous assumptions regarding parameters, distributions, and model structure embedded in these models (as well as any other existing models) that may potentially have an effect on the overall outcome of the study.

In addition, the primary results presented above are assuming future climate impacts are applied to recent historical conditions and the 2006 baseline crop insurance book of business. There are numerous behavioral adjustments that would be expected under changing climate conditions, but attempting to model all of these responses was outside the scope of the current project. For instance, producers would be expected to respond to changing climate conditions by changing planting dates and cultivars (planting dates change in EPIC model simulations based on degree days). Also, changes in expected net returns and variability of those returns for alternative crops would lead not only to potential changes in crop mix and irrigation status, which we did model using FASOM, but also producer selection of insurance products and coverage levels. In addition, to the extent that changing climatic conditions are negatively affecting yields over time, there will be greater incentives to conduct research on drought-tolerant, heat-tolerant, and other crop varieties better suited to the changing conditions, which would tend to reduce climate impacts on crop yields. Similarly, to the extent that AIPs believe AIPs would also be expected to make changes to their crop insurance portfolios in response to changing expected net gains and variability of net gains for different crops and states and to alter their retention rates within constraints imposed by the SRA. Another consideration is that climate impacts taking place outside the U.S. could have major effects on trade patterns and global commodity prices that would also influence producer decisions.

Given the large uncertainties regarding the direction and magnitude of effects for individual crops and regions, it remains premature to provide definitive answers regarding the projected impacts of future climate conditions on the U.S. crop insurance program. Between the scenarios included in this study, there are numerous cases where the mean and/or variance of the yield distribution for a given crop/region/irrigation status combination may be increasing in one scenario and decreasing in another, making it difficult to determine with confidence whether a given crop/region/practice is becoming more or less risky. One of the implications is that it is possible that expected losses could decline and returns could actually improve under some scenarios, especially at the national level when aggregating across all crops where there may be both positive and negative effects and the net effect will depend on the distribution of liabilities across crops, regions, and coverage levels. Therefore, one of the most important implications of this analysis is that there remains a need for additional data and research to improve our understanding of future climate and provide a more consistent picture of expected future impacts under a given GHG emissions scenario.

Under any of the future climate scenarios modeled, the crop insurance program is expected to be impacted through changes in expected losses that may necessitate modifications to the program to maintain actuarial soundness. However, to the extent that these changes occur very gradually over time, they may largely be handled through the normal annual updating process for insurance programs. The larger issue is the extent to which conditions in the near future can no longer be predicted reasonably well based on historical experience because conditions are changing too rapidly, certain crop/region combinations begin hitting temperature or water availability thresholds that have large non-linear negative yield effects, or there are changes in the probability of other catastrophic events that would increase requirements for the disaster reserve factor to adequately account for such events. However, there is currently not enough consensus on these effects to accurately determine specific changes to the crop insurance program would sufficiently mitigate these impacts.

Regardless of future climate scenario, issues that would likely need to be considered in the future development of the crop insurance program include the need to develop rates, loss adjustment standards, underwriting standards, and other insurance program materials that are appropriate for new production regions or for changes in practices within existing regions. For instance, areas that have not relied heavily on water-saving practices or irrigation in the past may begin switching to those practices in the future if drying occurs in their regions. Other regions may move in the opposite direction. Either would tend to make historical yield data less useful for predicting future yields. Certain crop varieties may also offer considerably better yields than others under hot, wet, or dry conditions. Generally, it is likely that there will need to be greater resources devoted to modeling the effects of the more rapidly changing conditions and practices that are expected under climate change and appropriately include them within insurance policy specifications, loss adjustment standards, and underwriting standards. Agricultural production has been adapting to changing conditions and practices from the beginning of human cultivation, but the key difference typically attributed to production under climate change scenarios is the extremely rapid rate of change in typical regional weather conditions. Devoting additional resources to both understanding these more rapid changes in future conditions and adapting agricultural production and risk management programs is expected to be important for maintaining the actuarial soundness and risk management offered by the U.S. crop insurance program.

Introduction

Agricultural producers face a number of production risks (e.g., weather, disease, pests) that can substantially affect their output levels from year to year as well as price risks, both of which affect farm revenue. Crop insurance is one important mechanism for managing the yield, price, and quality risks associated with agricultural production. Federally subsidized crop insurance has been available in the United States since the foundation of the Federal Crop Insurance Corporation (FCIC) in 1938. The U.S. Department of Agriculture (USDA) Risk Management Agency (RMA), created in 1996, operates and manages the FCIC. RMA provides multiple peril crop insurance via the FCIC for more than 75 crop and livestock commodities and continues to support the development of new risk management tools for producers.

An important issue that may potentially affect the performance of the crop insurance program over the next few decades is climate change, both through changes in average temperature and precipitation as well as through changes in the frequency and severity of extreme events such as flooding, drought, hail, and hurricanes or other severe weather events. Thus, Congress requested that the General Accounting Office (GAO) conduct a study of the potential impacts of climate change on federal insurance programs. The resulting study concluded that there were potentially significant effects on the crop insurance program and recommended conducting a more comprehensive study of the implications (GAO, 2007). Therefore, RMA requires an objective and unbiased analysis of the potential long-term implications of climate change for the crop insurance program and development of a program impact model that can be used to evaluate the impacts on the FCIC and approved insurance providers (AIPs).

The primary objective of this project is to provide RMA with analyses of the potential long-term implications of climate change for the U.S. crop insurance program. Impacts on both FCIC and AIPs were addressed using a program impact model developed as part of this project that can be used to estimate impacts under alternative scenarios. The model enables assessment of the implications for the Standard Reinsurance Agreement (SRA) between FCIC and the AIPs and identification of potential changes to the SRA or other aspects of the crop insurance program that may help to mitigate negative impacts and reduce FCIC exposure to losses.

The effects of climate change on agriculture and forests are extremely complex because of nonlinearities, regional and temporal differences, and interaction effects between numerous categories of impacts. For instance, higher temperatures may positively affect yields for at least some crops within some range of temperature increase, but will also tend to increase weed and insect damages, increase ozone damages, and likely have damaging effects above a certain threshold level. The impacts also depend on precipitation and water availability, management practices, and other factors. Section 2.1 reviews some of the literature that studies these issues.

In this study, we rely on the assessments developed by the Climate Change Science Program (CCSP) and the Intergovernmental Panel on Climate Change (IPCC) to inform the establishment of sound estimates of expected future climate conditions under alternative scenarios (e.g., CCSP, 2008; IPCC, 2007). An important issue in selecting the climate scenarios that are being analyzed in the study is that we selected scenarios where outputs from global circulation models (GCMs) are publicly available. GCMs characterize the global climate under alternative greenhouse gas (GHG) concentrations, and several sets of model runs have been conducted for IPCC scenarios. GCM output data on spatial distribution of temperature and precipitation changes associated with alternative IPCC scenarios have been archived for selected scenarios.[1] The data used to characterize potential future temperature, precipitation, and carbon dioxide (CO_2) concentrations under alternative climate scenarios are being drawn from these data archives.

In the remainder of this report, we present background information on projected climate change impacts, describe the data and methods applied, and present our findings. Section 2 reviews the existing literature on climate change impacts on agricultural production and presents an overview of the program impact model that has been developed to provide estimates of potential future losses under alternative climate scenarios and its component models. Section 3 provides a summary of the data and methods currently being used in this study. Section 4 presents key results of the analyses conducted for each of the primary climate scenarios. Section 5 discusses key implications of projected climate change impacts for U.S. crop insurance. In addition, Appendix A presents simulated climate and crop yield impacts for selected additional GCMs.

[1]See http://www.mad.zmaw.de/IPCC_DDC/html/SRES_AR4/index.html.

2

Background

Despite the large body of research that has been compiled and synthesized under the auspices of the IPCC, as well as more recent work done by numerous other researchers and institutions around the world, there are still large uncertainties surrounding many key aspects of global climate change. Past research on climate impacts on agriculture, forests, and water resources has generally focused on changes in mean temperatures and sometimes changes in mean precipitation. However, many other aspects of climate variability may have important impacts, including potential changes in spatial and temporal distribution of temperature and precipitation, pest and disease pressure, wildfires, and extreme weather events. Also, it is important to distinguish between dryland and irrigated agriculture in analyses of potential climate change because the impacts are likely to differ. In addition, despite the key role of economics and other social sciences in landowner behavior and government policy decisions, there has been far less research in the social sciences than the natural sciences, leaving key gaps in information regarding costs, people's expected behavioral adjustments, and net impacts under alternative policies. One such area is agricultural risk management and crop insurance. Thus, this study addresses some of the key considerations for the U.S. crop insurance program to begin filling existing gaps in information. In this section, we review the existing literature and present an overview of the program impact model developed in this study.

2.1 Review of the Literature on Potential Climate Change Impacts on Agriculture

The literature exploring the impacts of climate change on agriculture has grown substantially over the past two decades. While there has been a growing consensus that there have been and will continue to be changes in climate that will impact agriculture, there remains considerable uncertainty surrounding the magnitude of those impacts. The myriad of different factors that play a role in agricultural production and the interactions among them make a comprehensive analysis of climate impacts an extremely challenging task. Crop simulation models and other agronomic models used in prior research differ in complexity and in the degree to which they incorporate physiological processes (Boote, Jones, and Pickering, 1996). In addition, methods for incorporating GCM data in crop simulation models vary widely (Carbone et al., 2003) and there are a variety of economic modeling approaches (e.g., production function approach vs. hedonic approach) that have been applied. Thus, previous studies have yielded a wide range of estimated impacts on expected yields and variance.

In addition, location-specific differences in resource availability (e.g., much of the agricultural production in the Southwestern U.S. is irrigated and is highly dependent upon the accumulation and melting of mountain snow pack) will affect mitigation and adaptation possibilities. Thus, climate impacts and the ability to adapt are expected to vary considerably across U.S. regions. Examples of other phenomena that potentially impact on agriculture and occur simultaneously with changes in temperature and precipitation are changes in CO_2 concentrations and tropospheric ozone levels. However, most of the literature focuses on studying certain aspects of the problem rather than conducting comprehensive analyses. Below, we provide an overview of findings regarding the effects of temperature and precipitation as well as CO_2, ozone, and extreme weather events.

2.1.1 Temperature and Precipitation Effects

While inputs such as fertilizer, irrigation water, and engineered seed varieties can help expand production possibilities into additional regions, regional temperature and precipitation are still among the most crucial factors influencing agricultural production. Thus, the literature examining the impacts of climate change on agriculture has concentrated on the effects of changes in temperature and precipitation.

In one of the first key papers to examine the potential effects of climate change on U.S. agriculture, Mendelsohn, Nordhaus, and Shaw (1994) employ a hedonic approach to estimate the marginal value of climate by regressing land values on climate, soil, and socioeconomic variables using cross sectional data. Their findings suggest that temperature increases in all seasons (except autumn) will lower farm values, while increases in precipitation in all seasons (except autumn) will raise farm values. The paper also recognizes that irrigation is an important adaptation response. The authors estimate the impacts of climate change on U.S. farm values by applying these estimates to a climate change scenario. The scenario considered is that of a doubling of carbon dioxide emissions by the middle of the 21st century which is associated with a 5 degree Fahrenheit change in mean temperature and an 8% change in precipitation. This paper shows that the estimated impact of climate change is lower using hedonics rather than a production function approach. This is expected as the production function approach does not account for adaptation possibilities (such as switching of crops, etc) and thus tends to overestimate damages. The reported results range from a 4-6% decline to a slight increase in the value of agricultural output.

Criticisms of the hedonic approach as used in the Mendelsohn, Nordhaus, and Shaw (1994) include inadequate treatment of irrigation in the analysis, lack of robustness to weighting schemes and the difficulties in estimating dynamic adjustment costs due to fixed capital constraints in the short run. In an attempt to explore the first issue, Schlenker, Hanneman, and Fisher (2005) conduct Chow's tests to determine whether estimated coefficients from a hedonic regression using dryland and irrigated counties are significantly different and also test for differences in the coefficients of the climate variables. The results indicate that the economic effects of climate change on agriculture need to be assessed differently in dryland and irrigated areas and that pooling the dryland and irrigated counties could potentially yield biased estimates. Due to data constraints, the model is estimated for dryland counties and the estimated annual losses are about $5 to $5.3 billion for dryland non-urban counties. The study acknowledges that adding the impact on irrigated areas may potentially yield greater estimates of losses but the exact magnitude is uncertain.

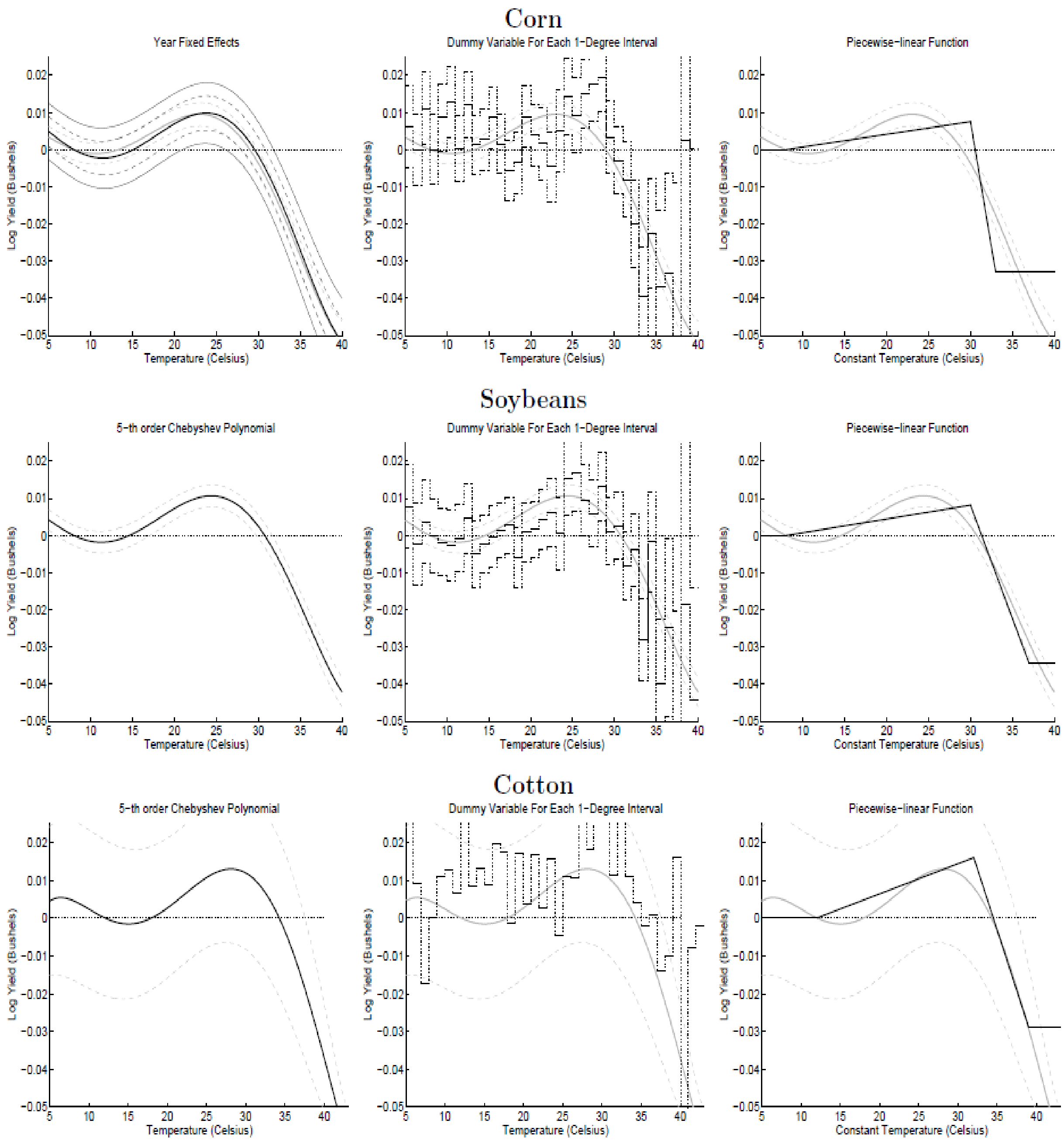
Schlenker, Hannemann, and Fisher (2007) examine individual farm values in California by matching farm values with a measure of surface water availability. Using degree days, which are calculated using a non-linear transformation of the temperature variable that is suggested by agronomic experiments to be a better predictor of plant growth than temperature, as a measure of climate in addition to various metrics of water availability (i.e. water rights, projected precipitation during growing and snow pack seasons), the authors estimate the economic impact on agriculture. Their findings indicate that climate change could significantly affect irrigated farmland value in California, reducing values by as much as 40%. More recent work by the authors suggest that the overall impacts of climate change could be "negative, robust, and large, ranging from 40-percent yield declines (slow-warming scenario) to 80-percent yield declines (fast-warming scenario) by the end of the century" (Schlenker, Hanneman, and Fisher, 2007).

Temperature increases affect crop responses in a non-linear fashion. Using a 55-year panel data on crop yields, Schlenker and Roberts (2006) found increases in crop yields (for corn, soybeans, and cotton) with higher temperatures until reaching threshold values. Their results show very large decreases in crop yields toward the end of the century as temperatures exceed these threshold levels (see Figure 2-1). The study estimates that yields of these three crops are expected to decline by 25- 44% under a slow warming scenario (IPCC B1 Scenario), and 60-79%, respectively, under a quick warming scenario (IPCC A1 Scenario) at the end of the century. Thus, the negative effects on agriculture could become very large in the long-term future if temperatures begin to reach threshold levels.

A key component of the study of climate change impacts on crop insurance is the effect of climate change on the variability of crop yields (as opposed to mean yields) as this reflects producer risk. Isik and Devadoss (2006) developed a framework for determining climate change impacts on crop yields and variability and yield and the covariance of yields among crops. Using a stochastic production function and two long-term climate change scenarios (Hadley 2025-2034 and Hadley 2090-2099), the paper estimates the impacts climate change would have on several crops traditionally cultivated in Idaho: potatoes, sugar beets, wheat, and barley. Mean potato yields are projected to increase 0.4 – 1.1% for the 2025–2034 scenario and 7.0–8.7% for the 2090–2099 scenario. Mean wheat yields are projected to increase 0.4–1.0% for the 2025–2034 scenario and by about 1.1–1.2% for the 2090–2099 scenario. On the other hand, barley and sugar beet yields are projected to decline about 4.6% and 1.0% in the 2025–2034 scenario, respectively. Mean yields are projected to decline 10.9% for barley and 2.4% for sugar beets under the 2090–2099 scenario. The variances of yields are estimated to decrease for wheat, barley and sugar beets but would increase slightly for potato. The covariance between wheat and potato yields and between barley and potato yields is estimated to decline significantly while that between wheat and barley increases marginally.

In an attempt to address the omitted variables problem arising in hedonic models, Greenstone and Deschenes (2007) use a county-level panel data to estimate the effect of weather on agricultural profits, conditional on county and state by year fixed effects. They then multiply the estimates by the simulated change in climate change (from the Hadley 2 model) to obtain the economic impact on agriculture. The authors do note that the primary limitation is that adaptation possibilities cannot be fully realized in a single year and thus damages may be overstated. The estimated increase in annual profits is $1.3 billion or 4% and this is robust to different specifications thus rendering the possibility of large negative or positive impacts unlikely. However, this paper does demonstrate heterogeneity in impacts across states and the simulated increases in temperature and precipitation do not have any significant effect on the yields corn for grain and soybeans. This paper also demonstrates that the hedonic approach is sensitive to control variables used, sample, and weighting schemes.

Figure 2-1. Non-Linear Relationship between Temperature and Yields



Source: Schlenker and Roberts (2006)

Reilly et al. (2003), using predictions from general circulation models from the Canadian Center Climate Model and the Hadley Centre Model, examined the effects changes in temperature and precipitation over the period of 2030-2090 would have on U.S. agriculture. The authors estimated the net effect on economic welfare and found the effects were positive but there were regional differences. The estimated increase in economic welfare was $0.8 billion (2000 U.S. $) in 2030 and $12.2 billion in 2090. Southern regions of the U.S. suffered productivity losses, while the Northern regions experienced cropland expansion and production shifting. Dryland cropping benefited more than irrigated cropping due to the projected increases in precipitation levels. An extension of this study using additional climate scenarios found similar results (McCarl and Reilly, 2006).

In a study using the CERES-Maize agronomic model to examine corn yields of the Corn Belt region of the U.S., Southworth et al. (2000) find that climate change will significantly impact corn yields in both the southern and northern ranges of the Corn Belt. The study focuses on the response of three types of corn (long, medium and short-season) under climatic change. The paper indicates that northern areas of the Corn Belt (southwest Wisconsin, eastern Wisconsin, south-central Michigan, northwest Ohio, and the Michigan thumb) will experience yield increases under climate change, while southern areas (western Illinois, eastern Illinois, southern Illinois, southwest Indiana, and east-central Indiana) will experience significant yield declines. Long-season corn, the predominant variety, is projected to respond favorably in the Northern areas of the Corn Belt (yield increases 0 to 45%), while in southern areas of the Corn Belt long-season maize is projected to experience significant yield declines (0 to -45%).

As part of its comprehensive analysis, the Climate Change Science Program (CCSP) SAP 4.3 report presents estimates that production of soybeans in the southern U.S. may fall 3.5% for a 1.2^0C increase in temperature from the current mean temperature of 26.7^0C. Meanwhile, soybean yields in the upper Midwest region of the U.S. are projected to increase 2.5% for a 1.2^0C above the mean of 22.5^0C (Boote, Jones, and Pickering, 1996; Boote, Pickering, and Allen, 1997). These results are indicative of the production shifts that may occur across regions.

Baldocchi and Wong (2006) analyze the potential impacts climate change could have on fruit and nut bearing trees in California. They analyze the impact climate change will have on periods of winter chill, periods where temperatures fall below 45^0 F, and the subsequent effects on crop yields. Winter chill periods are projected to fall below the 200-1200 hours that are necessary for most of the nut and fruit bearing trees of California, and yields are projected to decline as a result of the reduction in winter chill hours. They found that the winter climate will reach critical thresholds (hours of winter chill become too few) for many fruits by the end of the century, such that growers may have to substitute different crops. Additionally, the paper shows that a greater occurrence of extreme temperatures will have negative impacts on fruit quality during the summer." California produces 95% of the United State's apricots, almonds, artichokes, figs, kiwis, raisin grapes, olives, cling peaches, dried plums, persimmons, pistachios, olives, and walnuts. Since the production of these commodities is so concentrated into one geographical area the climatic impacts in these agricultural markets could be profound.

As mentioned above, the effects of climate change on agriculture are complex. For instance, higher temperatures may positively affect yields for at least some crops within some range of temperature increase, but will also tend to increase weed and insect damages and will have associated increased ozone damages, and are likely to have damaging effects above a certain threshold. The impacts also depend on precipitation and water availability, management practices, other aspects of climate change (such as extreme weather events) and the interaction between these factors. In the event of changes in precipitation levels and/or timing due to climate change, there are possible mitigation options such as adoption of irrigation to help alleviate water scarcity. In addition, adoption of heat-tolerant or drought-tolerant varieties may help to mitigate impacts. However, successful adaptation will depend on the availability of such varieties, the yields provided, and the relative seed and production costs. Selected studies exploring these factors and the interactions among them are described below.

2.1.2 CO_2 Fertilization, Ozone Effects, and Extreme Weather Events

Other important factor associated with climate change scenarios that needs to be assessed in conjunction with temperature and precipitation changes is the effects from CO_2 fertilization – a phenomenon where crop growth increases due to higher concentrations of carbon dioxide. Another factor to consider is potential reductions in yields due to increasing levels of tropospheric ozone. Tropospheric ozone (O_3), a naturally occurring compound in the troposphere, can become a pollutant at high enough concentrations, causing detrimental effects on crop growth. Another important aspect of climate change is changes in the intensity and frequency of extreme weather events. Examples of some of these are drought, flood, wildfire, hurricane, and periods of extreme heat or freeze.

One reason that many assessments find relatively small aggregate impacts on U.S. agriculture is that temperature and precipitation changes under climate scenarios occur gradually over time, providing growers with opportunities to mitigate impacts by changing crops, altering planting times, and making other management changes to adapt to changes in climate. However, past assessments have frequently ignored potential increases in yield variability due to increasing occurrence of episodic events such as wildfires, flooding, and hurricanes or changes in El Niño—Southern Oscillation (ENSO) cycles. These events are a potentially major source of crop losses, although there is still considerable uncertainty regarding climate impacts on these events. Chen and McCarl (2009) examined the damages from hurricanes on agriculture and the possible damages from an increase in frequency/intensity, as well as the nature of sectoral reactions to mitigate damages. The reduction of average state-level crop yields due to hurricanes ranges from 0.56% to 13.04%. Crop yield variances are significantly affected by hurricane intensity, and the magnitudes of yield variances due to hurricanes are higher than the impacts on average crop yields. These estimations imply that hurricanes not only damage crop yield but also raise crop production risk. Changes in cropping patterns can harden the sector with vulnerable crops like corn, cotton, and oranges reduced in incidence in the strike zone and increasing elsewhere, and such moves reduce sector-wide damages by 8.02%.

In another study of the impacts of extreme weather events on agriculture, Rosenzweig et al. estimate the total damages from the 1988 summer drought were $56 billion (normalized to 1998 dollars using an inflation wealth index), while those from the 1993 Mississippi River Valley floods exceeded $23 billion. The study highlights certain aspects of climate change such as increases in sequential extremes e.g., prolonged droughts followed by heavy rains which could reduce important pollinating insects and severely impact soil quality and increase pest infestations. All of these factors potentially impact agricultural productivity and thus ideally need to be included in a study conducted to obtain estimates of impacts of climate change on agriculture.

A number of studies have examined the influence of CO2 concentrations on agricultural crop and forest growth. These studies have typically found positive effects on growth and improved efficiency of water use, although this effect may be larger in experimental studies than in the field (e.g., Long et al., 2006). However, these studies tend to hold other factors constant, whereas increases in CO2 are projected to occur simultaneously with changes in temperature, precipitation, and other factors that may constrain the positive yield response to increasing CO2. Thus, it is important to assess changes in these factors simultaneously. All else being equal, higher concentrations of CO_2 increases crop growth. This result has long been substantiated in the literature, with both laboratory and FACE (free-air CO_2 enrichment) experiments demonstrating that crops respond favorably to CO_2 fertilization. However, that does not necessarily imply that the beneficial effects of increased CO_2 will offset negative effects associated with increased temperatures and changes in precipitation. The CCSP SAP 4.3 report notes that a doubling of CO_2 concentrations (from 330ppm to 660ppm) is projected to increase yields of C_3 crops (e.g. soybeans, cotton, hay, wheat, rice, barley and potatoes) by 33% and that of C_4 crop (e.g. corn and sorghum) by 10%, all else equal (Kimball, 1983).

In a recent study, Carbone et al. (2003) explored the yield responses of soybeans and sorghum crops grown in the Southeastern U.S. under two different spatial scales of climate change scenarios. The study involved using the CROPGRO-Soybean and CERES-Sorghum crop simulation models analyzing responses under three different cases: a case without CO_2 fertilization, a case with CO_2 fertilization and a case with CO_2 fertilization and adaptation. The results indicate that mean soybean yields would fall between 69% below baseline comparisons for a coarse (fine) scale climate change without fertilization, and 54% below baseline with fertilization. CO_2 fertilization does appear to offset some of the yield decreases associated with climate change. Adaptation strategies such as changing planting dates and shifting cultivars does mitigate impacts but yield still decreases by 8% and 18% for the two scenarios respectively. Similar results were obtained for sorghum – the yields decreased by 51%, 42% and 15% for the fine scale climate change only, fertilization and adaptation cases. The responsiveness of sorghum to elevated CO_2 was not as marked as soybeans, which is consistent with expectations given that sorghum is a C_4 crop.

In the same paper, Carbone et al. (2003) simulated soybean and sorghum yield for the western U.S. and Great Lakes regions. Output from the crop simulations was inputted into the Agricultural Sector Model (ASM) to measure net U.S. agricultural productivity in response to the two same climate scenarios. The results indicate an overall yield increases for soybeans in the Great Plains and Great Lakes regions as precipitation increases during the spring and summer months. Sorghum yields were projected to decline in Kansas, Nebraska, Oklahoma, and the eastern half of Texas and increase in Nebraska and the Texas High Plains and these changes are consistent with patterns in precipitation changes in the regions. The Carbone et al. analysis highlights the fact that climate change will potentially lead to differential impacts on agricultural productivity.

Increases in the levels of tropospheric ozone concentration coupled with increases in extreme weather-related events also reduce crop yields (Morgan et al, 2006). Using a free-air gas concentration enrichment (FACE) this study shows that an increase in ozone concentration from an average daytime ambient level of 56 ppb to a treatment 69 ppb reduces soybean seed yields by 20% and net primary production losses were estimated to be 17%.

2.1.3 Summary of General Findings in the Literature

Overall, studies have typically concluded that U.S. agriculture will likely not see major impacts over at least the next few decades, but findings vary considerably depending on emissions scenario and GCM used for climate simulations. They also depend on the measure of impact; studies that have looked at farm land value or profitability have tended to find smaller negative or more positive impacts than those focused on crop yields. Because the demand for food is relatively inelastic, widespread reductions in yield could result in an increase in revenue and profits to the farm sector. Also, national level results tend to smooth out potential distributional effects across regions as relative yields and cropping patterns shift across regions. There may also be important differences in impacts between irrigated and non-irrigated crops as precipitation patterns and water resource availability changes. An important issue to consider as one moves far enough out into the future to reach the temperature increases projected for the late 21^{st} century is the potential for non-linear temperature effects such as those found by Schlenker and Roberts (2006) as temperature thresholds are potentially exceeded more frequently.

Additional key issues that have been ignored in many of the existing studies included the potential effects of increased pest and disease pressures as well as potential changes in extreme weather events. In addition, many studies focus on mean yields, not necessarily on the variability of yields and the tails of the distribution, although changes in the tails of the distribution are an important determinant of crop insurance program performance. It is widely recognized that there are numerous areas where additional research is needed to improve understanding of the highly complex interactions and threshold effects of changes in climate that are occurring simultaneously with numerous other pressures on agriculture and natural resources in the U.S.

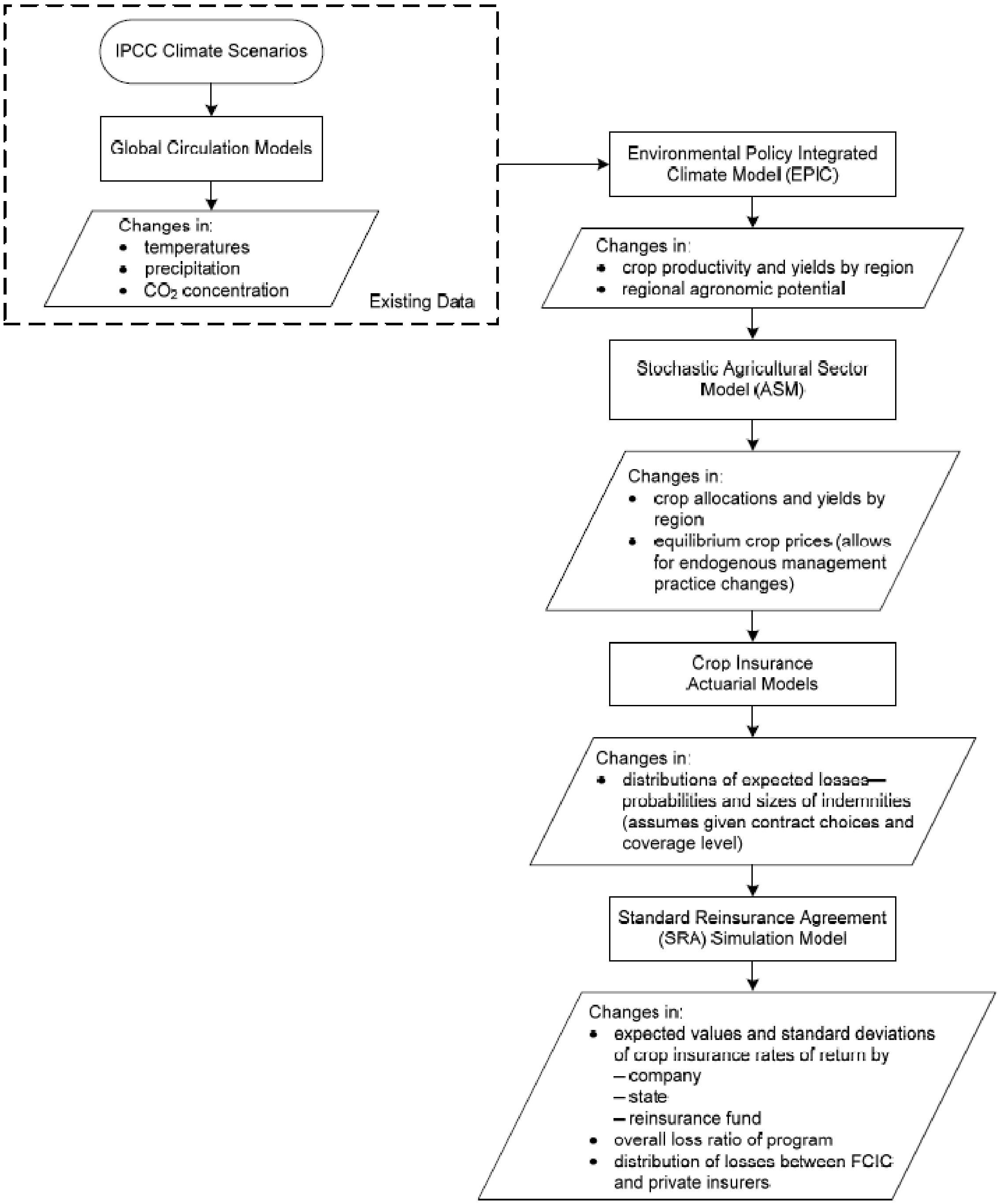
2.2 Model Description

Following the Program Impact Concept and Direction Report developed under Task 1, we have developed a program impact model that combines updated versions of several different existing models and methodologies to generate estimates of the impacts on the FCIC and AIPs under alternative climate scenarios. Figure 2-2 provides an updated and more detailed overview of our model linkages. We describe each of the models below.

2.2.1 IPCC Scenarios and Global Circulation Models

In 1988, the World Meteorological Organization (WMO) in collaboration with the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC). The IPCC was tasked with a clear role: "to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation". The IPCC provides policy makers with the tools and information that could be used in developing comprehensive policies to deal with the issue of human-induced climate change. Since its inception, the IPCC has produced four assessment reports (AR) on the "state of knowledge" on climate change. These reports, beginning with AR1 in 1990 and leading up to AR4 in 2007, are the product of an interdisciplinary approach consisting of private, academic and government professionals from across the globe. These reports provide an outlook on climatic change based on emissions scenarios (i.e., greenhouse gas concentrations). These scenarios and the accompanying GCM output data from the IPCC are an important component of current climate change research.

Figure 2-2. Overview of Model Linkages for the Program Impact Model



Interactions among complex dynamic systems result in greenhouse gas (GHG) emissions. Future emissions are driven by different factors such as demographic development, socio-economic development and technological change and there are uncertainties in the future evolutions of these factors. Using alternative modeling approaches, IPCC developed a set of scenarios to represent a range of driving forces and emissions based on the current knowledge regarding these uncertainties (Nakicenovic et al., 2000). Figure 2-3 provides a schematic illustration of the scenarios and Tables 2-1 and 2-2 provide an overview of driving forces.

The assumptions of the four storylines and scenario family are based on different directions for future developments and these are briefly described below:

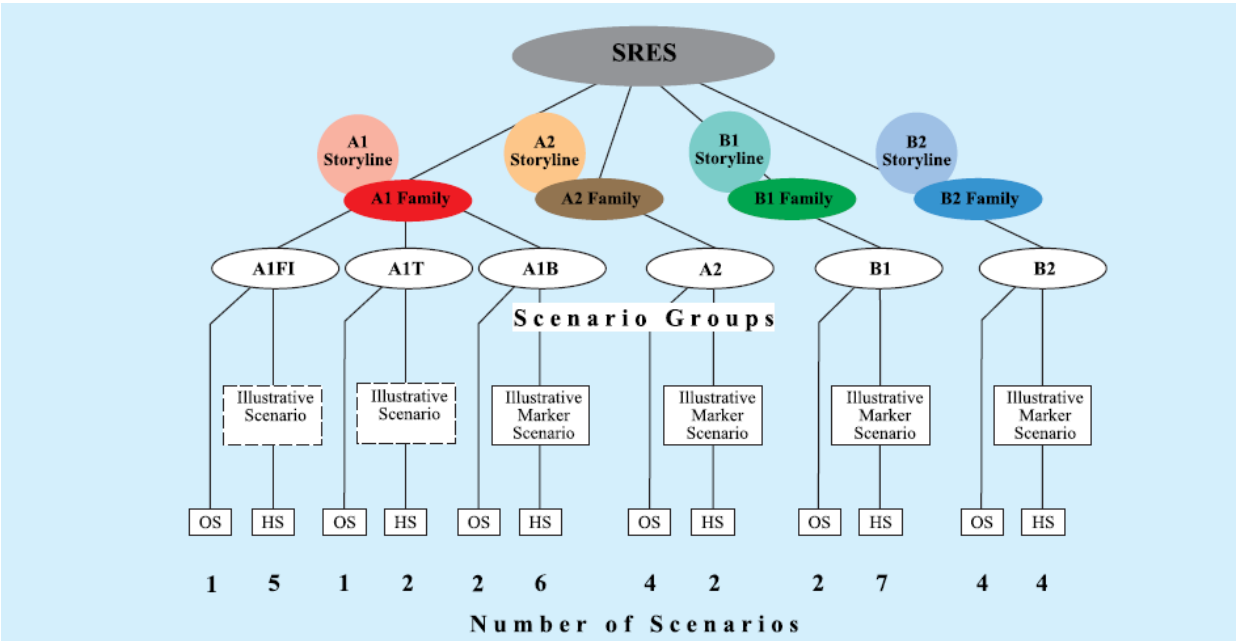
- A1: A future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis:
  - fossil intensive (A1FI),
  - non-fossil energy sources (A1T)
  - balance across all sources (A1B) where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies.

- A2: A very heterogeneous world where the underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is primarily regionally oriented and per capita economic growth and technological changes are more fragmented and slower than in other storylines.

- B1: A convergent world with the same global population that peaks in midcentury and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

- B2: A world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.

Figure 2-3. Schematic Illustration of SRES Scenarios



Source: IPCC Special Report: Emissions Scenarios (Summary for Policymakers), 2000.

Note: Four qualitative storylines yield four sets of scenarios called “families”: A1, A2, B1, and B2. Altogether 40 SRES scenarios have been developed by six modeling teams. All are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of six scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments of energy technologies: A1FI (fossil fuel intensive), A1B (balanced), and A1T (predominantly non-fossil fuel). Within each family and group of scenarios, some share “harmonized” assumptions on global population, gross world product, and final energy. These are marked as “HS” for harmonized scenarios. “OS” denotes scenarios that explore uncertainties in driving forces beyond those of the harmonized scenarios. The number of scenarios developed within each category is shown.

Table 2-1. Overview of Primary Driving Forces in 1990, 2020, 2050, and 2100

Family		A1			A2	B1	B2
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Population (billion)	5.3						
2020		**7.6** (7.4-7.6)	**7.5** (7.2-7.6)	**7.6** (7.4-7.6)	**8.2** (7.5-8.2)	**7.6** (7.4-7.6)	**7.6** (7.6-7.8)
2050		**8.7**	**8.7** (8.3-8.7)	**8.7**	**11.3** (9.7-11.3)	**8.7** (8.6-8.7)	**9.3** (9.3-9.8)
2100		**7.1** (7.0-7.1)	**7.1** (7.0-7.7)	**7.0**	**15.1** (12.0-15.1)	**7.0** (6.9-7.1)	**10.4** (10.3-10.4)
World GDP (10^{12} 1990US$/yr)	21						
2020		**53** (53-57)	**56** (48-61)	**57** (52-57)	**41** (38-45)	**53** (46-57)	**51** (41-51)
2050		**164** (163-187)	**181** (120-181)	**187** (177-187)	**82** (59-111)	**136** (110-166)	**110** (76-111)
2100		**525** (522-550)	**529** (340-536)	**550** (519-550)	**243** (197-249)	**328** (328-350)	**235** (199-255)
Per capita income ratio: developed countries and economies in transition (Annex-I) to developing countries (Non-Annex-I)	16.1						
2020		**7.5** (6.2-7.5)	**6.4** (5.2-9.2)	**6.2** (5.7-6.4)	**9.4** (9.0-12.3)	**8.4** (5.3-10.7)	**7.7** (7.5-12.1)
2050		**2.8**	**2.8** (2.4-4.0)	**2.8** (2.4-2.8)	**6.6** (5.2-8.2)	**3.6** (2.7-4.9)	**4.0** (3.7-7.5)
2100		**1.5** (1.5-1.6)	**1.6** (1.5-1.7)	**1.6** (1.6-1.7)	**4.2** (2.7-6.3)	**1.8** (1.4-1.9)	**3.0** (2.0-3.6)

[a] For some driving forces, no range is indicated because all scenario runs have adopted exactly the same assumptions.

Source: IPCC Special Report: Emissions Scenarios (Summary for Policymakers), 2000.

Note: Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the ranges across all 40 SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table. Technological change is not quantified in this table.

Table 2-2. Overview of Secondary Driving Forces in 1990, 2020, 2050, and 2100

Family		A1			A2	B1	B2
Scenario group	**1990**	**A1FI**	**A1B**	**A1T**	**A2**	**B1**	**B2**
Final energy intensity (10^6J/US$)[a]	16.7						
2020		**9.4** (8.5-9.4)	**9.4** (8.1-12.0)	**8.7** (7.6-8.7)	**12.1** (9.3-12.4)	**8.8** (6.7-11.6)	**8.5** (8.5-11.8)
2050		**6.3** (5.4-6.3)	**5.5** (4.4-7.2)	**4.8** (4.2-4.8)	**9.5** (7.0-9.5)	**4.5** (3.5-6.0)	**6.0** (6.0-8.1)
2100		**3.0** (2.6-3.2)	**3.3** (1.6-3.3)	**2.3** (1.8-2.3)	**5.9** (4.4-7.3)	**1.4** (1.4-2.7)	**4.0** (3.7-4.6)
Primary energy (10^{18}J/yr)[a]	351						
2020		**669** (653-752)	**711** (573-875)	**649** (515-649)	**595** (485-677)	**606** (438-774)	**566** (506-633)
2050		**1431** (1377-1601)	**1347** (968-1611)	**1213** (913-1213)	**971** (679-1059)	**813** (642-1090)	**869** (679-966)
2100		**2073** (1988-2737)	**2226** (1002-2683)	**2021** (1255-2021)	**1717** (1304-2040)	**514** (514-1157)	**1357** (846-1625)
Share of coal in primary energy (%)[a]	24						
2020		**29** (24-42)	**23** (8-28)	**23** (8-23)	**22** (18-34)	**22** (8-27)	**17** (14-31)
2050		**33** (13-56)	**14** (3-42)	**10** (2-13)	**30** (24-47)	**21** (2-37)	**10** (10-49)
2100		**29** (3-48)	**4** (4-41)	**1** (1-3)	**53** (17-53)	**8** (0-22)	**22** (12-53)
Share of zero carbon in primary energy (%)[a]	18						
2020		**15** (10-20)	**16** (9-26)	**21** (15-22)	**8** (8-16)	**21** (7-22)	**18** (7-18)
2050		**19** (16-31)	**36** (21-40)	**43** (39-43)	**18** (14-29)	**30** (18-40)	**30** (15-30)
2100		**31** (30-47)	**65** (27-75)	**85** (64-85)	**28** (26-37)	**52** (33-70)	**49** (22-49)

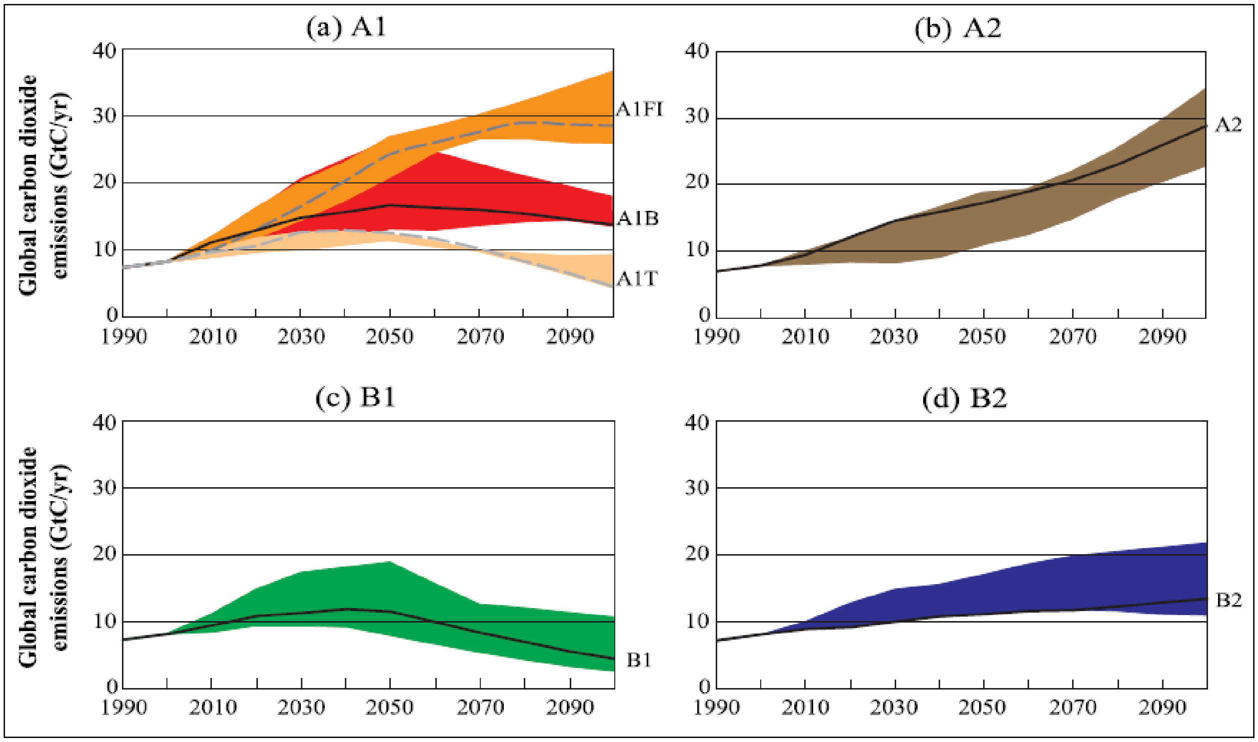
[a] 1990 values include non-commercial energy consistent with IPCC WGII SAR (Energy Primer) but with SRES accounting conventions. Note that ASF, MiniCAM, and IMAGE scenarios do not consider non-commercial renewable energy. Hence, these scenarios report lower energy use.

Source: IPCC Special Report: Emissions Scenarios (Summary for Policymakers), 2000.

Note: Bold numbers show the value for the illustrative scenario and the numbers between brackets show the value for the ranges across all 40 SRES scenarios in the six scenario groups that constitute the four families. Units are given in the table. Technological change is not quantified in this table.

Each of these storylines has different implications for GHG emissions over time and therefore atmospheric GHG concentrations. Figure 2-4 illustrates global carbon dioxide emissions across different scenarios. IPCC or any other emissions scenarios provide information on GHG emissions, but not climate effects. GHG emissions projections are used as inputs into Global Circulation Models (GCMs), which are highly complex atmospheric models generating simulated values for temperature, precipitation, relative humidity, wind speed, and other climate variables for a grid covering the entire globe.

Figure 2-4. Global CO_2 Emissions under Alternative IPCC Scenarios



Source: IPCC Special Report: Emissions Scenarios (Summary for Policymakers), 2000.

Note: Total global annual CO_2 emissions from all sources (energy, industry, and land-use change) from 1990 to 2100 (in gigatonnes of carbon (GtC/yr)) for the families and six scenario groups. The 40 SRES scenarios are presented by the four families (A1, A2, B1, and B2) and six scenario groups: the fossil-intensive A1FI (comprising the high-coal and high-oil-and gas scenarios), the predominantly non-fossil fuel A1T, the balanced A1B in Figure 2-4a; A2 in Figure 2-4b; B1 in Figure 2-4c, and B2 in Figure 2-4d. Each colored emission band shows the range of harmonized and non-harmonized scenarios within each group.

Global climate models are continually developing and improving, although uncertainties remain due to the complex nature of the climate system and the evolving scientific understanding of interconnections between climate and the ocean and terrestrial systems. GCMs have been developed at climate research centers located around the world, and they have been applied for a number of climate scenarios. Selected data from GCM model runs for AR4 have been archived for use in climate research and are made freely available to researchers.[2] The GCMs used in this study represent a range of the most

[2] Results from selected GCM simulations are archived at http://www.ipcc-data.org/index.html, among other locations.

robust models and were selected on the basis of available data and model skill. The models were extensively evaluated for the most recent IPCC Assessment Report published in 2007 (the Fourth Assessment Report, AR4) (Meehl et al., 2007; Randall et al., 2007) and were found to provide credible quantitative estimates of future climate change, particularly at continental and larger scales and for temperature changes. This confidence is ascribed to the models based on their foundation in accepted physical principles and their ability to reproduce observed features of current climate and past climate changes. For example, model simulation of temperature increases over the past two decades have been validated by subsequent measurements, and the observed faster increase in daily minimum temperature compared to daily maximum temperature has also been consistent with observed trends. In regards to extreme events, model skill is considered greater for extremes of temperature (as opposed to precipitation) and over longer time periods (e.g. multi-day events). The spatial resolution of the GCMs used in the IPCC assessment is generally not high enough to resolve tropical cyclones, and especially to simulate their intensity. Higher resolution regional models have greater ability to resolve cyclones, but limited skill in simulating intensity of individual events.

Uncertainties in climate model simulations remain, and the largest of these is in representation of cloud dynamics. This uncertainty results in different projections of temperature change between models using the same greenhouse gas forcing. In addition, the spatial resolution of GCMs precludes direct simulation of small-scale processes. Instead, these must be represented in approximate form as they interact with larger-scale features in the models. The differences in sub-continental scale patterns of climate change between different GCMs are attributed to these uncertainties (Randall et al., 2007)

The models we used are among the models with published radiative forcing covering the full range of climate sensitivity. They therefore span the range of models in terms of dynamical cores, spatial resolution, physics representations, as well as model heritage (i.e., models from different research groups where model development has followed different paths) (Meehl et al., 2007).

The available model data were limited by the archived model results at the Program for Climate Model Diagnosis and Intercomparison (PCMDI) web site (http://www-pcmdi.llnl.gov/). While many GCM's do simulate a full range of data necessary for impacts studies with models such as EPIC, these data may not be archived due to 1) requirements of the GCM intercomparison studies, 2) server capacity of the hosting web site, and 3) modeler confidence in output variables. These limitations often result in limited daily data availability and in limited availability of both maximum and minimum temperature. The models selected here were chosen on the basis of completeness of data requirements for the EPIC model. All models selected are in the top 50 percent of relative skill for the variables considered and have acceptable northern hemisphere error metrics that are higher than mean model error (Glecker, Taylor, and Doutriaux, 2008).

Data were downloaded from the PCMDI website for the continental United States and interpolated to observed historical weather data points for the EPIC database modeling units (8-digit hydrologic units) using a bilinear interpolation. Precipitation bias correction was performed by computing an adjustment factor based on the relationship between observed and modeled climate in the baseline period. Minimum and maximum temperatures were also bias corrected following the same method.

For this project, the IPCC SRES scenario A1B was selected for analysis. This scenario is characterized by a high rate of growth in CO2 emissions and most closely reproduces the actual emissions trajectories during the period since the SRES scenarios were completed (2000-2008) (van Vuuren and Riahi, 2008). Actual emissions in recent years have been above the A1B scenario projections so it is reasonable to focus on this scenario group versus those in the B1 and B2 scenario groups that have lower emissions projections. At the same time, there has been considerable interest and policy development to encourage non-fossil fuel energy, which is consistent with the A1B scenario vs. A1F1 or A2 that assume a heavier future reliance on fossil fuels. In addition, the climate model intercomparison project that included archiving of daily climate data for the 2045-2055 timeframe was only conducted with A1B and the use of daily climate projections was considered a high priority for this study to help capture the effects of climate variability within the growing season. The emissions and climate change implications of the different SRES scenarios do not diverge significantly until after 2050, and therefore there is little additional insight from use of multiple SRES scenarios in the 2010-2040 time period.

It is common practice in climate change analyses to use multiple GCM projections to reflect the uncertainty inherent in such projections. Assumptions and procedures vary substantially across different GCMs. Thus, for similar projections of GHG concentrations, there are a range of climate projection results. Multiple scenarios are being used to generate a range of results characterizing some of the uncertainty regarding climate change under the given IPCC scenario selected. The four primary GCMs being analyzed in this study are as follows (see Appendix A for climate and yield change estimates for two additional GCMs simulated over the 2010-2040 period as well as a scenario based on the CCSP SAP 4.3 assessment)[3]:

- GFDL-CM2.0 and GFDL-CM2.1 models developed by the Geophysical Fluid Dynamics Laboratory (GFDL), USA,
- Coupled Global Climate Model (CGCM) 3.1 developed by the Canadian Centre for Climate Modelling and Analysis, Canada.
- Meteorological Research Institute (MRI) coupled atmosphere-ocean General Circulation Model (CGCM) 2.2 developed by the Meteorological Research Institute, Japan Meteorological Agency, Japan.

In order to supply the disaggregated climate data needed by the Environmental Policy Integrated Climate (EPIC) model, we rely on data from these models to characterize potential future temperature, precipitation, and CO_2 concentrations. Table 2-3 summarizes national average changes in minimum and maximum temperature as well as precipitation under each of the four GCMs for both spring and summer seasons. Mean temperatures are simulated to rise under all four of the GCMs modeled in this study. The largest increase in mean temperature (4.34^{0}C in JJA max temp) is simulated by GFDL-CM2.0; conversely MRI-CGCM2.2 forecasts the smallest increase in mean temperature (1.23^{0}C in JJA max temp). The

[3] We had initially included three GCM scenarios in the analysis, but added a fourth to better capture variation across models. Both GFDL-CM2.0 and GFDL-CM2.1 are now being included because they have substantially different seasonal precipitation patterns; in contrast to the GFDL models, CGCM3.1 has similar temperature changes across spring and summer and more moderate changes in precipitation; and the MRI-CGCM2.2 has lower temperature changes than the other three models being considered, along with larger increases in precipitation.

GFDL-2.0 model also has reductions in total precipitation whereas MRI-CGCM2.2 has the largest increases in precipitations in both spring and summer. GFDL-CM2.1 has a smaller temperature increase than GFDL-CM2.0, but a more severe reduction in precipitation in the summer months. Average national effects for CGCM3.1 tend to fall in the middle of the other GCMs considered. As mentioned elsewhere, these GCMs cover a range of the different temperature and precipitation outcomes presented in the IPCC and other assessments to help provide a range of outcomes for the crop insurance program.

Table 2-3. Changes in Temperature and Precipitation under GCMs Modeled, 2045-2055 Relative to 1990-2000 Climate Baseline

Model	Season	Change Max Temp (°C)	Change Min Temp (°C)	Change in Precipitation (%)
GFDL-CM2.0	MAM	2.78	2.41	-7.4
GFDL-CM2.0	JJA	4.34	3.44	-8.5
GFDL-CM2.1	MAM	1.66	1.72	0.6
GFDL-CM2.1	JJA	4.03	3.45	-16.5
CGCM3.1	MAM	2.45	2.41	2.1
CGCM3.1	JJA	2.27	2.17	0.7
MRI-CGCM2.2	MAM	1.23	1.37	9.5
MRI-CGCM2.2	JJA	1.28	1.57	8.7

Below we include climate and crop yields maps for each of these GCMs. To focus on the most relevant areas for this project, we include data only for agriculturally important areas having non-negligible crop production in the maps. In addition, we focus on changes in conditions in the spring and summer months because they constitute the primary growing season. Figures 2-5 through 2-8 present maps of the projected differences in minimum and maximum temperatures and precipitation in spring (March, April, and May, denoted MAM) and summer (June, July, and August, denoted JJA) across the U.S. relative to a 1990-2000 climate baseline for each of the primary GCMs used.

Mean minimum and maximum temperatures generally increase for all regions of the U.S. in both spring and summer for the climate models considered, with summer months typically showing larger increases. As mentioned earlier in this section, another important consideration is the number of days that temperatures exceed a given threshold because temperatures affect crop responses in a non-linear fashion. For instance, based on simulation results from the GFDL-CM2.1 model, which falls in the middle of the projections of average temperature increases, the number of days exceeding 30°C increases by at least 15 days per year across all regions modeled except for parts of northern New York Vermont, New Hampshire, and Maine. The majority of the U.S. has increases in the number of days exceeding 30°C of at least 30 days per year in these simulations, with large areas of the Corn Belt, Great Plains, Southeast, Southcental, West, and Western Texas regions showing increases of 45 days per year or more. There are also large areas in the central U.S. projected to experience increases in the number of days above 40°C of at least 15 days per year with greater increases in parts of Texas, Oklahoma, New Mexico, Arizona, Kansas, Missouri, Arkansas, Louisiana, Alabama, and Mississippi.

Changes in precipitation patterns differ by season and climate model, but tend to show drying in the Midwest during the summer growing season. While the central U.S. tends to become hotter and dryer under the climate models used, both temperature increases and drying in the Midwest are less severe in the CGCM3.1 and MRI-CGCM2.2 simulations than in the GFDL-CM2.0 and GFDL-CM2.1 model simulations and many areas in the South, West, and northern Midwest show increases in precipitation. Because water availability is a major issue affecting projected yields under alternative climate scenarios, the varying precipitation patterns in the climate models selected helps to provide information on the range of outcomes.

In the spring months, the GFDL-CM2.0 model projects decreases in precipitation in the South Central and Midwest regions. Regions with particularly large reductions in precipitation include Louisiana, Alabama, Arkansas, Mississippi, and the Eastern portion of Texas. Modest increases in springtime precipitation are simulated for the Northern U.S. and the Mid-Atlantic. When comparing projected springtime precipitation levels of the two GFDL GCMs, it is apparent that GFDL-CM2.1 model projects a wetter U.S. Rather than receiving less precipitation in the spring, the Midwest and Northeast are projected to become considerably wetter and the South Central U.S. doesn't dry out nearly as much.

The summer growing months are projected to experience substantial declines in precipitation levels under the GFDL-CM2.0 model simulation. States in the Midwest are most affected with parts of Nebraska, Kansas, Iowa, Indiana, Illinois, and Ohio experiencing the largest decreases in the region. Additionally, South Florida is projected to see large reductions in summer precipitation levels. While most of the US sees considerable declines in summertime precipitation, the Carolinas, parts of the Mid-Atlantic, and the Southwest are projected to see substantial increases in precipitation. In contrast to its springtime projections, average precipitation levels during the summer months are projected to fall much more than under any of the other GCMs used in this study with reductions concentrated in the central portion of the U.S. The East Coast from Georgia to New York and Massachusetts, the Northern Great Plains, and parts of the Southwest and Great Lakes regions experience increases in summer precipitation under these model simulations.

CGCM3.1 and MRI-CGCM2.2 project wetter spring months overall, although there is drying in the West, Northeast, and Southcentral regions in the CGCM3.1 model and primarily in Texas and Oklahoma in the MRI-CGCM2.2 model. During the summer growing months, there are relatively small changes in precipitation in either direction for most of the country in the CGCM3.1 projections, though Texas, along with parts of the Southeast and Northern Great Plains, see increases in precipitation. The MRI-CGCM2.2 model has more extremes in its summer precipitation projections, with relatively large increases in the Carolinas and the Midwest and relatively large decreases in the most southern regions of states along the Gulf Coast from Texas to Florida.

Figure 2-5. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the GFDL-CM2.0 GCM, 2045-2055

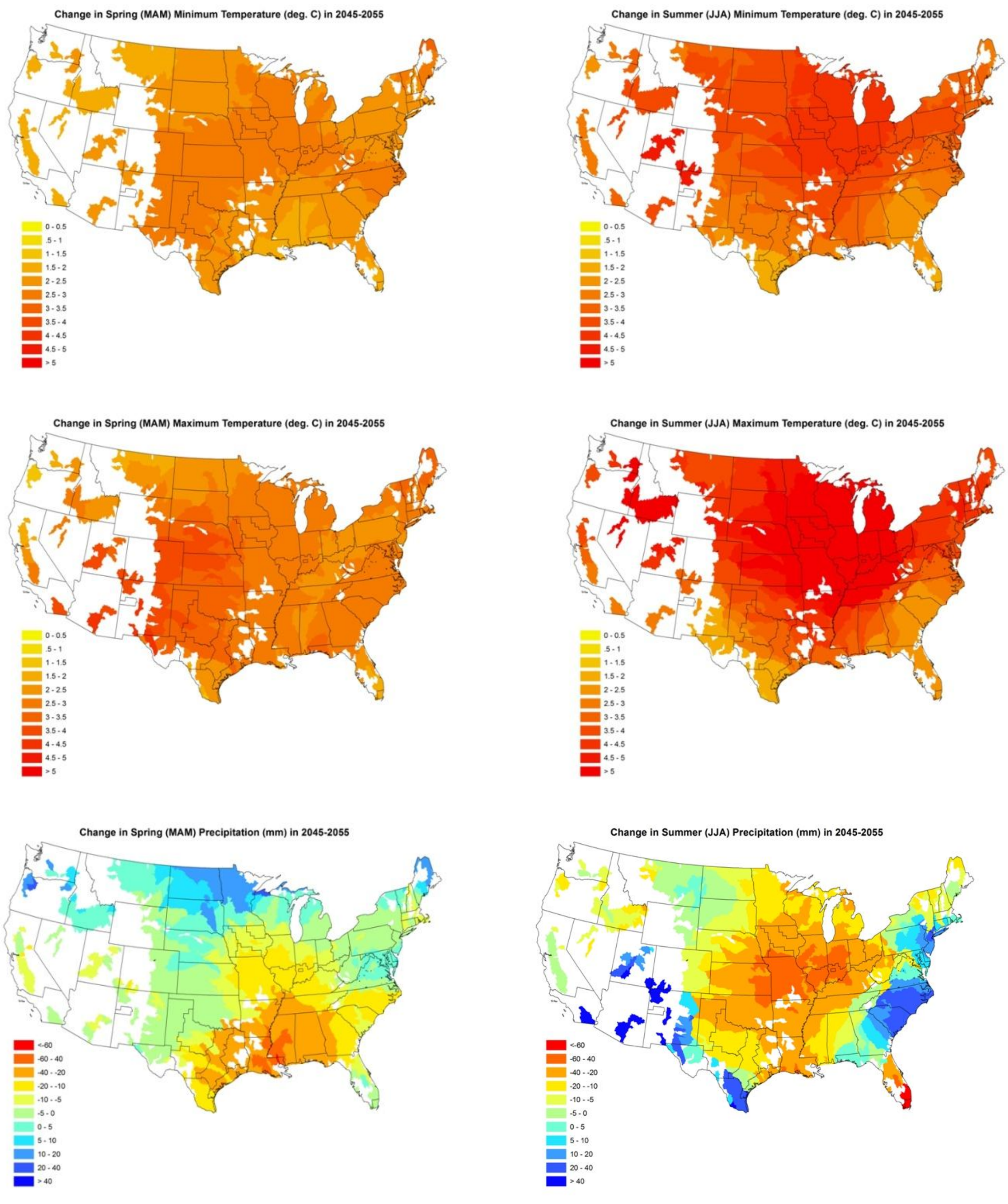


Figure 2-6. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the GFDL-CM2.1 GCM, 2045-2055

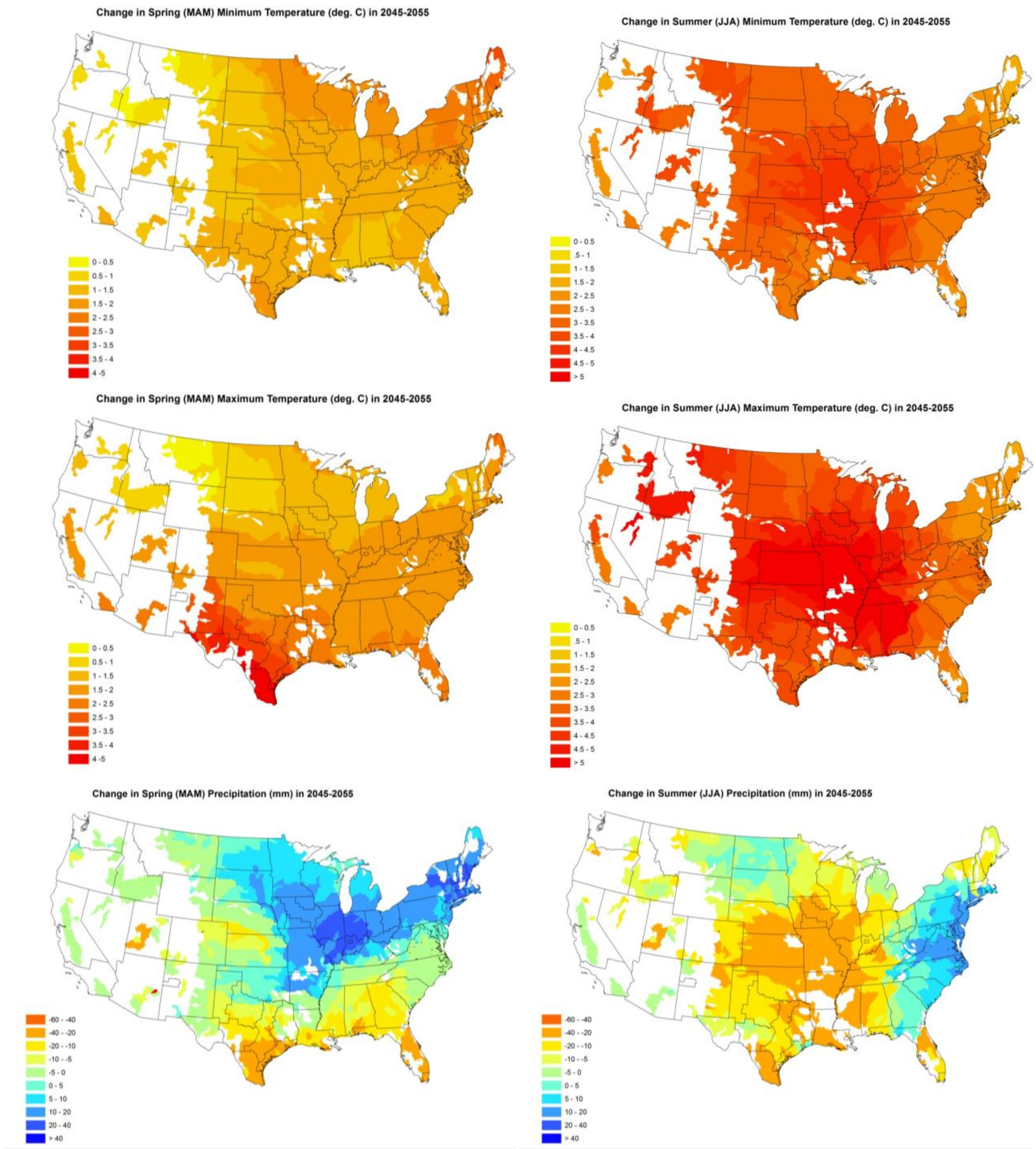


Figure 2-7. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the CGCM3.1 GCM, 2045-2055

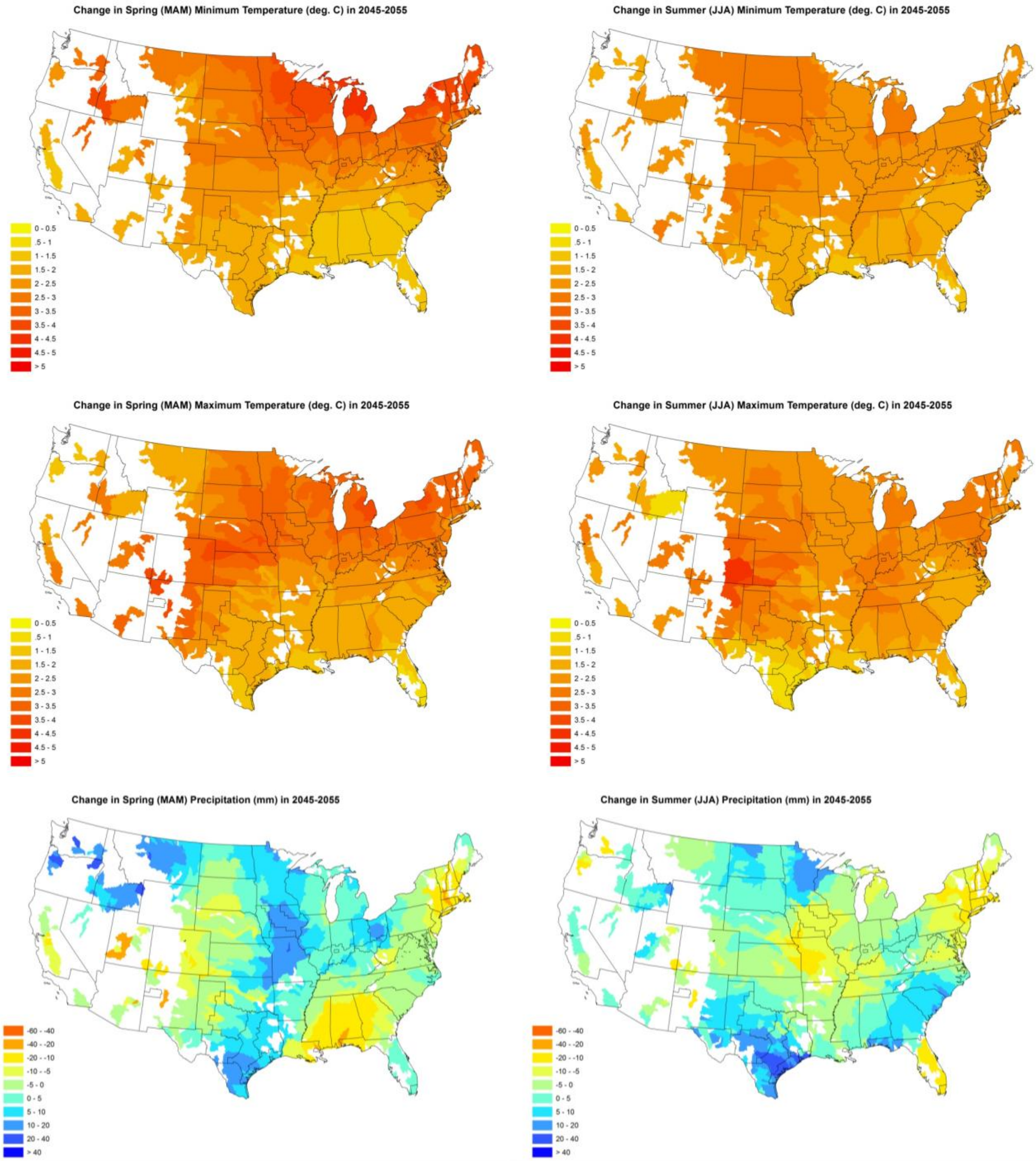
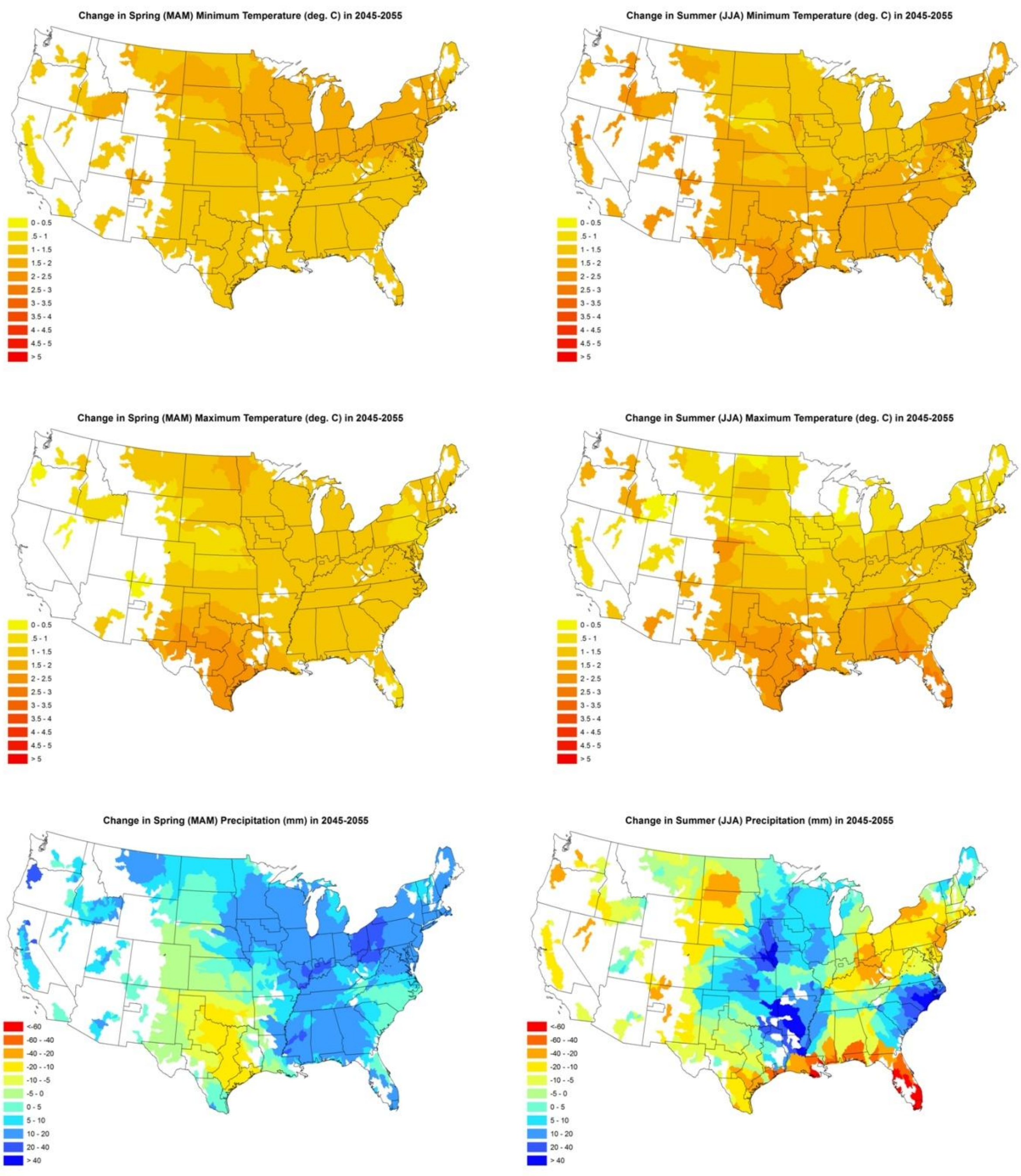


Figure 2-8. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the MRI-CGCM2.2 GCM, 2045-2055



2.2.2 EPIC Modeling

EPIC, originally called the Erosion-Productivity Impact Calculator, was jointly developed by USDA and Texas Agricultural Experimental Station (Texas A&M) to assess the effect of soil erosion on soil productivity. There have been numerous enhancements to the model over time as well as an expansion in the focus of the model that resulted in a name change. The model is currently referred to as the Environmental Policy Integrated Climate model. EPIC version 0509 was used in this study.

The EPIC model is a single-farm biophysical process model that can simulate crop/biomass production, soil evolution, and their mutual interaction given detailed farm management practices and input climate data (Williams, 1995). Crop growth is simulated by calculating the potential daily photosynthetic production of biomass. The daily potential growth is decreased by stresses caused by shortages of radiation, water and nutrients, by temperature extremes and by inadequate soil aeration. Each day's potential photosynthesis is decreased in proportion to the severity of the most severe stress of the day.

Stockle et al. (1992a,b) adapted EPIC to simulate the CO_2-fertilization effect on radiation use efficiency (RUE) and evapotranspiration (ET). Elevated atmospheric CO_2 concentration increases photosynthesis in C_3 plants and reduces evapotranspiration in both C_3 and C_4 plants because of reduced stomatal conductance. Improved water use efficiency occurs in both C_3 and C_4 plants. A non-linear equation was developed in EPIC to express the RUE response to increasing CO_2 concentrations following experimental evidence summarized by Kimball (1983). Their analysis showed crop yield increases of 33% with a doubling of atmospheric CO_2, and assign a 99% confidence in this response ranging from 24 to 43%. Stockle et al. (1992a,b) modeled this response as a function of crop type. The parameters developed by Stockle et al. have been found to be consistent with recent results arising from FACE experiments (Amthor, 2001).

EPIC has undergone intensive improvements and testing under a variety of climates, soils, and management environments. Examples of improvements and validation results reported in the literature include those for water erosion and snowmelt runoff (Purveen et al., 1997; Chung et al., 1999), wind erosion (Potter et al., 1998), crop yield (Roloff et al., 1998), climatic variability (Izaurralde et al., 1999; Legler, Bryant, and O'Brien, 1999), climate change (Easterling et al., 1996; Brown and Rosenberg, 1999; Izaurralde et al., 2003; Thomson et al., 2002), nutrient cycling (Cavero et al., 1998), and soil carbon sequestration (Izaurralde et al., 2001). A complete review of applications and validation of EPIC was completed by Gassman et al. (2005).

EPIC has been widely applied to a range of applications. JGCRI applies a database of cropland areas and management practices in the United States based on the Natural Resources Inventory (Potter et al., 2004). This database was applied with EPIC in the Consortium for Agricultural Soils Mitigation of Greenhouse Gases (CASMGS) program to estimate national changes in crop productivity and soil carbon for the United States under four sets of climate change scenarios and similarly has been used by the DOE Center for Carbon Sequestration in Terrestrial Ecosystems program (CSiTE) for evaluation of bioenergy crops on a national scale. National-scale results from climate change impacts assessments with EPIC have been applied in economic models for the U.S. National Assessment of Climate Change (Izaurralde et al.,

2003) and a comprehensive integrated assessment of climate change impacts on national crop productivity (Thomson et al., 2005a, b).

The model has been used in several previous studies of climate change impacts, including Brown et al. (2000) and Thomson et al. (2005a, b), among others. For instance, Brown et al. (2000) used the EPIC model to compare yields, water use, and soil erosion for switchgrass, corn, sorghum, soybeans, and winter wheat under baseline climate conditions and under a simulated greenhouse-forced climate change with and without CO_2 fertilization effects for the Missouri- Iowa-Nebraska-Kansas region of the United States. They found that temperature increases between 4° and 8°C increased switchgrass yields in Midwestern states but decreased yields for traditional agricultural crops such as corn, soybeans, and sorghum. Climate change simulations were repeated with an elevated CO_2 concentration of 560 ppm. Switchgrass yields increased further with added CO_2, up to 2.6 Mg/ha more than with just climate change alone. The increased CO_2 resulted in decreased water stress, thus improving yields for all of the crops. Yield gains for winter wheat increased by 0.5 Mg/ha from baseline.

Another more recent addition of EPIC has been the incorporation of a complete soil carbon model. In earlier applications of EPIC, soil carbon was simulated in a relatively simplistic fashion as a function of soil nitrogen levels (Gassman et al., 2005). EPIC's ability to capture soil carbon dynamics underwent a major revision (Izaurralde et al. 2001; Post et al., 2004), and "in the revised approach, simulated carbon and nitrogen compounds are stored in either biomass, slow, or passive soil pools. Direct interaction is simulated between these pools and the EPIC soil moisture, temperature, erosion, tillage, soil density, leaching, and translocation functions" (Gassman et al., 2005).

EPIC Application in this Study

EPIC ver.3060 has been previously applied in simulations of regional productivity of corn, soybeans, winter wheat, cotton, hay, and switchgrass for the United States at the 8-digit hydrologic unit scale. For this project, the model datasets were extended to also provide simulations of rice, barley, and potatoes. The management datasets were also extended to include simulations of irrigated and dryland production over the entire simulation region for corn, soybean, wheat, cotton, hay and barley. Rice and potato were simulated under irrigated conditions only. Table 2-4 gives the total number of simulations conducted. Excluding regions with little agricultural production, 1,450 hydrologic units are included for the United States. Multiple soils are represented within each of the hydrologic units, resulting in 7,540 total possible runs. Each crop is simulated for its present day primary growing area and, for this study, the growing area was extended for each crop to include modeling units that intersected a 100km buffer of the current growing area. This extension thus captures the potential for future changes in the most suitable growing regions for specific crops and increases the future options for farmers. Thus, the EPIC model was applied to simulate the yield of multiple crops on each representative land parcel included for the model runs under multiple climate scenarios. The differences between EPIC-simulated baseline and climate change scenario crop yields provide the basis for determining the changes in crop yields under the alternative climate change scenarios relative to baseline conditions.

The EPIC model accounts for climate-induced changes in temperature, precipitation, and other variables. Two types of weather data can be used as inputs: monthly mean values with statistical distribution or daily time series for the model period. For this study, model simulations for the 2010-2040 time period (and associated 1960-1990 baseline) were simulated with monthly weather. EPIC includes a statistical weather generator to calculate daily model inputs. When daily time series weather are available, such as for the 2045-2055 time period (and associated 1990-2000 baseline), these data can drive the model directly. As the EPIC model simulates plant growth on a daily time step, when run with daily weather input the changes in frequency and intensity of rainfall events, and changes in temperature extremes are captured by the model simulation. These dynamics are also inherent in the statistical distribution of the monthly weather input. The two time periods and climate model input data were selected on the basis of available data.

EPIC provides results at the level of a representative farm. However, because the location of the farms within a modeling unit is not known to greater spatial detail, results are aggregated to the 1,450 eight-digit U.S. Geological Survey (USGS) hydrologic basins for the United States for reporting purposes. In addition, the output was shared out to the county-level with zonal statistics functions in GIS software in order to develop estimates of changes in yield potential for each crop at the county level for input to the economic and actuarial models.

Table 2-4. Number of EPIC Simulations Performed for this Study

Crop	EPIC Simulations per Scenario	Total EPIC Simulations
Barley	4,764	52,404
Corn	22,046	242,506
Cotton	4,196	46,156
Hay	18,038	198,418
Potato	1,794	19,734
Rice	1,038	11,418
Sorghum	4,400	48,400
Soybean	17,958	197,538
Wheat (winter and spring)	14,840	163,240
TOTAL	89,074	979,814

2.2.3 Stochastic FASOM

In the next stage of application of the Program Impact Model, the shifts in crop production estimated within EPIC are incorporated in the stochastic version of the Forest and Agricultural Sector Optimization Model (FASOM). FASOM (Adams et al., 2005) has been developed by Dr. Bruce McCarl and others to model economic decisions and assess agricultural market outcomes under alternative specifications. FASOM and related models (e.g., the Agricultural Sector Model [ASM]) have been used extensively in numerous forest and agricultural policy applications, including a large number of climate change–related studies for the IPCC, CCSP, USDA, Department of Energy (DOE), Environmental Protection Agency (EPA), and others.

FASOM includes several major groupings of agricultural and forest commodities, depending on the sector and whether they are raw, are processed, used for bioenergy, or mixed for livestock feed. These commodity groups are

- raw crop, livestock, forestry, and biofuel feedstock primary commodities grown on the land;
- processed, secondary commodities made from the raw crop, livestock, and wood products;
- energy products made from biofuel feedstocks; and
- blended feeds for livestock consumption.

Agricultural commodities are quite frequently substitutable in demand. For example, sorghum is a close substitute for corn on a calorie-for-calorie basis in many uses, and beet sugar is a perfect substitute for sugar derived from sugarcane. Also, a number of feed grains are substitutes in terms of livestock feeding. FASOM contains a set of processing activities that make secondary commodities. Secondary commodities are generally included in the model either to represent substitution or to depict demand for components of products. For example, processing possibilities for soybeans are included depicting soybeans being crushed into soybean meal and soybean oil because these secondary commodities frequently flow into different markets. Thus, the model reflects a large degree of demand substitution.

FASOM includes all states in the conterminous United States, broken into 63 subregions for agricultural production and 11 market regions (see Table 2-5). The 11-region breakdown reflects the existence of regions for which there is agricultural activity but no forestry, and vice versa. Forestry production is included in 9 of the market regions (all but Great Plains and Southwest), whereas agricultural production is included in 10 of the market regions (all but Pacific Northwest—West side). The Great Plains and Southwest regions are kept separate because they reflect important differences in agricultural characteristics. Likewise, there are important differences in the two Pacific Northwest regions (PNWW, PNWE) for forestry, so they are maintained separately, although only the PNWE region is considered a significant producer of agricultural commodities tracked in the model.

Table 2-5. FASOM Regions and Subregions

Key	Market Region	Production Region (States/Subregions)
NE	Northeast	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia
LS	Lake States	Michigan, Minnesota, Wisconsin
CB	Corn Belt	All regions in Illinois, Indiana, Iowa, Missouri, Ohio (IllinoisN, IllinoisS, IndianaN, IndianaS, IowaW, IowaCent, IowaNE, IowaS, OhioNW, OhioS, OhioNE)
GP	Great Plains	Kansas, Nebraska, North Dakota, South Dakota
SE	Southeast	Virginia, North Carolina, South Carolina, Georgia, Florida
SC	South Central	Alabama, Arkansas, Kentucky, Louisiana, Mississippi, Tennessee, Eastern Texas
SW	Southwest (agriculture only)	Oklahoma, All of Texas but the Eastern Part (Texas High Plains, Texas Rolling Plains, Texas Central Blacklands, Texas Edwards Plateau, Texas Coastal Bend, Texas South, Texas Trans Pecos)
RM	Rocky Mountains	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming
PSW	Pacific Southwest	All regions in California (CaliforniaN, CaliforniaS)
PNWE	Pacific Northwest—East side (agriculture only)	Oregon and Washington, east of the Cascade mountain range
PNWW	Pacific Northwest—West side (forestry only)	Oregon and Washington, west of the Cascade mountain range

FASOM includes all cropland, pastureland, rangeland, and private timberland throughout the conterminous United States. The model tracks both area used for production and idled (if any) within each land category. In addition, the model tracks the movement of forest and agricultural lands into developed uses. Land categories included in the model are specified as follows:

- **Cropland** is land suitable for crop production that is being used to produce either traditional crops (e.g., corn, soybeans) or dedicated energy crops (e.g., switchgrass). The 1997 U.S. Department of Agriculture (USDA) National Resource Inventory (NRI) data (most recent NRI dataset that is publicly available at a spatially disaggregated level) coupled with USDA National Agricultural Statistics Service (NASS) data on county-level harvested acreage were used to specify land availability. Cropland is tracked by crop tillage system and irrigated/dryland status as well as the amount of time it has been in such a system to allow tracking of sequestered soil carbon and the transition to a new soil carbon equilibrium after a change in tillage. Cropland can be converted to cropland pasture or forestland.

- **Cropland pasture** is managed land suitable for crop production (i.e., relatively high productivity) that is being used as pasture, but can potentially be converted to crop production or forestland.

- **Forest pasture** is pasture on land with varying amounts of tree cover that can also be used for livestock production, although forage productivity of these lands tends to be relatively low. This land category is further subdivided into forest pasture in forest (pasture on private timberland), forest pasture in agriculture (woodland pasture on farmland), and forest pasture in public (pasture on forested public lands that can be grazed). Forest pasture in agriculture can be converted to private timberland, but the other two categories of forest pasture cannot be converted to any other uses.

- **Rangeland** comprises both public and private rangeland, which is typically unimproved land where a significant portion of the natural vegetation is native grasses and shrubs. Rangeland generally has low forage productivity and is unsuitable for cultivation. In addition, much of the rangeland in the U.S. is publicly owned. It is assumed that rangeland cannot be used for crop production or forestland.

- **Forestland** in FASOM refers to private timberland, with a number of subcategories (e.g., different levels of productivity, management practices, age classes) tracked (see below for additional details). The model also reports the number of acres of private forestland existing at the starting point of the model that remains in standing forests (i.e., have not yet been harvested), the number of acres harvested, the number of harvested acres that have been reforested, and the area converted from other land uses (afforested). Public forestland area is not explicitly tracked because it is assumed to remain constant over time. Forestland can be converted to cropland, cropland pasture, or forest pasture in agriculture.

- **Developed** (urban) land is assumed to increase over time at an exogenous rate for each region based on projected changes in population and economic growth. It is assumed that the land value for use in development is sufficiently high that the movement of forest and agricultural land into developed land will not vary between the policy cases analyzed. Each of the four land categories described above moves into the developed land category at an exogenous rate (with the exception of forest pasture in forest and forest pasture in public), decreasing the total land base available for forestry and agriculture over time.

- **Conservation Reserve Program (CRP) land** is specified as land that is voluntarily taken out of crop production and enrolled in the USDA's Conservation Reserve Program. Land in the CRP is generally marginal cropland retired from production and converted to vegetative cover, such as grass, trees, or woody vegetation to conserve soil, improve water quality, enhance wildlife habitat, or produce other environmental benefits. However, it is possible for this land to move back into cropland as landowner commitments to maintain land in CRP expire.

Land is allowed to move between categories subject to the restrictions discussed under each category above. The conversion costs of moving between land categories are set at the present value of the difference in the land rental rates between the alternative uses based on the assumed equilibration of land markets.

Budgets are included for all primary crop and biofuel feedstocks included in the model. For each crop, production budgets are differentiated by region, tillage choice (three choices: conventional tillage, conservation tillage, or no-till), and irrigated or dryland and cropland type (four as discussed in land use section above). The differentiation included results in thousands of cropping production possibilities (budgets) representing agricultural production in each 5-year period. For livestock production, budgets are included that are defined by region, animal type, and feeding alternative. Hundreds of livestock production possibilities (budgets) represent agricultural production in each 5-year period.

Supply curves for agricultural products are generated implicitly within the system as the outcome of competitive market forces and market adjustments. This is in contrast to supply curves that are estimated from observed, historical data. This approach is useful here in part because FASOM is often used to simulate conditions that fall well outside the range of historical observation (such as large-scale tree-planting programs or implementation of mandatory GHG mitigation policies).

FASOM uses commodity supply and demand curves for the U.S. market that are calibrated to historic price and production data with constant price differentials between regions and the nation for some crops. In addition, the model includes supply and demand data for major commodities traded on world markets such as corn, wheat, soybeans, rice, and sorghum across 37 foreign regions.[4] FASOM includes information on transportation costs to all regions, which affect equilibrium exports.

The model solution requires that all markets are in equilibrium (i.e., quantity supplied is equal to the quantity demanded in every market modeled at the set of market prices in the model solution). The demand and supply curves included within the model and that need to be in equilibrium in each 5-year period include

- regional product supply,
- national raw product demand,
- regional or national processed commodity demand,
- regional or national supply of processed commodities,
- regional or national (depending on commodity) export demand,
- regional or national (depending on commodity) import supply,
- regional feed supply and demand,
- regional direct livestock demand,
- interregional transport perfectly elastic supply,
- international transport perfectly elastic supply, and

[4] FASOM foreign regions include the European Economic Community, North Central Europe, Southwest Europe, Eastern Europe, Adriatic, Eastern Mediterranean, Former Soviet Union, North Africa, East Africa, West Africa, South Africa, Red Sea, Iran, India, Taiwan, Japan, South Korea, North Korea, China, Bangladesh, Indonesia, Myanmar, Pakistan, Philippines, Thailand, Vietnam, West Asia, Southeast Asia, Australia, Caribbean, Eastern Mexico, Eastern South America, Western South America, Argentina, Brazil, Canada, and Other.

- country-specific excess demand and supply of rice, sorghum, corn, soybeans, and the individual types of wheat modeled.

Processed commodities such as soybean meal, gluten feed, starch, and all livestock feeds are manufactured and used on the 11-market region basis but are supplied into a single national domestic market as well as to meet export demand.

In this study, the stochastic version of FASOM is used to model crop allocation decisions by crop and management categories based on the relative returns and variability of returns under alternative cropping patterns under the yield distributions associated with the climate scenarios modeled. FASOM also generates equilibrium commodity prices under alternative scenarios that is used in assessing effects on revenue insurance products. The distribution of production, yields, and prices modeled under baseline conditions and climate scenarios is used to calculate and compare losses in the crop insurance program. FASOM has been applied previously in risk management applications (Chen and McCarl, 2000; Chen, McCarl, and Adams, 2001; Chen, Gillig, and McCarl, 2001) to assess producer response to changes in production risk.

2.2.4 Crop Insurance Actuarial Models

The next step involves using the changes in yield distributions simulated using EPIC in actuarial models of major crop insurance programs for the crops that are modeled within EPIC. Shifts in the yield distributions affect the probability of losses exceeding a given coverage level and, therefore, simulated indemnities. This modeling effort provides estimates of changes in the distribution of projected losses (probabilities and sizes or indemnities) under alternative climate scenarios.

Actuarial simulation models were developed to determine the projected loss cost ratios under alternative climate change scenarios. Climate change affects yield distributions and, consequently, the probability and size of crop insurance losses. Parametric yield distributions are estimated using historical district-level yield data and these distributions are then used to simulate loss costs for the different yield and revenue insurance products in this study. Price distributions estimated from historical futures price data are used (together with the yield distributions) for simulating loss costs for revenue insurance products. The estimated loss cost distribution from the historical data is considered the “initial” or "current” or “base” loss cost distribution (for 2006). The resulting mean yield and yield variance changes from the EPIC and FASOM models are then used to estimate the “shift” in the yield and loss cost distribution for particular climate change scenarios, as described in more detail in Section 3.

2.2.5 Standard Reinsurance Agreement Simulation Model

Finally, we are incorporating information on yield and price variability and crop insurance market outcomes from the EPIC, stochastic FASOM, and actuarial models into the SRA model developed to estimate the impacts that the SRA has on outcomes under alternative climate change scenarios. The SRA model was originally developed for RMA by Mario Miranda in the late 1990s. The model has been used in publications by project team member Dr. Vedenov (e.g., Vedenov et al., 2004; Vedenov et al., 2006), including analyses of the 1998 SRA, alternative SRAs that were discussed but not implemented, and drafts of the 2005 SRA on underwriting gains and losses of insurance portfolios held by participating organizations.

The model uses the estimated distributions developed after applying

- the EPIC model to estimate changes in crop yields under alternative climate scenarios and the agronomic potential for producing crops in regions where they had not been grown previously;
- the stochastic FASOM model to account for endogenous prices and generate price distributions under the alternative climate scenarios; and
- actuarial models for the crops being assessed in this study that provide estimated losses based on the simulated yields, prices, and insurance products under each climate scenario modeled.

The objective of the SRA model is to simulate distributions of rates of return from underwriting crop insurance, which depend heavily on the terms of the SRA between FCIC and the AIPs. The pre-SRA rates are driven by gross underwriting gains or losses defined for modeling purposes as the difference between the premiums collected and indemnities paid. The post-SRA rates of return are determined by particular realizations of companies' loss ratios at the state level and the SRA parameters (retention rates, breakpoints, and shares). Thus, to analyze the effect of SRA on the rates of return, we model the distribution of loss ratios by state and reinsurance fund for each participating organization reinsured by the FCIC.

The FCIC has offered reinsurance on crop insurance contracts since 1981 with the passage of the Federal Crop Insurance Act of 1980. The SRA between the FCIC and AIPs establishes terms and conditions for the FCIC to provide subsidy and reinsurance on eligible crop insurance contracts. Private insurance companies interested in reinsurance through RMA must meet the requirements laid out in the most recent version of the SRA. Thus, the specific provisions of the SRA have substantial implications for risk sharing and the distribution of returns. The most recent version of the SRA went into effect in 2004, although its major provisions remain largely unchanged from the 1998 agreement (Vedenov et al., 2006).

Currently, companies must assign crop insurance contracts designated for reinsurance to one of three funds: Assigned Risk Fund, Developmental Fund, or Commercial Fund. Each fund has differing retention and cession limits. The Assigned Risk Fund has historically been the repository for the riskiest assets. Its cession and retention limits differ by state (see Table 2-6).

Table 2-6. Maximum Premium Cession and Retention of Ceded Premium for the Assigned Risk Reinsurance Fund by State

State	Maximum Premium Cession	Retention of Ceded Premium		State	Maximum Premium Cession	Retention of Ceded Premium
Alabama	75%	15%		Montana	75%	15%
Alaska	75%	15%		Nebraska	25%	25%
Arizona	75%	15%		Nevada	75%	15%
Arkansas	50%	20%		New Hampshire	75%	15%
California	50%	20%		New Jersey	50%	20%
Colorado	75%	15%		New Mexico	75%	15%
Connecticut	75%	15%		New York	50%	20%
Delaware	50%	20%		North Carolina	75%	15%
Florida	50%	20%		North Dakota	75%	15%
Georgia	75%	15%		Ohio	25%	25%
Hawaii	50%	20%		Oklahoma	75%	15%
Idaho	50%	20%		Oregon	75%	15%
Ilinois	25%	25%		Pennsylvania	50%	20%
Indiana	25%	25%		Rhode Island	75%	15%
Iowa	25%	25%		South Carolina	75%	15%
Kansas	50%	20%		South Dakota	50%	20%
Kentucky	50%	20%		Tennessee	50%	20%
Louisiana	75%	15%		Texas	75%	15%
Maine	75%	15%		Utah	75%	15%
Maryland	50%	20%		Vermont	75%	15%
Massachusetts	75%	15%		Virginia	50%	20%
Michigan	50%	20%		Washington	50%	20%
Minnesota	25%	25%		West Virginia	75%	15%
Mississippi	75%	15%		Wisconsin	50%	20%
Missouri	50%	20%		Wyoming	75%	15%

Source: 2009 Standard Reinsurance Agreement. http://www.rma.usda.gov/pubs/ra/.

The Developmental Fund and Commercial Fund each have three funds into which eligible insurance contracts are placed:

- Fund C for catastrophic,
- Fund R for revenue insurance, and
- Fund B for all other crop insurance plans.

Plans placed in the Developmental Fund are required to retain 35% of net book premium and associated liabilities. This percentage is higher than any requirement under the Assigned Risk Fund. Companies placing insurance plans in the Commercial Fund are required to have a 50% retention limit.

In 2007, AIPs ceded $1,391,706,075 in premium (21.3%) and $9,833,662,393 in liability (14.6%) along with $1,178,410,527 in losses (34.2%) to FCIC reinsurance pools. To the extent that the relative riskiness of different crops and/or the risk associated with the entire crop insurance portfolio changes under alternative climate scenarios, AIPs decisions regarding reinsurance pools to which they assign their contracts may be impacted.

In addition to the limits placed on retention and cession, other key aspects of the SRA affecting the distribution of returns include the shares of gains and losses between the AIPs and the FCIC at different loss ratios and the breakpoints at which the shares change. Pre-SRA rates are driven by gross underwriting gains or losses, defined for modeling purposes as the difference between the premiums collected and indemnities paid. The post-SRA rates of return are determined by particular realizations of companies' loss ratios at the state level and the SRA parameters (retention rates, breakpoints, and shares). Table 2-7 summarizes the current SRA shares of gains and losses, defined by loss ratio experienced. Figure 2-9 displays the transformation of loss ratios under the SRA between the pre-SRA loss ratios and the post-SRA ratios. To analyze the effect of SRA on the rates of return, the distribution of loss ratios by state and reinsurance fund for each participating organization reinsured by the FCIC needs to be modeled.

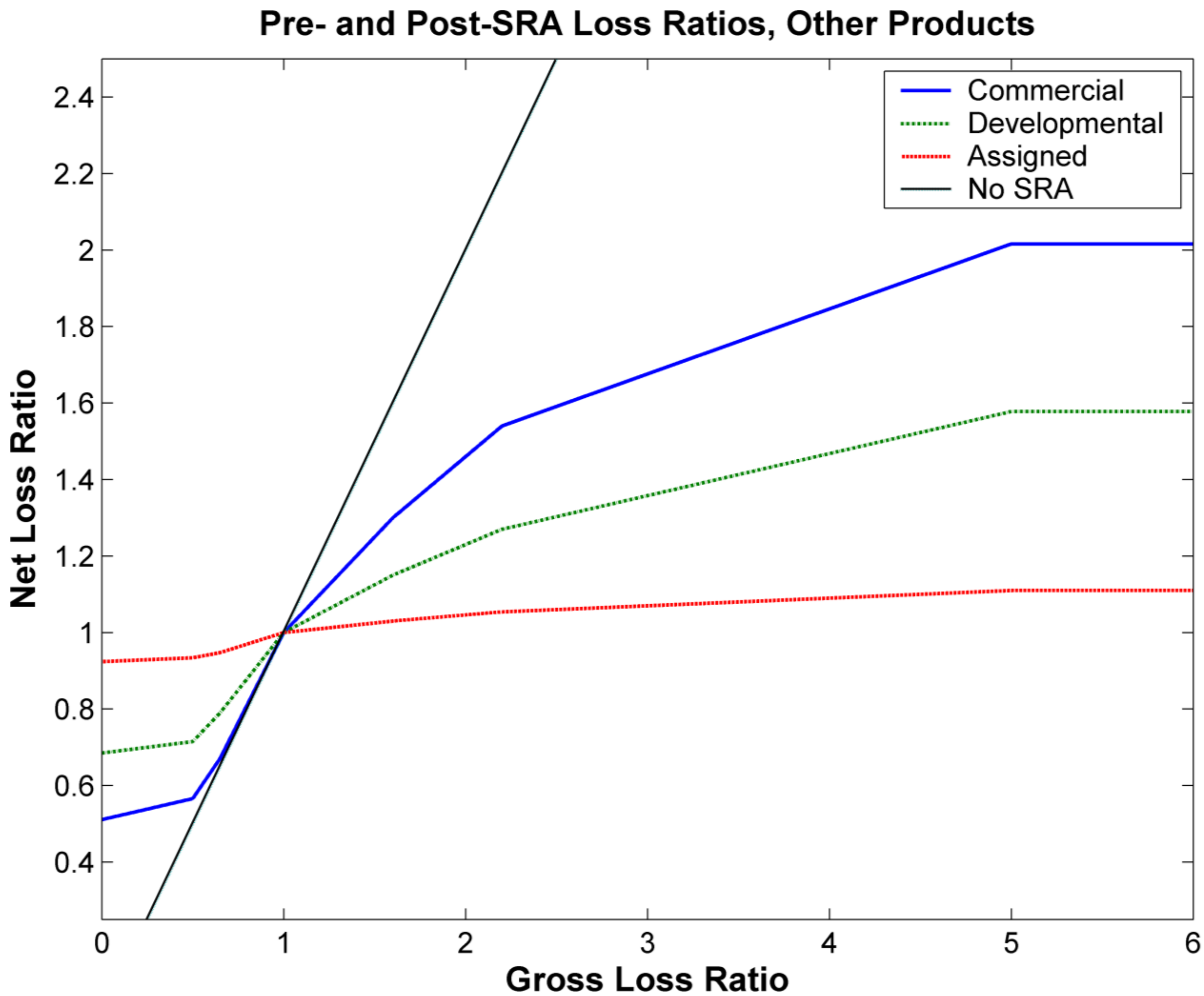
This is being achieved by using the simulated distributions of loss costs for each district, crop, and insurance product generated using the crop insurance actuarial models described in Section 2.2.4. The simulated loss costs are combined with data provided by RMA on liabilities, premium rates, and retention for the base year (2006) and aggregated to derive distributions of loss ratios for each company by state and reinsurance fund. The derived distributions of the loss ratios are then used along with the SRA parameters to compute expectations and standard deviations of the rates of return by company, state, and/or reinsurance fund.

The SRA model has been improved in a number of ways during this project, including the incorporation of additional crops, expanding and updating the time period covered, and updating the model to consider the current risk-sharing terms of the SRA. In addition, the model can be used to explore a variety of loss mitigation options. For instance, the model can readily be modified to reflect changes in the risk-sharing terms to any set of shares between the FCIC and AIPs. Another issue that the model can be used to address is the effects of limiting coverage. One example would be the potential impacts of limiting or eliminating the highest coverage levels currently available. In that case, we simply need to apply assumptions regarding the change in distribution of liabilities and premiums if higher coverage levels are no longer available to producers.

Table 2-7. Shares of Gains and Losses by Loss Ratio

	Gains			Losses		
Fund	**Fund C**	**Fund R**	**Fund B**	**Fund C**	**Fund R**	**Fund B**
	Loss Ratio 65% to 100%			Loss Ratio 100% to 160%		
COM	75%	94%	94%	50%	57%	50%
DEV	45%	60%	60%	25%	30%	25%
ARF	15%	15%	15%	5%	5%	5%
	Loss Ratio 50% to 65%			Loss Ratio 160% to 220%		
COM	50%	70%	70%	40%	43%	40%
DEV	30%	50%	50%	20%	22.5%	20%
ARF	9%	9%	9%	4%	4%	4%
	Loss Ratio less than 50%			Loss Ratio 220% to 500%		
COM	8%	11%	11%	17%	17%	17%
DEV	4%	6%	6%	11%	11%	11%
ARF	2%	2%	2%	2%	2%	2%

Figure 2-9. Transformation of Loss Ratios under the SRA



3

Data and Methods

This section describes the primary data being used in this project and their sources. In addition, we present more detailed information on the methods being applied to simulate losses under alternative scenarios.

3.1 Data

Yield data is vital for estimating yield distributions and assessing projected indemnities under alternative crop insurance products and coverage levels. Producers and insurers alike pay close attention to year over year variation in yield levels, which reflects the risk of production. Multiple-Peril Crop Insurance (MPCI) relies on the Actual Production History (APH) of a farm to determine coverage levels and qualification for indemnity payments. APH is a historical measure of farm-level yields, generally based on the most recent 3-10 years of production (in cases where there is little production history or none at all, transitional yields are used). Some insurance programs (e.g. GRP) provided by FCIC base coverage levels not on farm-level production, but instead, coverage (and hence, indemnity qualification) is based on area-wide production histories (yields are usually averaged over an entire county). These area-wide production histories are calculated based on the USDA's National Agricultural Statistics Service's (NASS) historical reporting. NASS crop yield data are the best available and are updated yearly. We used available data by irrigation status so that we could model dryland and irrigated crops separately, given that they are expected to be affected differently under our climate scenarios. Our modeling efforts rely on district-level NASS yield estimates and therefore represent yields achieved by the overall set of producers, both those with and without crop insurance.

Fourteen crops, representing about 86% of the total insured liability based on data for 2008, were modeled using NASS data. Those crops are: barley, corn, cotton, forage production, oats, peanuts, potatoes, rice, rye, sorghum, soybeans, sugarbeets, tomatoes, and wheat. Using NASS we were able to construct district-level production histories for each crop. Production histories varied for each crop with corn (beginning in 1910) having the longest and sorghum (beginning in 1940) accounting for the shortest. Table 3-1 below summarizes the year in which production histories were first recorded.

USDA RMA provided data on liabilities, premiums, and retention by reinsurance fund for the baseline year of 2006. These data were processed and incorporated into the SRA model to enable analyses of the financial impacts of alternative combinations of loss cost ratios. Individual policy data were also provided by RMA for nine major crops, including barley, corn, cotton, forage production, potatoes, rice, sorghum, soybeans, and wheat. These data consisted of Type 10 (policy records), 11 (acreage records), 15 (yield records), and 21 (loss records) for all nine crops from 1989-2007. Using SAS software, we merged the record types to create consistent data files over the entire study period that were used to provide data at a disaggregated level. In particular, we used data on irrigation status and type codes available in the individual policy data to split out liabilities and premiums by retention fund by irrigation as well as splitting wheat into spring and winter wheat.

Table 3-1. Beginning Year of Crop Production History

Crop	Year
Barley	1915
Corn (grain)	1910
Corn (silage)	1926
Cotton (pima)	1935
Cotton (upland)	1919
Hay (alfalfa)	1919
Hay (all)	1918
Oats	1915
Peanuts	1925
Potatoes	1919
Rice	1938
Rye	1919
Sorghum (grain)	1940
Sorghum (silage)	1943
Soybeans	1927
Sugarbeets	1939
Tomatoes	1996
Wheat (durum)	1928
Wheat (spring)	1919
Wheat (winter)	1918

When a producer chooses to insure a portion of his/her production he/she can choose between yield-based or revenue-based coverage. In choosing either coverage, indemnities are calculated based on a *predicted price*, or an *election price*, and the percentage of yield insured. The predicted price is established annually by the RMA and producers choose between 55–100% of this price as a basis for coverage. Predicted prices are determined for yield-based coverage. The RMA determines election prices each year for revenue-based insurance coverage. Election prices are set based on an *early season price* (commonly referred to in crop policy provisions as the *projected harvest price*) or a *harvest price*. Additionally, some crop insurance policies such as GRIP use an *expected price* instead of a projected harvest price (expected prices vary based on policy cancellation dates, while projected harvest prices are not date sensitive). The RMA uses the futures contract prices of select commodities to determine election prices. Below we detail the futures prices used for determining election prices (Note: Insurance for forage production is covered under the Rainfall Index and Vegetation Index policies which rely on weather data, and coverage is not based on election prices). Prices used for individual crops being analyzed for this study are described in more detail below.

Barley—The *early season price* (projected harvest price) is the simple average of the final daily settlement prices in February for the Winnipeg Commodity Exchange (WCE) October spring feed barley futures contract multiplied by 0.02177. This factor converts the WCE price from Canadian dollars per metric ton to Canadian dollars per bushel. To convert into U.S. dollars, multiply the price in Canadian dollars per bushel by the simple average of the final daily settlement prices in February on the September Canadian dollar futures contract on the CME, using the current U.S./Canadian exchange rate. The *harvest price* is the simple average of the final daily settlement prices in August for the WCE October spring feed barley futures contract multiplied by 0.02177. The *harvest price* uses the average August daily settlement prices of CME September Canadian dollar futures contracts to convert to U.S. dollars. We used the February and August daily settlement prices for September delivery of Chicago Mercantile Exchange (CME) Canadian dollar futures contract rounded to the nearest whole cent. These prices were collected for the 1991-2007 period. We used Portland cash barley prices in February and August to proxy early season and harvest prices, respectively, for the 1972-1990 period.

Corn—The *early season price* is the average February daily settlement price for the Chicago Board of Trade (CBOT) December corn futures contract rounded to the nearest whole cent. The *harvest price* for Crop Revenue Coverage and Revenue Assurance-Harvest Price Option insurance were determined based on the average October and November daily settlement prices, respectively, for CBOT December corn futures contract rounded to the nearest whole cent. These prices were collected for the 1959-2007 period.

Cotton—The *early season price* is the average January 15-February 14 daily settlement price for the New York Cotton Exchange (NYCE) December cotton futures contract rounded to the nearest whole cent. The *harvest price* was determined based on the average daily NYCE November settlement prices for December cotton futures rounded to the nearest whole cent. These prices were collected for the period from 1961-2007.

Oats— The *early season price* for oats was determined based on the most recent 10-year average of NASS oats price estimates. These prices were collected for the 1970-2007 period.

Peanuts— The *early season price* for peanuts was determined based on the most recent 10-year average of NASS peanuts price estimates. These prices were collected for the 1970-2007 period.

Potato—The RMA determines election prices for potato policies based on the most recent 10-year averages of NASS potato price estimates, adjusted to a "point-of-first-storage" or "point-of-first-sale" basis, as is appropriate. The updated 10-year averages may be modified on an annual basis as a result of RMA's assessment of current market conditions. These prices were collected for the 1959-2007 period.

Rice—The *early season price* is the average January daily settlement price for the CBOT November rough rice futures contract. The *harvest price* was determined based on the average daily October CBOT rough rice futures contract. These prices were collected for the 1986-2007 period. January and October cash rice prices were used to proxy early season and harvest prices for the 1972-1985 period, respectively.

Rye— The *early season price* for rye was determined based on the most recent 10-year average of NASS rye price estimates. These prices were collected for the 1970-2007 period.

Sorghum—The *early season price* is the average December 15 (of the previous year)-January 14 (of the harvest year) daily settlement price for the CBOT September corn futures contract rounded to the nearest whole cent, multiplied by the price percentage relationship between grain sorghum and corn, as determined by RMA based on the United States Department of Agriculture (USDA) January estimate of corn and grain sorghum prices, and rounded to the nearest whole cent. The *harvest price* is the average August daily CBOT September corn futures contract rounded to the nearest whole cent, multiplied times the price percentage relationship between grain sorghum and corn, as determined by RMA based on the USDA January estimate of corn and grain sorghum prices, and rounded to the nearest whole cent. These prices were collected for the 1970-2007 period.

Soybeans—The *early season price* is the average February daily settlement price for the CBOT November soybeans futures contract rounded to the nearest whole cent. The *harvest price* is the average October daily settlement prices for November soybeans futures contracts rounded to the nearest whole cent. These prices were collected for the 1959-2007 period.

Sugarbeets— The *early season price* for rye was determined based on the most recent 5-year average of NASS sugarbeets price estimates. These prices were collected for the 1970-2007 period.

Tomatoes (fresh and processing)—The *early season price* for tomatoes was determined based on the most recent 3-year average of NASS tomato price estimates. These prices were collected for the 1996-2007 period.

Hard Red Spring Wheat—The *early season price* is the average February daily settlement price for the Minneapolis Grain Exchange (MGE) September hard red spring wheat futures contract. The *harvest price* is the average August daily settlement price for the MGE September hard red spring wheat futures contract. These prices were collected for the 1970-2007 period.

Soft Red Winter Wheat—The *early season price* is the average of the August 15 - September 14 daily settlement prices for the following year CBOT July soft red winter wheat futures contract. Depending on where the insurance policy is sold, the *harvest price* is either the average of the June daily settlement price for the CBOT July soft red winter wheat futures contract or the average of the July 15-August 14 daily settlement price for the CBOT September soft red winter wheat futures contract. These prices were collected for the 1960-2007 period.

Hard Red Winter Wheat—The *early season price* is the average of the August 15-September 14 daily settlement prices for the following year Kansas City Board of Trade (KCBT) July hard red winter wheat futures contract. Depending on where the insurance policy is sold, the *harvest price* is either the average of the July 15-August 14 daily settlement price for the KCBT September hard red winter wheat futures contract or the average of the June daily settlement price for the KCBT July hard red winter wheat futures contract. These prices were collected for the 1970-2007 period.

3.2 EPIC Modeling for This Study

As noted earlier, the existing version of the EPIC model was modified to add barley and potatoes as part of this project and those crops are included in model outputs. In addition, consistent with the notion that crop production regions may be altered over time under climate change scenarios, the EPIC model has been modified to expand the area of potential crop production to better reflect the possibility of crop expansion into new production areas under climate change scenarios. This is frequently raised as a possibility under changes in climate and there is some historical evidence of production shifts over the past few decades. For example, Figure 3-1 shows the production-weighted latitude and longitude of national soybean production trending northwest over time between 1970 through 2007. The production-weighted centroid of soybean production has been trending northward by about 3.6 miles per year on average over this timeframe. Certainly there are factors other than climate change that may be affecting this shift in production regions, but exploring those potential factors further was outside the scope of this project. Nonetheless, it is consistent with other findings that production regions for a number of crops have been shifting, which may be at least partially attributable to changes in climatic conditions.

Of course, in addition to potential expansion into new areas, it is also possible that production will cease in some existing production areas under the climate change scenarios. However, we did not arbitrarily remove areas from the set of production possibilities; rather, potential changes in production regions are examined through the use of the FASOM model to simulate changes in market equilibrium crop production. We considered focusing our expanded production areas in regions to the north of current production areas because a northward shift is the general expectation of researchers examining potential agricultural impacts as temperature increases. We decided against that and instead chose to examine areas adjacent to current production areas in all directions for two primary reasons. The first is that precipitation is also a very important determinant of yield potential and it is possible that an area to the south of an existing production region could receive additional precipitation under one of the climate scenarios that would increase its yield potential relative to the baseline even with higher temperatures. The second is that shifts in crop production depend on the relative productivity of alternative crops available within a region. Thus, it is possible that a crop would move into a new production region because it is relatively less affected by the change in climate than crops that are currently grown in that region. These relative productivity effects could potentially lead to shifts in cropping patterns for individual crops that differ from the overall northward shift that is typically projected to occur under higher temperatures.

Figures 3-2 through 3-10 show the expanded areas modeled using EPIC. As noted above, these simulations provide estimates of potential yields for these U.S. regions, but the actual market production region will not necessarily correspond to the area of potential yields mapped out in this section.

Figure 3-1. Production-Weighted Location of U.S. Soybean Production, 1970-2007

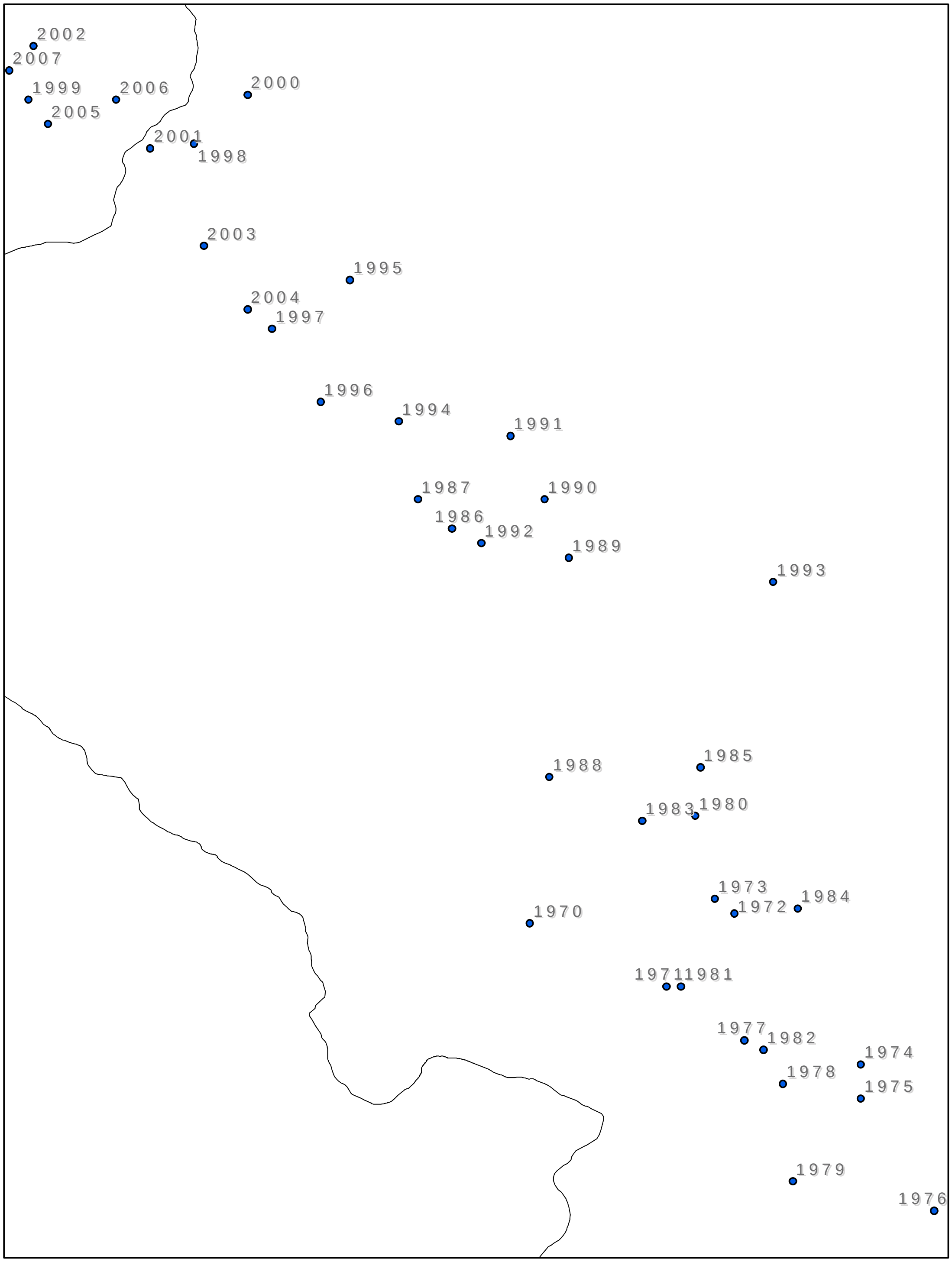
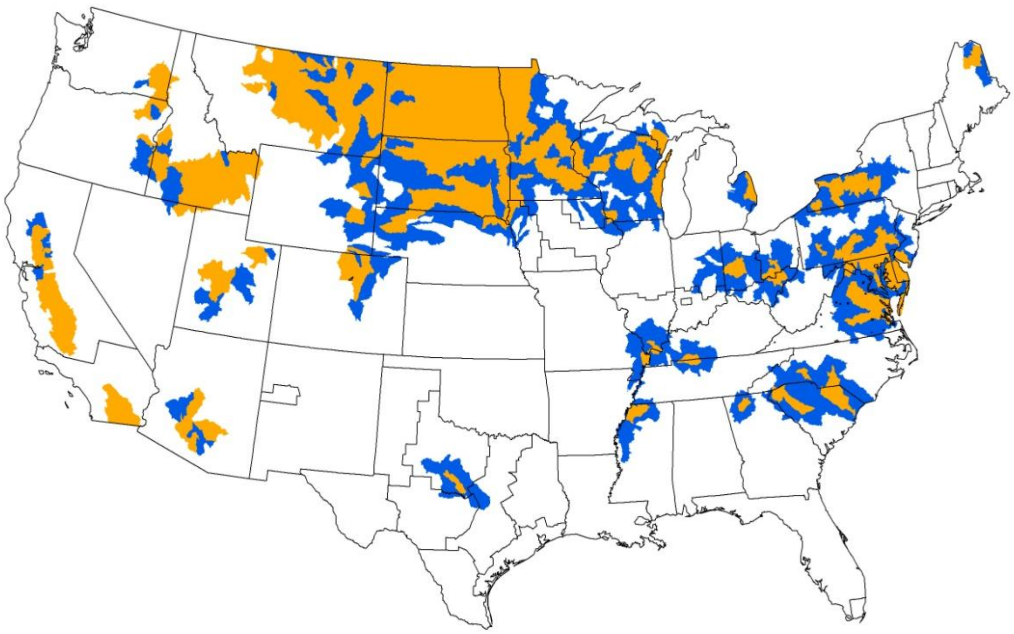
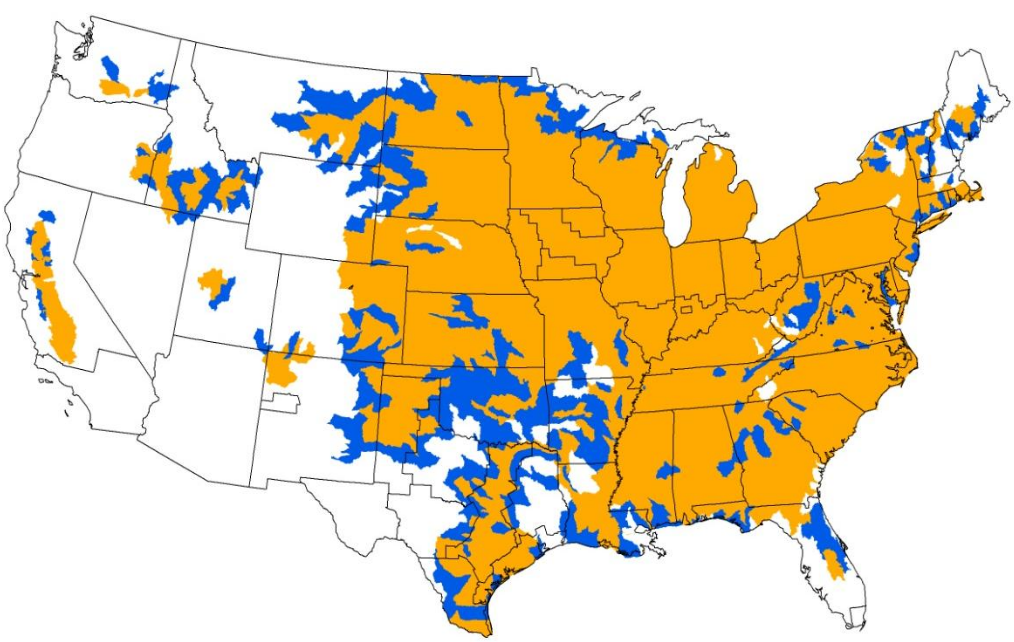


Figure 3-2. Current and Expanded Barley Range Modeled in EPIC



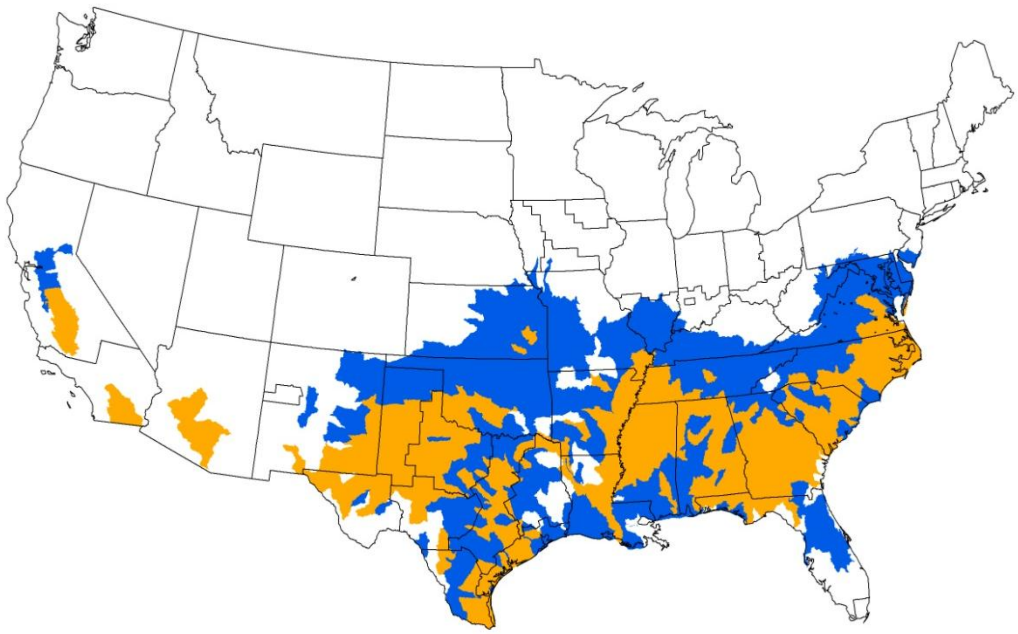
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-3. Current and Expanded Corn Range Modeled in EPIC



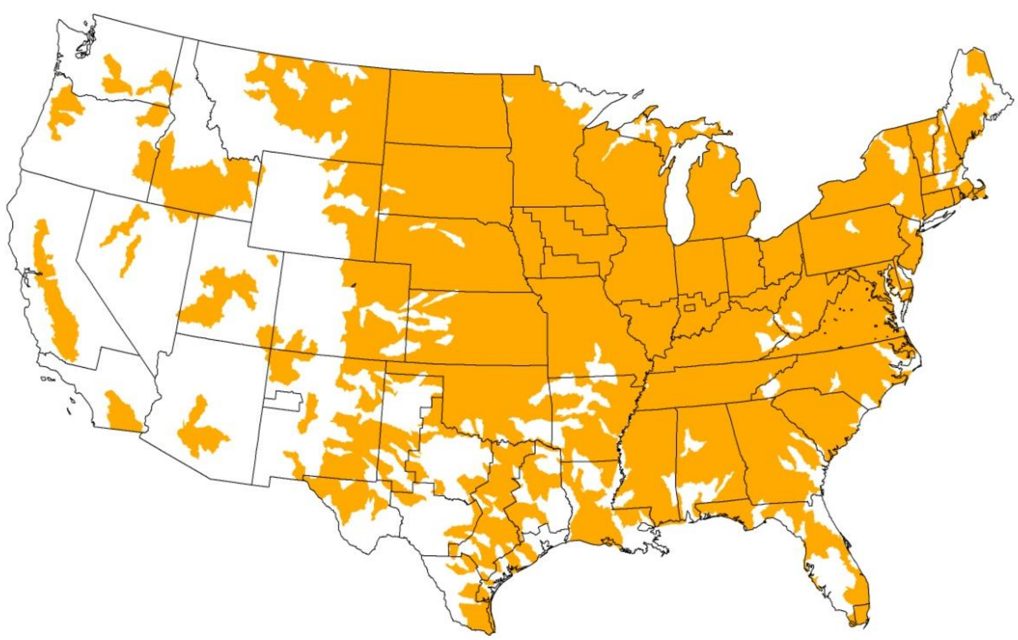
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-4. Current and Expanded Cotton Range Modeled in EPIC



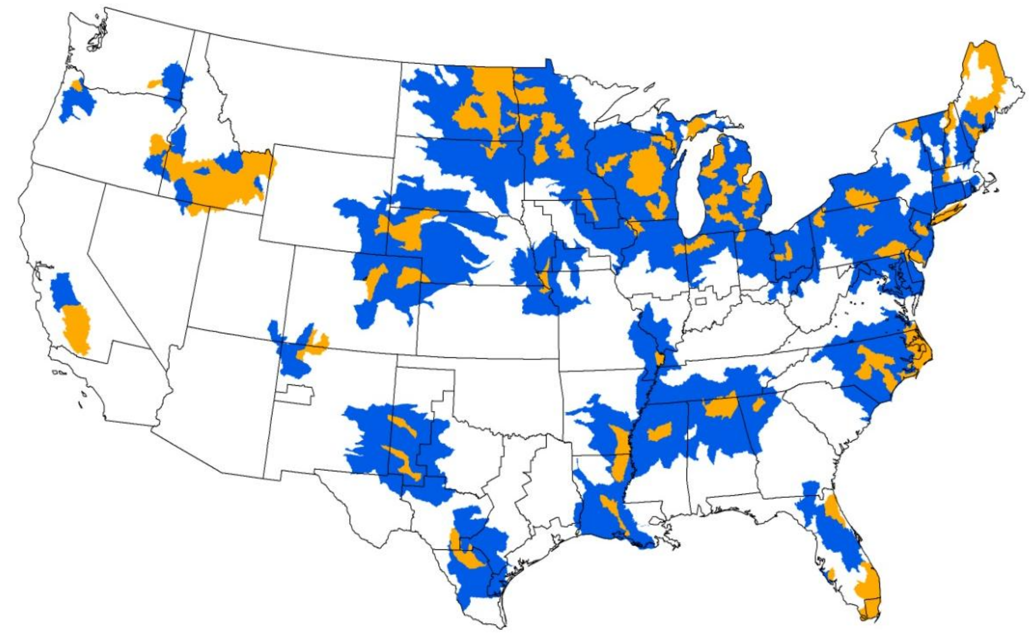
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-5. Hay Range Modeled in EPIC



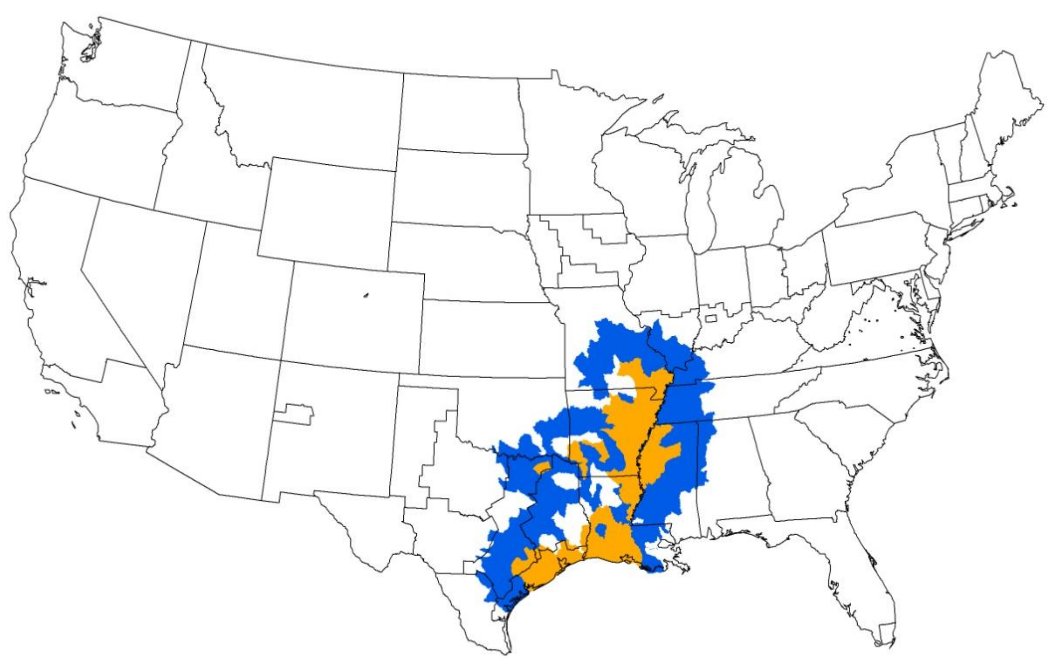
Note: Orange areas are current crop range included in database. Because hay production already covers almost all viable agricultural production areas within the U.S., the potential production range was not expanded for the climate change scenarios.

Figure 3-6. Current and Expanded Potato Range Modeled in EPIC



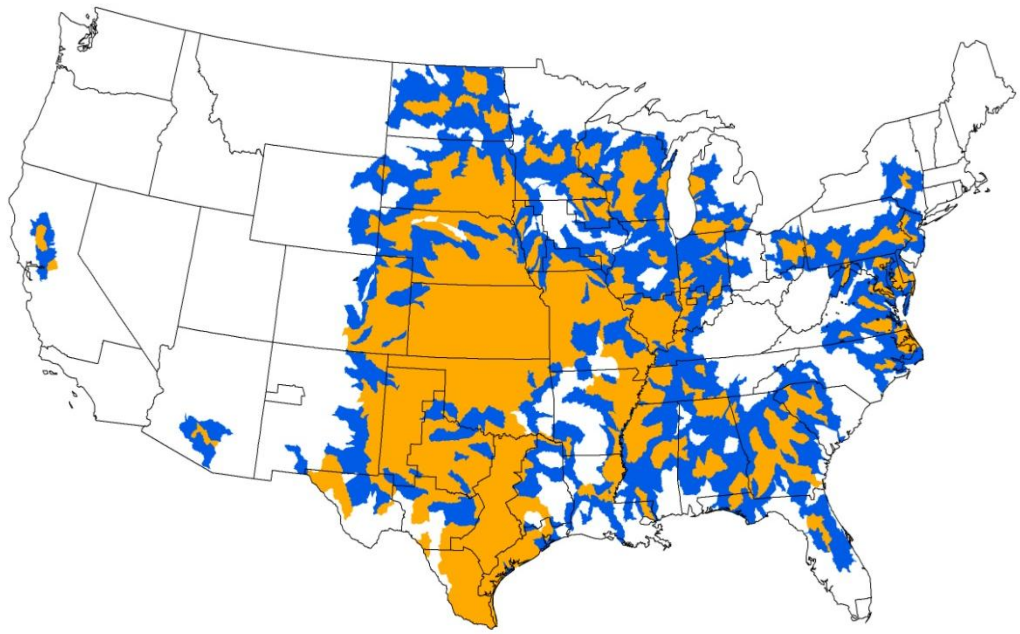
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-7. Current and Expanded Rice Range Modeled in EPIC



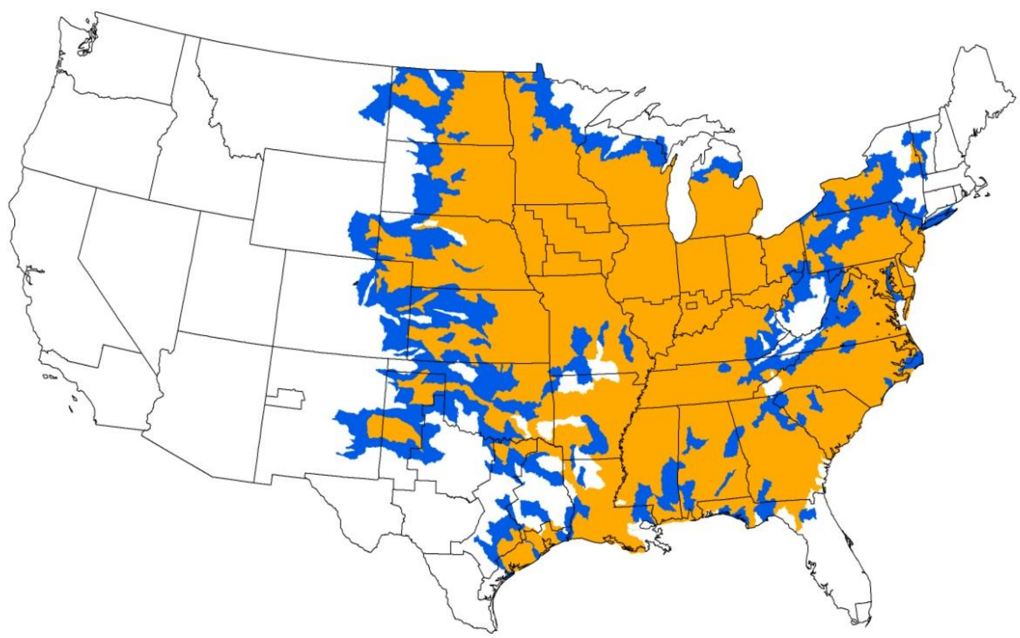
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-8. Current and Expanded Sorghum Range Modeled in EPIC



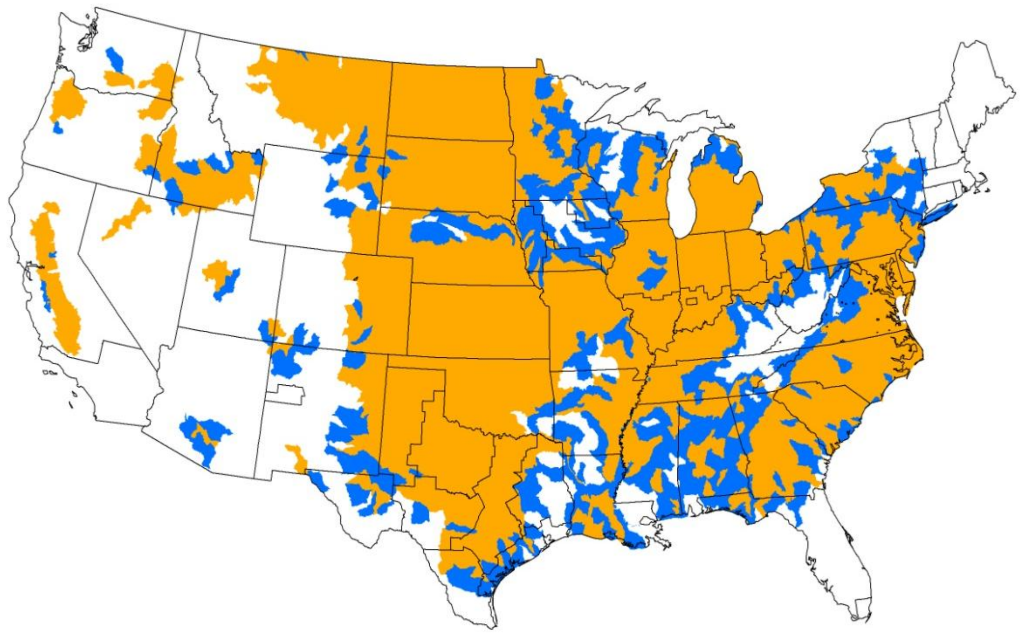
Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-9. Current and Expanded Soybean Range Modeled in EPIC



Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

Figure 3-10. Current and Expanded Wheat Range Modeled in EPIC



Note: Orange areas are current crop range included in database. Blue areas are the additional regions where potential crop production is being modeled to allow for shifts in cropping patterns under climate change scenarios.

3.3 Generating Simulated Loss Cost Ratios

In addition to updating and enhancing the EPIC model for this analysis, we developed methods for simulating loss cost ratios for the baseline and alternative scenarios that can be applied across all crops, regions, and insurance products that we are examining under this project. The key to getting simulated baseline loss cost ratios that match closely with historical loss cost ratios lies in calibration of the shapes of the yield distributions. To generate realistic loss cost ratios at the district level, we calibrate parameters of the yield distribution to match the simulated APH loss cost ratios with historical APH loss cost ratios. In this section, we describe the procedures used to generate the simulated the loss cost ratios.

Yield Detrending and Normalization

To generate simulated loss cost ratios under baseline conditions, we used historical district-level data that was collected from the NASS database. The yield variable used in the analysis is calculated by dividing the production values with the planted acres (rather than the harvested acres, which was used to calculate the yield variable reported in the NASS database) to more accurately measure yield risk. To account for time trends, we regressed district yield (1972-2007) on linear and quadratic trends, as shown in Equation 1.

(1) $$y_t = \alpha_0 + \alpha_1 t + \alpha_2 t^2 + \hat{e}_t .$$

Note that for data credibility reasons district-crop combinations with less than 20 years of yield data were not considered in our analysis.[5] This detrending procedure is used to account for secular trends in yields (i.e. due to exogenous technical change). Any inferences about yield risk must be conditioned upon such trends in order to derive valid measures of the relevant distributions.

The yield data are then converted to base-year equivalents:

$$\tilde{y}_t = \frac{y_t}{\hat{y}_t}\hat{y}_{2006}. \tag{2}$$

where y_t are the observed yields, $\hat{y}_t$ are the corresponding yield trends, and $\hat{y}_{2006}$ is the trend yield in base year 2006. Because 2006 was used as the reference, the detrended and normalized yield $\tilde{y}_t$ in 2006 is equal to its observed value in that year. The detrended yield observations are then used to construct empirical distributions of district yields (Goodwin and Ker, 1998; Ker and Goodwin, 2000; Ker and Coble, 2003). Individual farm yields are modeled as parametric distributions around district yields with distribution parameters calibrated to match historical loss costs observed in each district. Once the parameters of farm-level yield distributions are calibrated, it is assumed that they correctly represent the variability of within-district yields for the specific crop, district, and year and thus can be used to simulate the loss costs for all other products included in the model.

Estimating Harvest Price Distribution

In addition to yields, distributions of harvest-time prices are needed to calculate loss costs for revenue products. We use the following regression approach to estimate the distribution of harvest prices. For each crop, its harvest price is modeled as a function of planting period price and the deviation of detrended national yield from its mean. Assuming prices are log-normally distributed,

$$\ln p_{ht} = \ln p_{bt} + a\left(\ln \tilde{y}_{nat,t} - \ln \bar{\tilde{y}}_{nat}\right) + z_t, \tag{3}$$

where p_{ht} are harvest-time prices, p_{bt} are planting period prices, $\tilde{y}_{nat,t}$ are detrended national yields, $\bar{\tilde{y}}_{nat}$ is sample mean of detrended national yields, and z_t is normally distributed with mean zero and variance σ_p^2. According to equation 3, $\ln p_{ht}$ is normally distributed around mean $\left(\ln p_{bt} + a\left(\ln \tilde{y}_{nat,t} - \ln \bar{\tilde{y}}_{nat}\right)\right)$ and variance σ_p^2.

Preserving Spatial Correlation of Yield Distribution

In order to simulate expected loss costs, we could first estimate a "baseline" yield distribution by fitting a parametric beta distribution on the detrended normalized yields ($\tilde{y}_t$) over the entire time period. A beta distribution is used in this analysis since much of the empirical literature that model crop yields have utilized this distribution and this distribution tends to be more "flexible" (i.e. covers a wider area in

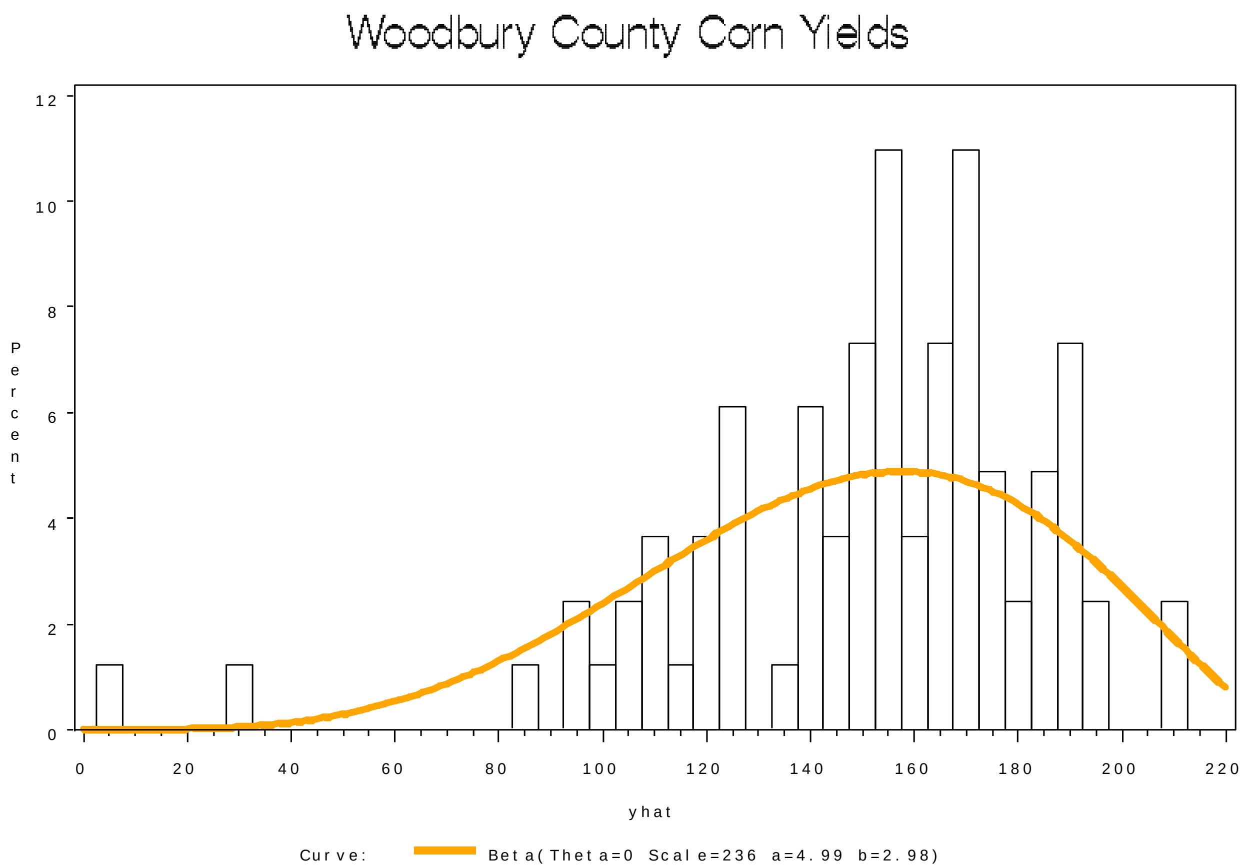
[5] We initially used county-level data, but due to the very high incidence of missing values and short time series for counties producing a given crop in 2007, we switched to district-level data after trying numerous strategies for estimating missing county yields that would still yield overall loss cost ratios similar to historical values. Another reason for moving to district-level data was to reduce computing time required for simulations of all crops and insurance products for both dryland and irrigated crops.

the skewness-kurtosis plane) than other parametric distributions (See Goodwin and Ker, 2002; Lu et al., 2008; Mitchell and Knight, 2008; Goodwin, 2008). The general formula for the beta probability density function is:

$$f(y) = \frac{(y-a)^{\alpha-1}(b-y)^{\beta-1}}{B(\alpha,\beta)(b-a)^{\alpha+\beta-1}}, \tag{4}$$

where α and β are shape parameters, *a* and *b* are the lower and upper bounds (respectively), and $B \cdot$ is the beta function. In this study, we assume that the lower bound (or minimum) yield value is zero (*a* = 0) and the upper bound (or maximum) yield value is the maximum observed yield within the state that a particular district is located. The shape parameters (α and β) are then estimated using maximum likelihood procedures. An example of a fitted beta distribution for corn in Woodbury County, IA is in Figure 3-11.

Figure 3-11. Example of Fitted Beta Distribution, Woodbury County, IA



The above approach is commonly applied in the crop insurance literature (e.g. Harri et al., 2009) However, the spatial correlation of yield distributions across counties due to weather, pest pressure and other environmental factors may not be sufficiently reflected in the α and β are shape parameters calculated using the above approach for the needs of this study, where baseline loss cost ratios need to line up closely with historical outcomes. A relatively simple way to incorporate the spatial correlation into the shape parameters of beta distribution is to calculate year- and district-specific α and β parameters conditional on the realized weather, pest and other environmental events that occurred in that year and district. As long as these environmental events are spatially correlated, this correlation will be reflected in the calculated shape parameters. A method of moments (MOM) procedure (see Johnson, Kotz, and Balakrishnan, 1994 for derivation details) is used to obtain shape parameters for beta distribution that vary from year to year depending on realizations of environmental events including weather. Thus, to preserve the spatial correlation of yield risks and loss cost ratios in any given year, we do *not* fit a beta distribution over the district yield time series between 1972 and 2007.

Instead, we assume that the NASS district yield is an average of a distribution of unobserved farm-level yields. Each district has a different distribution of farm-level yields in each year. We assume the yield distribution is Beta: the unknowns are the two beta shape parameters, α_t and β_t, and the maximum farm yield h_t. The two shape parameters are calculated as:

(5)
$$\alpha_t = \left(\frac{\tilde{y}_t}{b}\right)\left(\frac{\left(\frac{\tilde{y}_t}{b}\right)\left(1-\frac{\tilde{y}_t}{b}\right)}{\left(\frac{\sigma^2_{\tilde{y}t}}{b^2}\right)} - 1\right)$$

(6)
$$\beta_t = \left(1-\frac{\tilde{y}_t}{b}\right)\left(\frac{\left(\frac{\tilde{y}_t}{b}\right)\left(1-\frac{\tilde{y}_t}{b}\right)}{\left(\frac{\sigma^2_{\tilde{y}t}}{b^2}\right)} - 1\right)$$

where α_t and β_t are the shape parameters for year t, and $\sigma^2_{\tilde{y}t}$ is the variance of the normalized yield $\tilde{y}_t$.

Calibration of Yield Distributions

For each crop, district and year, we search for values of σ^2_{yt} and h_t that generate the smallest difference between the simulated and historical aggregate APH loss cost ratios. The simulated aggregate loss cost ratio is calculated as

(7)
$$LC^{agg}_{sim,t}\left(\sigma^2_{yt}, h_t\right) = \frac{\sum_{i_p \in B} L_{hist,t}(i_p) \times LC_{sim,t}\left(i_p \middle| \sigma^2_{yt}, h_t\right)}{\sum_{i_p \in B} L_{hist,t}(i_p)},$$

where $L_{hist,t}(i_p)$ are historical liabilities for the i th APH product, $LC_{sim,t}\left(i_p \middle| \sigma^2_{yt}, h_t\right)$ are simulated loss cost ratios, and B is the subset of APH products used for calibrating the yield distribution for each crop, district and year. The calibrated distribution parameters σ^2_{yt} and h_t are found by solving

$$\min_{\sigma_{yt}^2, h_t} \left| LC_{sim,t}^{agg}\left(\sigma_{yt}^2, h_t\right) - LC_{hist,t}^{agg} \right|.$$

Calculation of Loss Cost Ratios

Based on the parameters of the beta distributions, we then develop a simulation model to calculate the expected loss costs (and estimate a loss cost distribution) for each district-crop combination. First, 5,000 random yield realizations were drawn from the re-fitted distribution. Then, for each yield draw we calculate the indemnity (or loss) for the APH contracts ($Indemnity^{APH}$) as follows:

$$\text{(8)} \qquad Indemnity^{APH} = \max\left[0, p_m \times \ \theta y_e - y \ \right],$$

where p_m is the price, θ is the coverage level (θ=0.5, 0.55, …, 0.85), y_e is the expected yield, and y is the yield draw. The expression θy_e is also known as the yield guarantee. The CAT indemnity is calculated in the same way as the APH indemnity in (7) except that 55% of the price p_m is used (i.e. 0.55 x p_m) instead of just p_m. The loss costs at different coverage levels are then calculated for each yield draw by dividing the indemnity by the yield guarantee:

$$\text{(9)} \qquad Loss\ Cost^{APH} = \frac{Indemnity^{APH}}{p_m \theta y_e}.$$

Sample expected loss costs calculated for Woodbury County, IA are seen in Table 3-2.

Table 3-2. Summary Statistics of Expected Loss Costs for APH Corn Policies in Woodbury County, IA for 2007

Coverage Levels	Mean	St. Dev.	Min.	Max.
50%	0.0128	0.0664	0	0.9376
55%	0.0181	0.0783	0	0.9432
60%	0.0245	0.0906	0	0.9480
65%	0.0323	0.1033	0	0.9520
70%	0.0416	0.1160	0	0.9554
75%	0.0525	0.1286	0	0.9584
80%	0.0649	0.1408	0	0.9610
85%	0.0789	0.1526	0	0.9633

Note: (1) In this sample scenario, mean yield is 153.65 bu/acre and variance is 1283.96.

Note that there are basically two major farm-level revenue policies in crop insurance – the Crop Revenue Coverage (CRC) and the Revenue Assurance (RA). The RA policy also has two types – the Base Price Option (BPO) and the Harvest Price Option (HPO). The CRC and RA-HPO are fundamentally the same in the sense that the revenue guarantee can be recalculated at harvest using the higher of the harvest price or the planting time price. The main difference between CRC and RA-HPO is the month used to establish the base and harvest prices. For the corn policy, for example, the CRC uses the average settlement price in February for the December futures contract to establish the planting price and the average settlement price in October for the same December futures contract to establish the harvest price. On the other hand, the RA-HPO uses the November settlement price on the December futures contract to establish the harvest price (RA-HPO still uses February settlement price for the planting price).

In contrast to CRC and RA-HPO, the RA-BPO policy does not have the option to recalculate the revenue guarantee. It simply uses the planting time "base" price. But note that the RA-BPO policy is also fundamentally the same as another farm-level revenue insurance product called Income Protection (IP) or Indexed Income Protection (IIP). The mechanism for payment is the same in IP and RA-BPO except IP/IIP indexes the historical APH yield to the district average while the RA-BPO does not.

In terms of the loss cost simulation model, we account for the difference in calculating the revenue guarantee between CRC/RA-HPO and RA-BPO/IP. For the CRC/RA-HPO, we calculate the indemnity as follows:

(10)
$$Indemnity^{CRC/RA-HPO} = \max\left[0,\ (\max(p_b, p_h)\times\theta y_e) - yp_h\ \right],$$

where p_b is the planting time (or base) price and p_h is the harvest time price. For the RA-BPO/IP, we calculate the indemnity as follows:

(11)
$$Indemnity^{RA-BPO/IP} = \max\left[0,\ \ p_b\theta y_e - yp_h\ \right].$$

In the simulation model (for the base 2006 year), the harvest time price distributions used in the simulations are defined as in Equation 3. The loss cost for the revenue insurance policies (CRC/RA-HPO and RA-BPO/IP) can then be calculated as:

(12)
$$Loss\ Cost^{CRC/RA\text{-}HPO\ or\ RA\text{-}BPO/IP} = \frac{Indemnity^{CRC/RA\text{-}HPO\ or\ RA\text{-}BPO/IP}}{p_h\theta y_e}.$$

Once the base-year loss costs for major crops are simulated for each of the major insurance products using the procedures above, we estimated a regression to determine the relationship between loss cost ratios for an aggregate of all other crops included in the crop insurance program and the loss cost ratios simulated for major crops in that district. The parameters estimated from these regressions were used to simulate the loss cost ratios for the all other crops aggregate for each district and simulation year.

Loss cost ratios for CAT are expected to be the same as for 50 percent buy-up insurance if the pool of insured producers within a crop/district combination purchasing CAT has the same yield distribution as the overall pool of producers. However, we found that the loss ratios implied by the yield distribution using the techniques described above were too high to replicate historical loss experiences for CAT. This is consistent with less-risky producers self-selecting CAT insurance. To account for this self-selection in calibrating to historical experience, we calculated scaling factors based on the relative loss cost ratios for CAT and 50 percent buy-up for each crop/district based on available historical data. Those scaling factors were applied to the loss cost ratios calculated from the calibrated yield distribution for 50 percent buy-up to generate the loss cost ratios used for CAT coverage. This adjustment made the simulated loss experience for CAT much closer to historical values.

Similarly, using the same calibrated yield distributions to generate expected loss cost ratios for a given coverage level across all reinsurance pools generated simulated indemnities that were too high for premiums placed in the Commercial reinsurance fund and too low for those placed in the Developmental or Assigned Risk funds relative to historical outcomes. This is consistent with expectations that AIPs would place policies from crop/district combinations or individual producers that they consider overly risky relative to the premium earned (and thus having higher expected loss ratios) into the Developmental or Assigned Risk funds. Therefore, we also calculated scaling factors for each crop/district by reinsurance fund based on available historical data and applied those factors to shift the distribution of loss cost ratios by reinsurance fund. The effect of this adjustment is that overall loss cost ratios for crop/district combinations in a given simulation year remain approximately the same, but indemnities are reallocated between reinsurance funds to better reflect historical experience.[6]

Following construction of the baseline loss cost ratios for each year in our sample, we now need to incorporate the mean yield changes and yield variability changes under our climate change scenarios to ultimately simulate the effect of climate change on district-level yield distributions and expected loss costs. The estimated changes in the mean and variability of yields and prices derived from the EPIC and FASOM models were used as inputs to the simulation model. Note that the EPIC and FASOM models are only able to estimate changes in the mean and variance of the distribution under our climate change scenarios (rather than providing an estimated change or shift in the whole distribution).

Assume that the estimated climate change effect on mean yield and yield variance based on the EPIC and FASOM models for a future year, say 2050, are $\Delta\tilde{y}$ and $\Delta\sigma_y^2$, respectively. We can then calculate the new "climate change affected" mean yield and yield variance as follows: $\tilde{y}_c = \tilde{y} + \Delta\tilde{y}$ and $\sigma_{yc}^2 = \sigma_y^2 + \Delta\sigma_y^2$. Using the new mean yield and yield variance, together with the MOM approach, we can adjust the two shape parameters of the base beta distribution shown in Equations 5 and 6 to capture the climate change effect on the yield distribution:

(13) $$\alpha_c = \left(\frac{\tilde{y}_c}{b}\right)\left(\frac{\left(\frac{\tilde{y}_c}{b}\right)\left(1-\frac{\tilde{y}_c}{b}\right)}{\left(\frac{\sigma_{\tilde{y}c}^2}{b^2}\right)} - 1\right)$$

[6] Alternatively, one could potentially estimate separate yield distributions by reinsurance fund, but we did not have sufficient data to separate out district-level yield outcomes for liabilities placed into different reinsurance pools.

(14) $$\beta_c = \left(1 - \frac{\tilde{y}_c}{b}\right)\left(\frac{\left(\frac{\tilde{y}_c}{b}\right)\left(1 - \frac{\tilde{y}_c}{b}\right)}{\left(\frac{\sigma^2_{\tilde{y}c}}{b^2}\right)} - 1\right),$$

where *b* is the new upper bound (*a* is assumed to remain equal to zero) , and α_c and β_c are the new shape parameters that defines the new yield distribution affected by climate change.

Figure 3-12 shows a simulated change in the beta distribution resulting from changes in the mean and variance of yields due to our climate change scenarios. Note that this example case reveals scenarios with both higher and lower mean yields as well as scenarios with higher and lower variability than the baseline. Thus, the expected loss cost ratios could be either higher or lower than the baseline depending on the scenario examined.

A similar MOM procedure is used to adjust the lognormal distribution given the change in the mean and variance of prices from climate change. The new scale (μ_c) and shape (σ_c) parameters of the lognormal price distribution are adjusted as follows:

(15) $$\mu_c = \ln E \; p_c \; - \frac{1}{2} \; 1 + \frac{Var(p_c)}{E(p_c)^2}$$

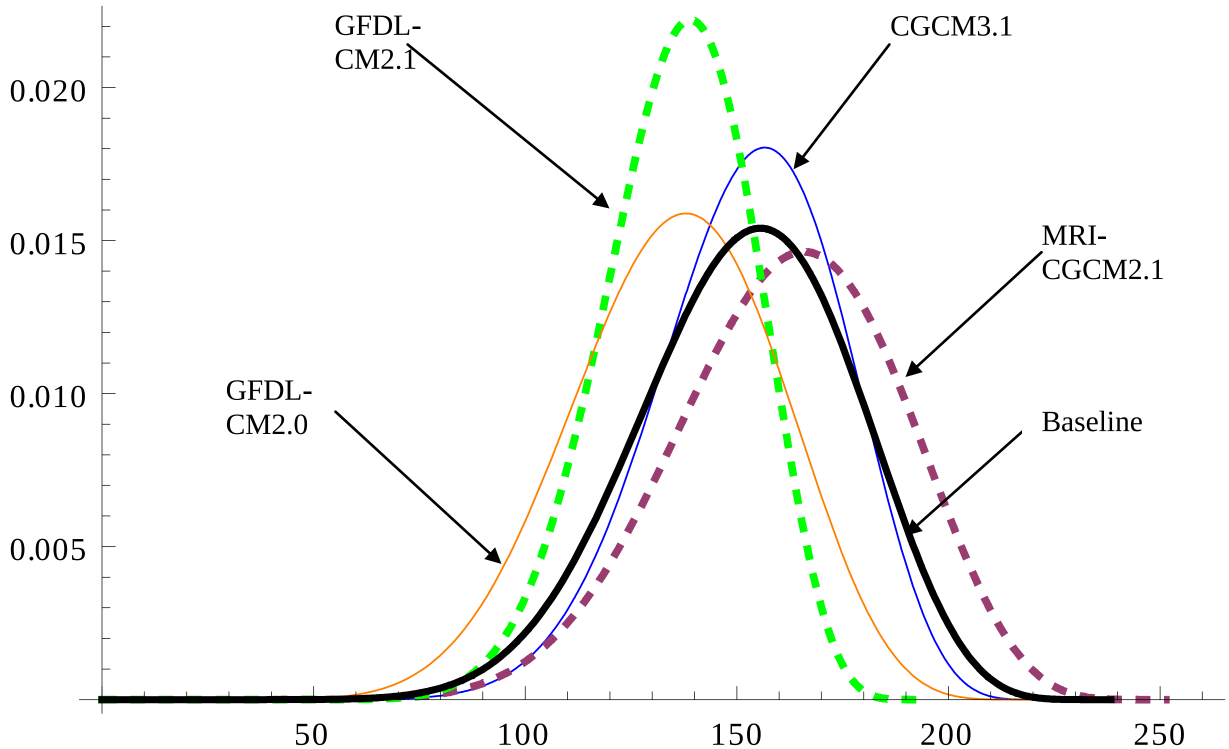
(16) $$\sigma_c = \overline{\; ln \; \frac{Var(p_c)}{E(p_c)^2}}$$

where $E(p_c)$ and $Var(p_c)$ are the new mean price and new price variance with climate change.

Once the resulting yield and price distributions due to climate change have been determined, the expected loss cost simulation models for the APH and revenue policies (as described in the previous sections above) can then be implemented to determine the loss cost distributions that can be attributed to a specific climate change scenario.

All of the simulation procedures described above are then used for each crop and district considered in the study (i.e. the simulation program is “looped” through all credible crop-district combinations) to estimate the potential overall effect of climate change on crop insurance loss costs.

Figure 3-12. Simulated Changes in the Yield Distribution of Corn in Woodbury County, IA under Climate Change Scenarios Considered



Notes: (1) Baseline: $\alpha = 12.6$, $\beta = 7.18$, max = 238.4
(2) CGCM3.1: $\alpha = 15.45$, $\beta = 7.41$, max = 226.08
(3) MRI-CGCM2.1: $\alpha = 12.65$, $\beta = 7.01$, max = 251.38
(4) GFDL-CM2.1: $\alpha = 17.35$, $\beta = 7.65$, max = 195.50
(5) GFDL-CM2.0: $\alpha = 11.68$, $\beta = 6.85$, max = 223.88

3.4 Simulating Financial Impacts

These simulated loss cost files are then provided as an input to the SRA model, which combines the loss cost files with base year data on liabilities and premiums by district, crop, company, insurance product, and reinsurance fund as well as state-level retention data by crop and company in order to generate a distribution of loss ratios for each company. The version of the model that we have developed for this project has several advantages over previous versions, including updated data, a substantially longer historical data time series, data for additional crops, and exploration of alternative modeling techniques to better fit our crop yield distributions. In addition, we developed a more user-friendly interface than has been available previously using Visual Basic and Excel to run the underlying Fortran routine. The SRA model treats specific values of loss ratio brackets, shares of gains/losses, and retention requirements by reinsurance fund as input parameters to the model. The model has been modified to enable changing these values through the Excel interface to explore alternative specifications.

The simulated loss costs for each crop-reporting district, crop, and insurance product are combined with the data on liabilities and premium rates for the base year and aggregated to derive distributions of loss ratios for each company by state and reinsurance fund. The derived distributions of the loss ratios are then used along with the SRA parameters to compute expectations and standard deviations of the rates of return by company, state, and/or reinsurance fund.

This is being achieved by using the simulated distributions of loss costs for each county, crop, and insurance product generated using the crop insurance actuarial models described in Section 2.2.4. The simulated loss costs are combined with data provided by RMA on liabilities, premium rates, and retention for the base year (2006) and aggregated to derive distributions of loss ratios for each company by state and reinsurance fund. The derived distributions of the loss ratios are then used along with the SRA parameters to compute expectations and standard deviations of the rates of return by company, state, and/or reinsurance fund.

The SRA Model simulates distributions of rates of return for the baseline and alternative climate scenarios. The model computes in three stages, a data reading routine, a main processing routine and a subroutine. Outputs generated from the data reading routine are used as inputs in the main processing routine, and the outputs from the main processing routine serve as inputs in the subroutine. The subroutine simulates the effect of the SRA on rates of return.

The data reading routine begins the model simulation. In this stage, the model data are read in to the model and manipulated as necessary. To generate output, the data reading routine uses the following parameters:

- Number of years of loss data (36, 1972 – 2007)
- Number of states (48)
- Potential number of districts in a state (999)
- Number of reporting organizations in 2006 (17)
- Number of reinsurance funds (9)
- Number of products, including combination of major insurance plans and coverage levels (51)
- Number of crops (11)

Using these parameters, the data reading routine then uses the following as inputs:

- The distribution of simulated loss costs by district, crop, insurance product, coverage level, and irrigation status for each simulated year as generated by the actuarial model
- Liability for state, district, product, coverage level, company, and irrigation status by reinsurance fund based on base year (2006) data provided by RMA

- Premium for state, district, product, coverage level, company, and irrigation status by reinsurance fund based on base year (2006) data provided by RMA

- Base year retention rates by company and state for each reinsurance fund

- Base year share and breakpoint parameters for each reinsurance fund

This portion of the SRA model computes aggregated indemnities, liabilities and premiums all by state, organization, fund and year. After the data reading routine has generated aggregated liabilities, premiums and loss costs, these data are then used as inputs into the main processing routine to simulate the distribution of rates of return.

To accurately reflect the effects of the SRA on the rates of return from underwriting crop insurance, we examine all of the reinsurance funds and APH, CRC, RA (BPO), RA (HPO) and CAT coverage. With the exception of CAT, the insurance products range from 50% to 85% coverage in 5% increments for our simulations.[7] The reinsurance share rates, retention rates and break points that are outlined in the current SRA are used to parameterize the SRA main processing routine. The model uses the aggregate liabilities, premiums and loss costs as inputs to generate the following outputs:

- Retained premiums

- Gross and net gains

- Pre-SRA and post-SRA loss ratios

- Rates of return by state, organization and year for each reinsurance fund

- Rates of return and standard deviations of returns over the period simulated by state, organization and year for each reinsurance fund

In addition to simulating the distributions of rates of return, the model can be used to explore a variety of loss mitigation options. For instance, the model can be readily modified to reflect changes in the risk-sharing terms to any set of shares between the FCIC and AIPs that one would like to examine. Another possible application of the model is to examine the potential for state or region-based SRA parameters for areas expected to be disproportionately affected by climate impacts, if such areas can be clearly identified and the potential impacts quantified with sufficient confidence.

[7] Although not all of these product/coverage level combinations are currently available, we simulated a consistent set of coverage levels across them, which provides information on what loss cost ratios may have been had that coverage level been available. However, if there are no liabilities at a given coverage level, then the indemnities for that product/coverage level combination will be zero in our simulation results.

Results

In this section, we present our findings, including simulations of changes in crop yields; market outcomes, including shifts in crop mix and production practices; and financial impacts on the FCIC and AIPs. Although this modeling system builds on existing models that have been used for climate change assessments and reflects what we consider reasonable and appropriate assumptions, it is very important to recognize the considerable uncertainties surrounding the results of this study or any study assessing the potential impacts of climate change on agricultural production. In addition to uncertainties associated with the parameters, distributions, and modeling strategies employed for this analysis, there are considerable uncertainties regarding future GHG emissions as well as associated climate impacts. This is readily apparent in the differences in climate projections across the GCMs employed for this study, which were chosen to provide a range of outcomes, but still cover only a subset of the available GCMs being used for climate analyses. Nonetheless, this analysis provides unique insights into some of the potential effects of future climate change on agricultural production in the U.S. and related financial impacts on the crop insurance portfolio.

4.1 Simulated Crop Yields

As presented in Section 2, there are substantial changes in projected weather conditions under the projected climate conditions derived from GCM simulations for climate scenario A1B relative to baseline conditions. As a result, there are also corresponding changes in simulated yields under the alternative scenarios. Figures 4-1 through 4-9 present changes in yields for major U.S. crops simulated using the EPIC model for each of the four primary GCMs used for this study. Yields were simulated for hydrologic unit code regions within their current and potential production range consistent with the maps shown in Section 3. Yield potential was simulated for each of these crops for both dryland (non-irrigated) and irrigated production conditions with the exception of potatoes and rice, which were assumed to be irrigated. Yields for both irrigated and non-irrigated production were simulated for the entire crop production region even if only or the other has historically been used in a region. This was done to provide inputs to FASOM on what potential yields would be if irrigation status were changed for a crop within a region. This introduces the possibility that producers could either begin irrigating or stop irrigating if the changes in relative yields and production costs resulted in changes in relative profitability.

All yields were simulated holding everything constant except for climate conditions to generate values under both baseline climate and alternative climate scenario conditions. Using input from GFDL-CM2.0, GFDL-CM2.1, MRI-CGCM2.2 and CGCM3.1 GCMs, we compare the potential yield changes in dryland and irrigated cropping for the 2045-2055 period as modeled using EPIC. There is considerable regional variation in simulated changes in yields across scenarios and cropping practices. In general, irrigated crops are less affected under the climate scenarios in our simulations, primarily because they are not facing the water limitations that impact the dryland crops. The EPIC simulations assume that crops can be irrigated to a level that eliminates water stress. A particular concern for climate change is that in areas where the need for irrigation is greatest due to a reduction in precipitation, the supply of water for irrigation will also be reduced. Therefore, locations with large increases in irrigated crop and reductions in precipitation may be vulnerable to production losses as well. To fully consider this risk requires integration of crop modeling with hydrologic modeling for projections of future water supply, which is outside the scope of the current project. Although irrigated crops tend to be less affected in these simulations, there are cases where dryland yields increase due to greater water availability while non-water limited irrigated crop yields decrease due to the net impacts of higher temperatures. As a result, changes in yields are often larger in absolute value for dryland production than irrigated.

Simulated yields for irrigated barley are projected to increase across the majority of the production region, with fairly large increases in simulated potential yields. Simulation results for dryland barley yields, on the other hand, tend to shows increases in the eastern half of the U.S. and decreases in the western half. Simulated potential yields decline by 30% or more in parts of the Dakotas and the Rockies region, areas that are presently home to substantial barley production.

EPIC simulated corn yields differ considerably based on the GCM scenario being modeled. Two of the GCMs, CGCM3.1 and MRI-CGCM2.2, predict flat to increasing yields in dryland and irrigated corn throughout the Midwest and Southern U.S., while GFDL-GCM2.0 and GFDL-CM2.1 predict flat to decreasing yields in the Midwest. In all four scenarios, dryland corn yields tend to experience larger changes, with both greater yield increases in some regions and larger declines in others. As mentioned previously, this is consistent with dryland yields being more sensitive to changes in precipitation in these simulations. Projected corn yields vary across each GCM scenario, and the variation is considerable in the Corn Belt. In all the scenarios, the Rockies region experiences the largest increase in simulated yields.

EPIC simulation results tend to show cotton yields that are increasing in the eastern and western portions of the cotton production range and declining in between. Each of the models except GCM3.1 indicate that some of the largest simulated yield reductions would occur in southern Texas and Arizona. Generally, there tend to be reductions in yield in several of the major cotton belt states under these simulations.

Simulated hay yields tend to be increasing in the western and eastern portions of the production range, except for portions of the Southeast, whereas they tend to be decreasing in much of the Midwest and Southcentral regions as well as more southern portions of the Southeast. Yield impacts are relatively consistent across scenarios, with the primary difference being how far north yield reductions extend in the central U.S. Each of the scenarios simulated shows similar yield effects for both dryland and irrigated hay.

All potato production we model in EPIC is irrigated. The simulation results for potatoes show substantial variation across climate scenarios. Simulation based on the MRI-CGCM2.2 climate projections shows increasing yields throughout much of the U.S. (with the exception of the most southern regions). Simulations with CGCM2.2 have yields increasing in the most northern portions of the production regions with decreases in most other areas. The GFDL-2.0 and GFDL-2.1 simulation results show large reduction in potato yields across most areas in the U.S.

Rice production (also assumed to be all irrigated) is concentrated in the Lower Mississippi River basin and in Central California. Under all four scenarios, simulated rice yields in Central California generally increase across the region. Simulated rice yields in the Lower Mississippi River basin are generally declining over much of the region under the two GFDL GCMs, while there is a mixture of negative and positive yield effects under CGCM3.1 and generally increasing yields under MRI-CGCM2.2. There is considerable variation in the projected yield changes in rice producing regions of eastern and central Texas across scenarios.

Generally, simulated sorghum yields fall in the Midwest, South Central, and Southeastern U.S. in the climate scenarios other than MRI-CGCM2.2, which shows increases over much of the country with the exception of Texas, Florida, and some small regions scattered about the eastern half of the U.S. Northern and western regions of the sorghum production range simulated, as well as Mid-Atlantic states, tend to show increasing yields across all scenarios for both dryland and irrigated production.

Simulated yields for soybeans show very similar patterns overall to those found for sorghum. As for sorghum, simulated yields are generally falling in the Midwest, South Central, and Southeastern U.S. with increases to the north and west and in the Mid-Atlantic States for the CGCM3.1, GFDL-2.0, and GFDL-2.1 scenarios. The simulations based on the MRI-CGCM2.2 climate projections, on the other hand, show yields increasing across the majority of the U.S.

Finally, simulated wheat yields show a different pattern than any of the other crops simulated using EPIC. For wheat, yields tend to be increasing throughout most of the U.S. except for the most northern portions of the production range. In this case, it is the Dakotas, Lake States, Mid-Atlantic, and Northeast states that tend to have declining simulated yields, with increasing yields predominating throughout the majority of the rest of the U.S.

In addition to the major crops simulated using EPIC, we calculated percentage changes in mean yield and variability for additional crops as well. We used proxy crops and regions to define the potential changes in yield distribution for grapefruit, oats, oranges, silage, sugarbeets, sugarcane, and tomatoes for use in the FASOM model.

Figure 4-1. Percentage Change in Dryland and Irrigated Barley Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

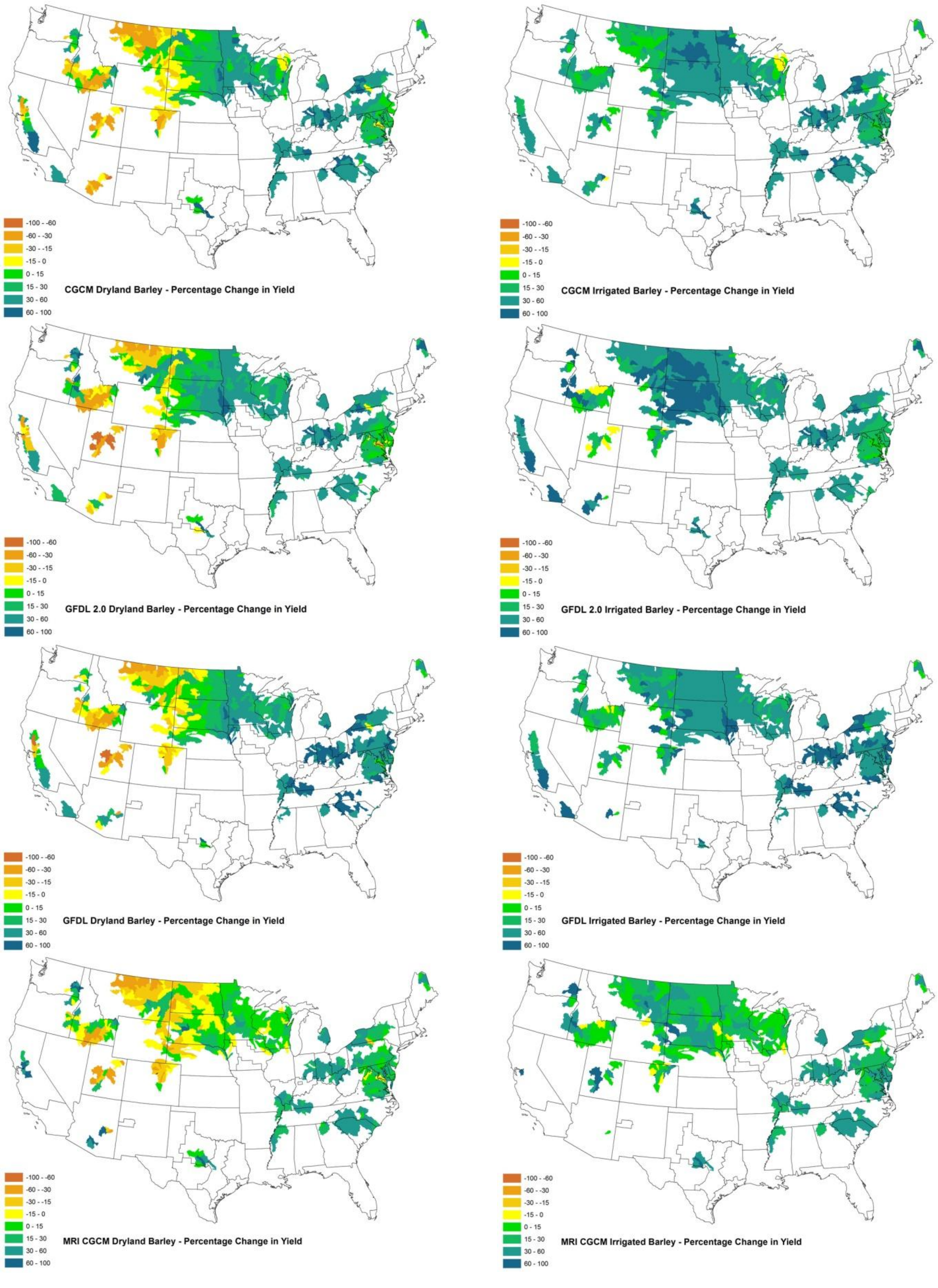


Figure 4-2. Percentage Change in Dryland and Irrigated Corn Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

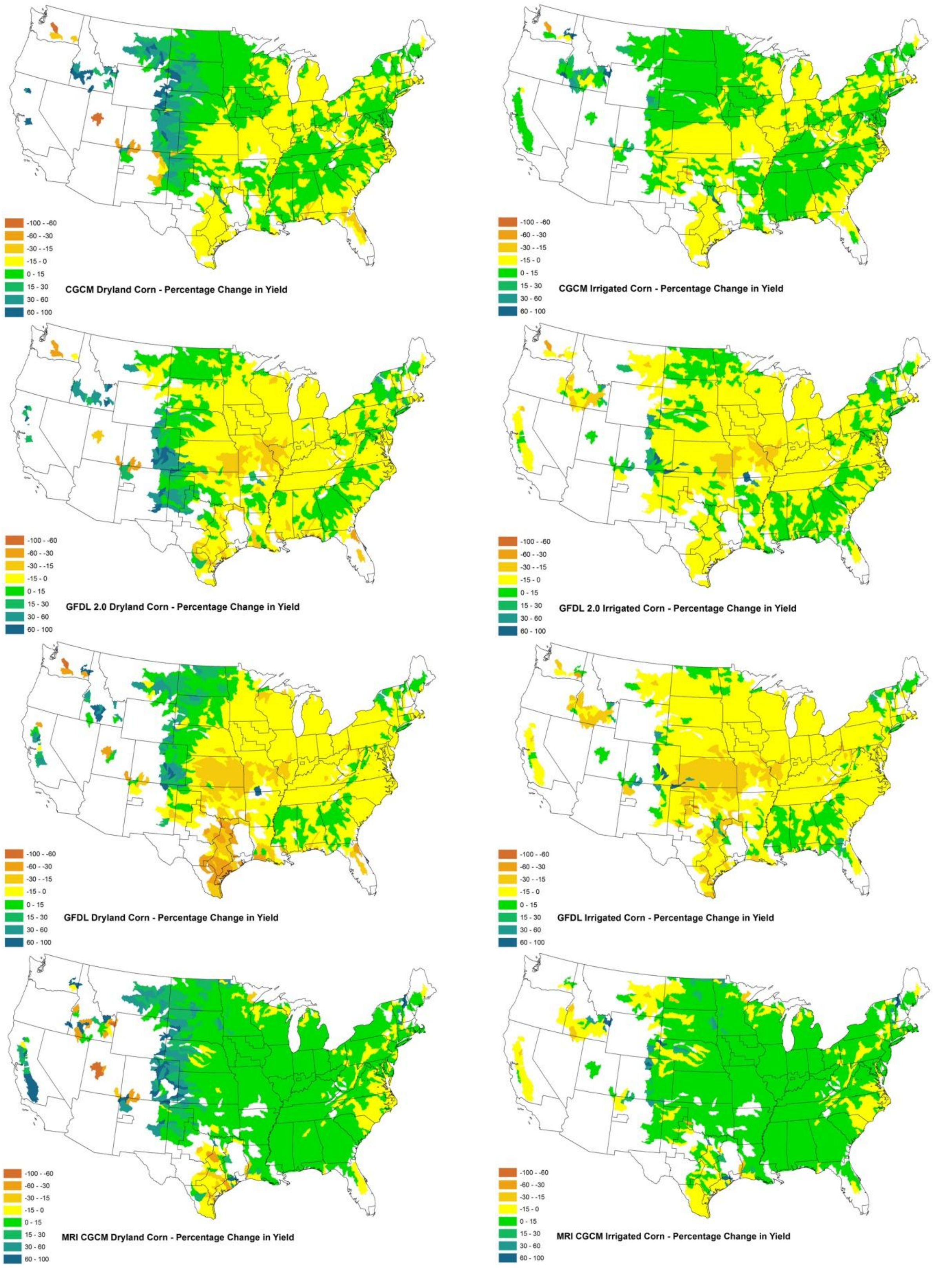


Figure 4-3. Percentage Change in Dryland and Irrigated Cotton Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

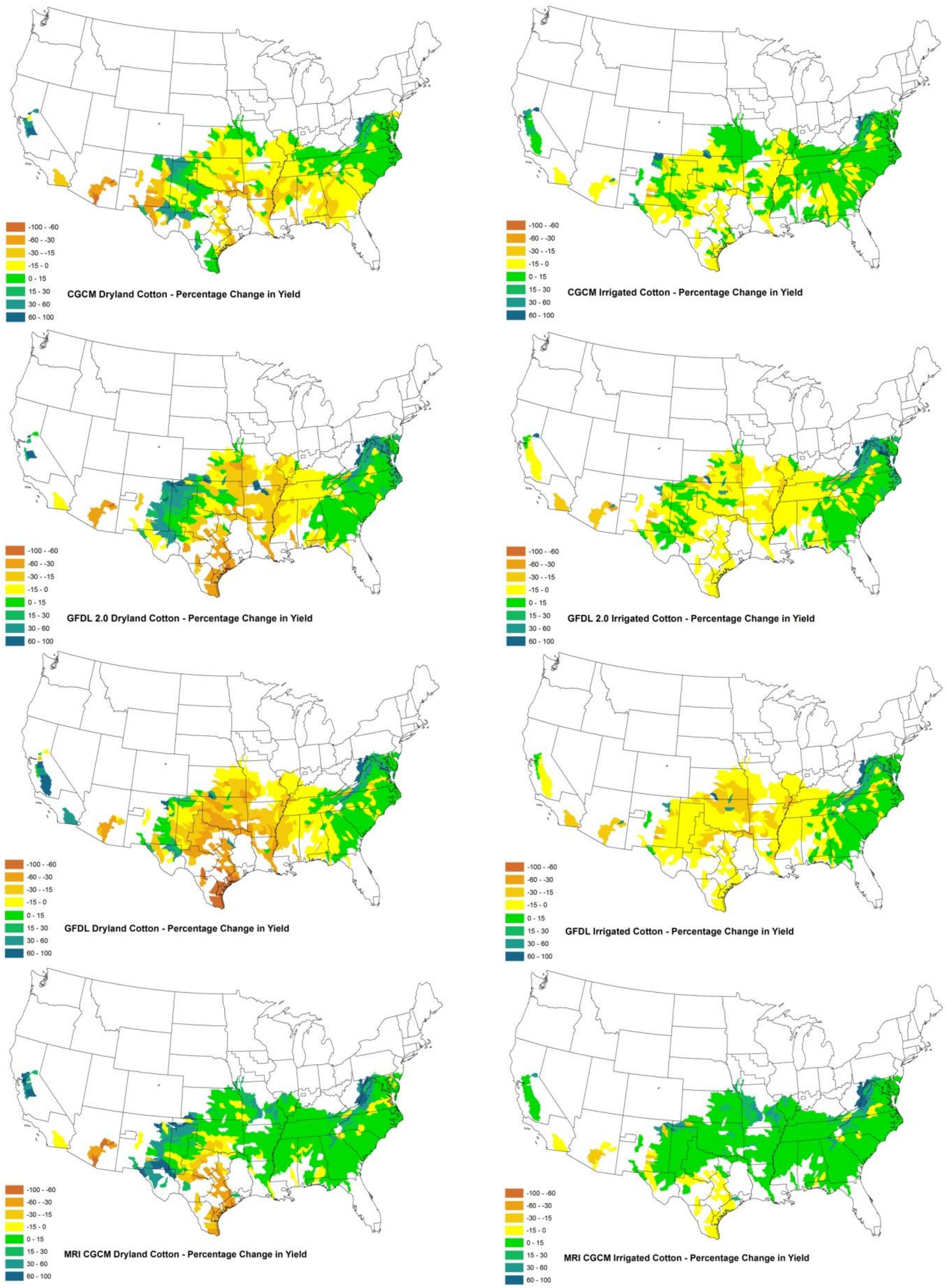


Figure 4-4. Percentage Change in Dryland and Irrigated Hay Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

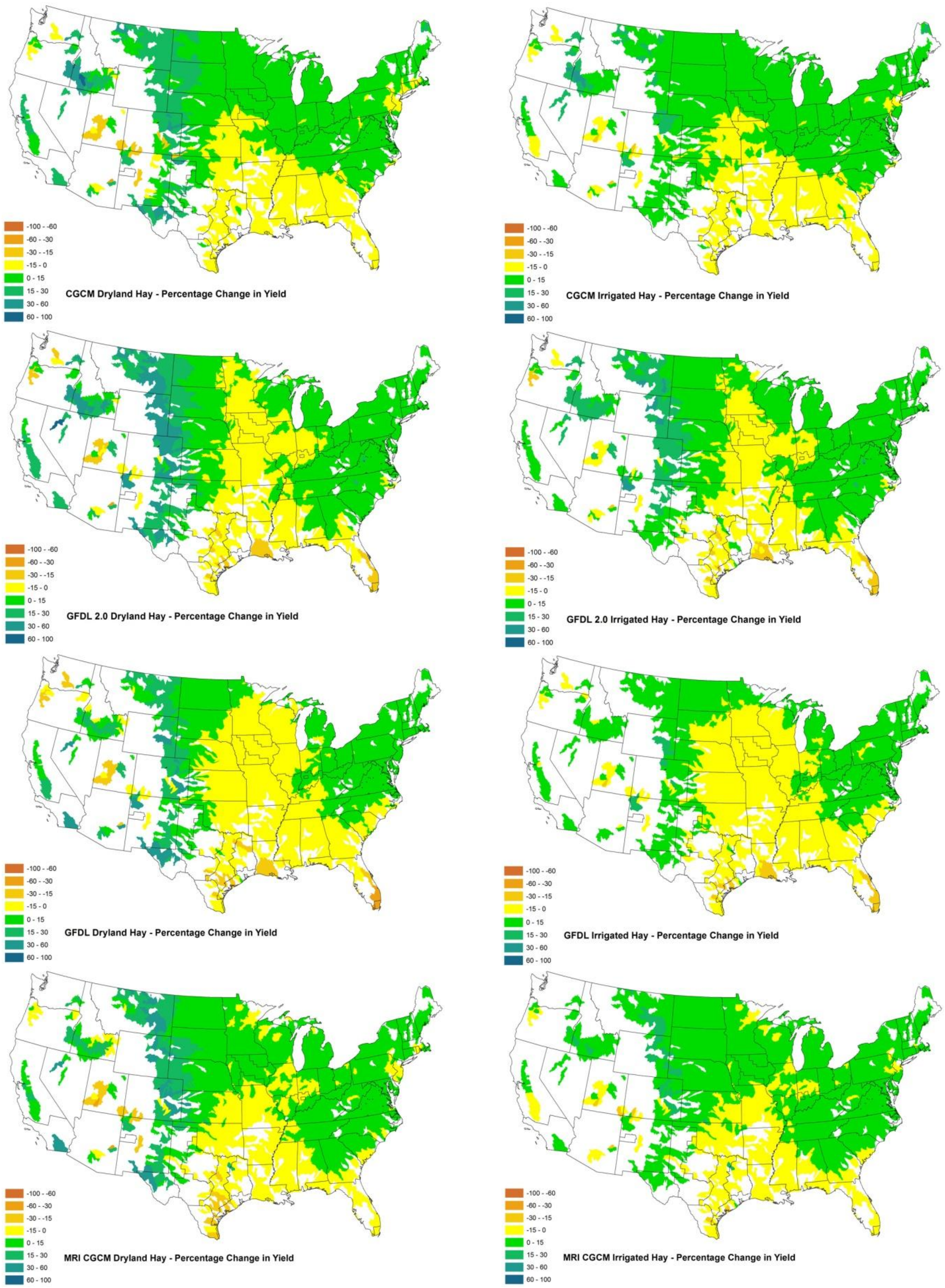


Figure 4-5. Percentage Change in Irrigated Potato Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

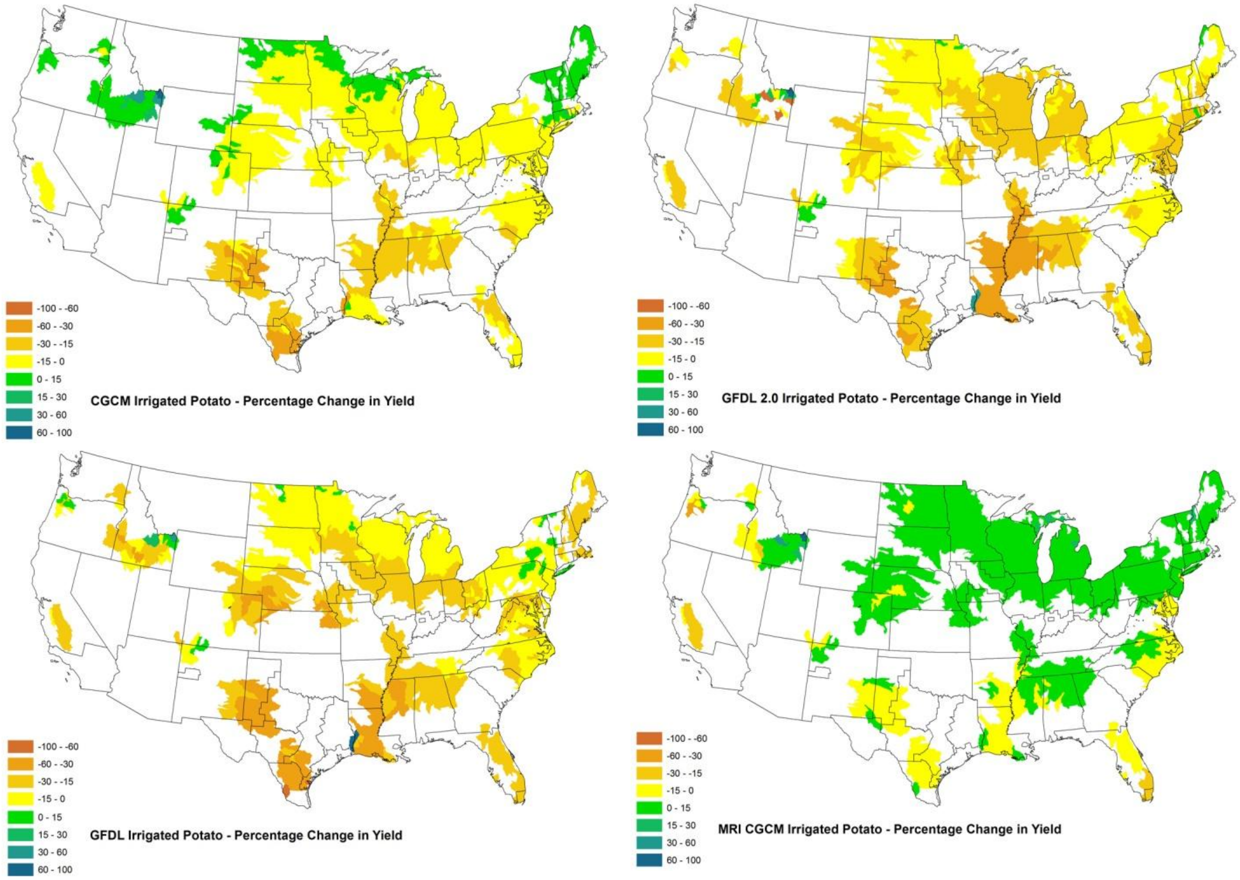


Figure 4-6. Percentage Change in Irrigated Rice Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

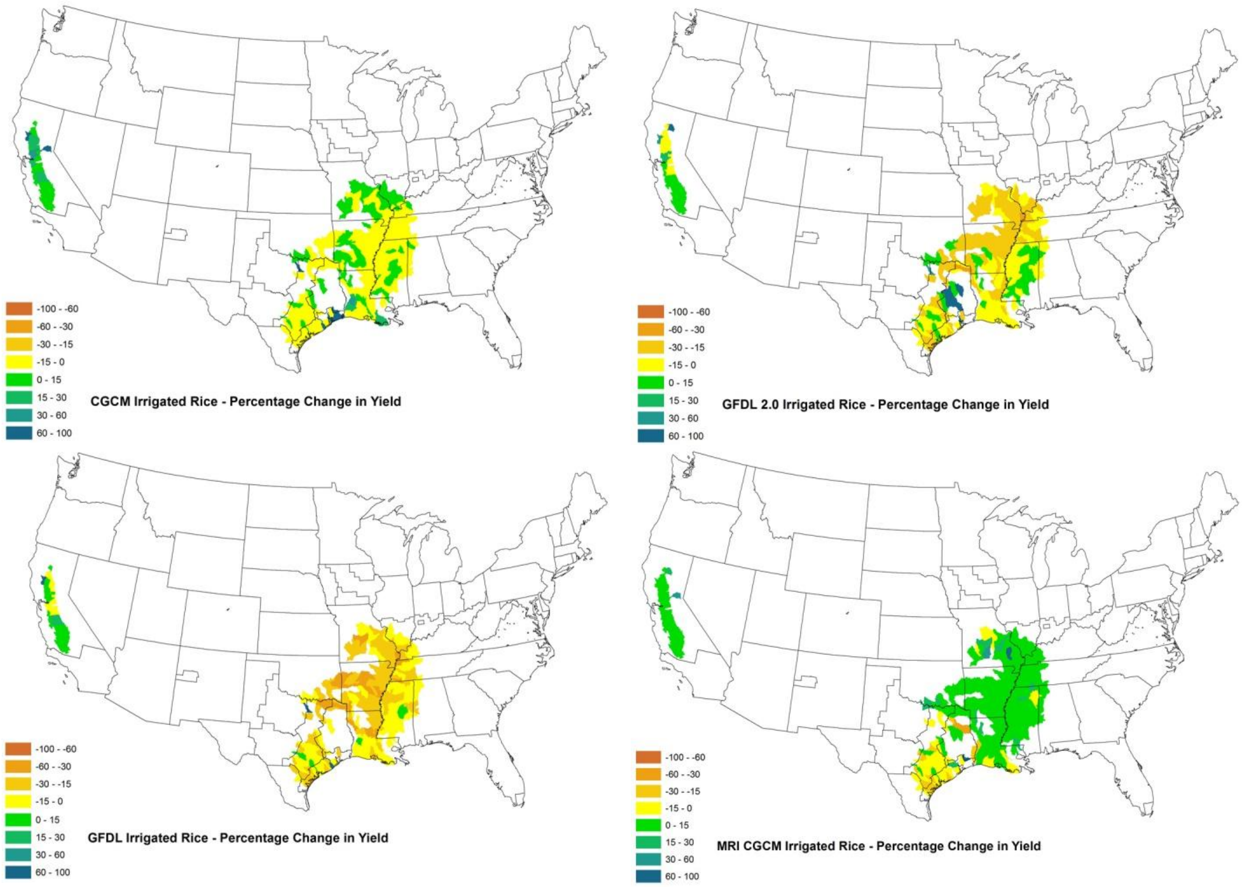


Figure 4-7. Percentage Change in Dryland and Irrigated Sorghum Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

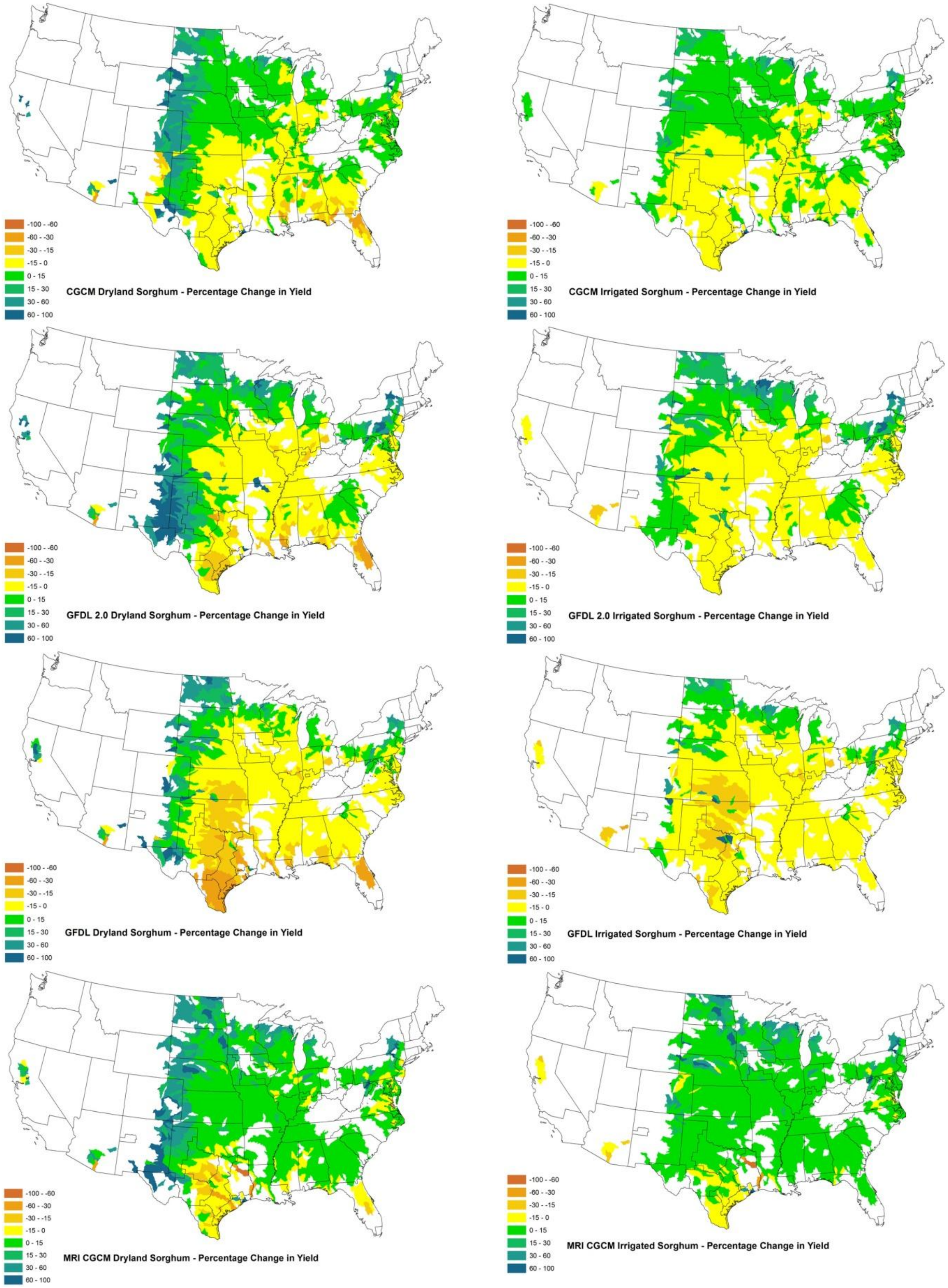


Figure 4-8. Percentage Change in Dryland and Irrigated Soybean Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055

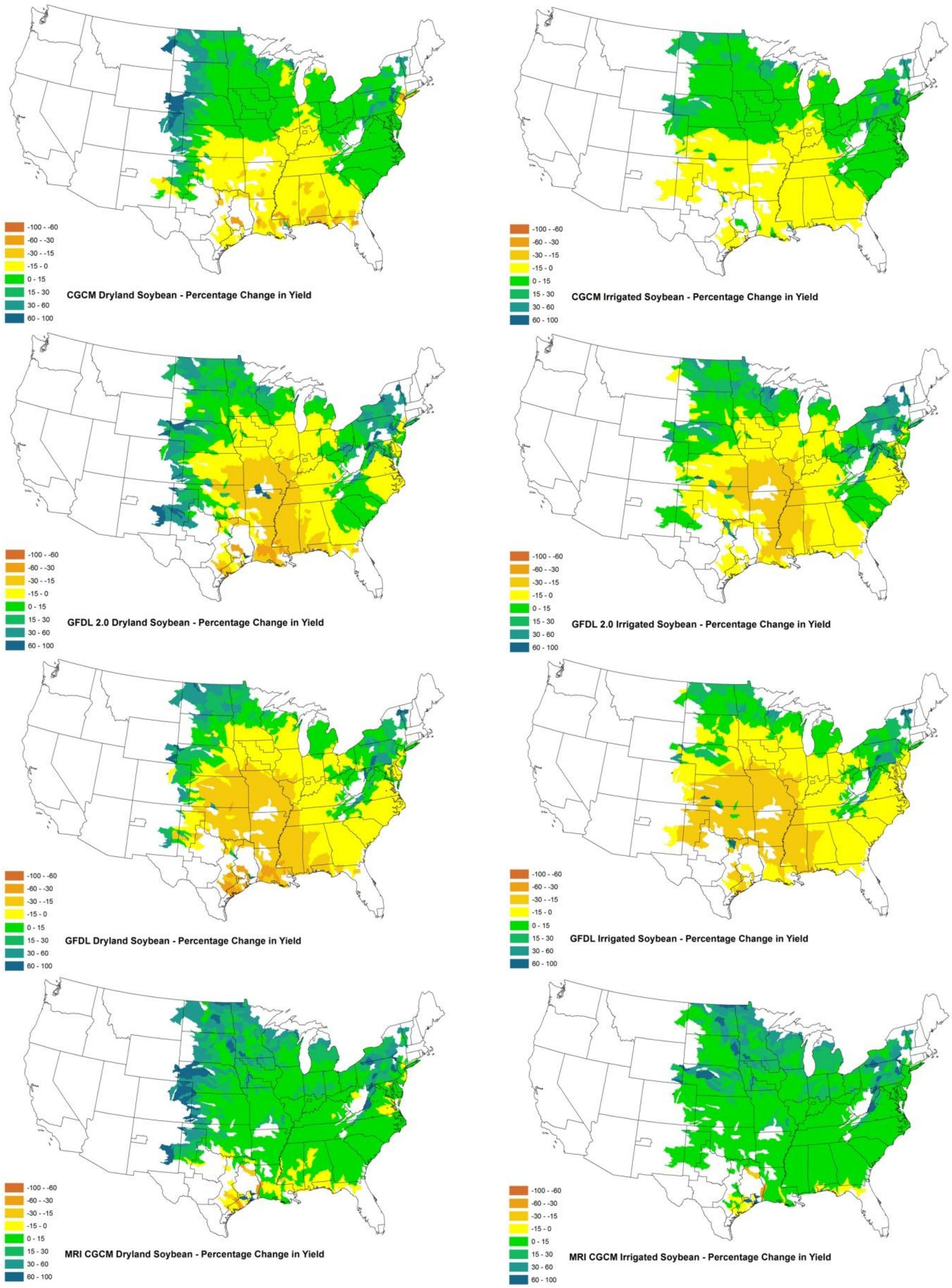
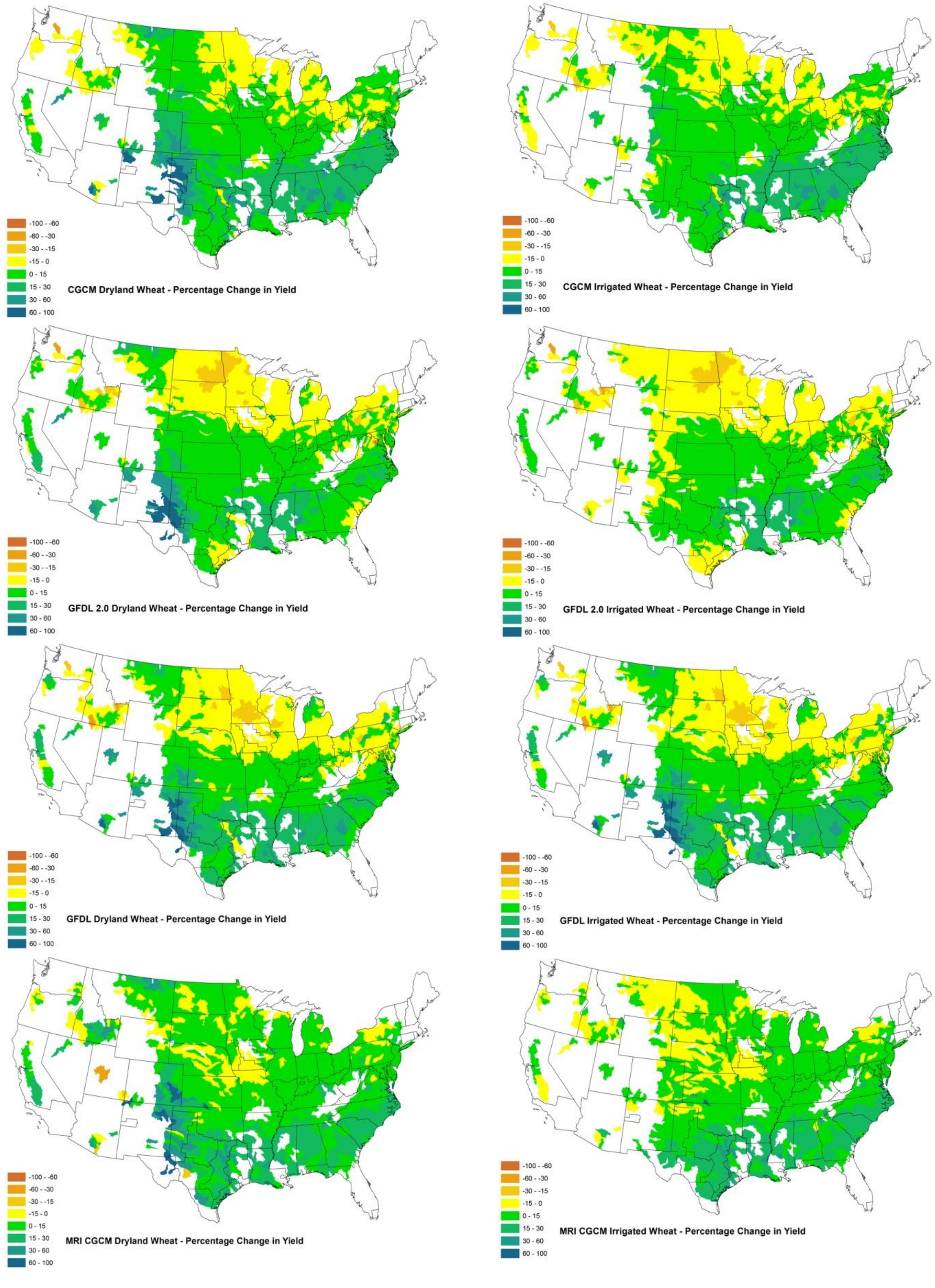


Figure 4-9. Percentage Change in Dryland and Irrigated Wheat Yields under the GCMs Simulated for the Longer-Term Using EPIC, 2045-2055



4.2 Market Outcomes

We then used weighted averages of the finer-scale simulation data to construct average values consistent with the 63 state and sub-state regions in FASOM. Table 4-1 presents examples of the yield shifts calculated for one of the crops incorporated into FASOM, barley. Table 4-2 shows the changes in standard deviation of barley yield incorporated into the model. The corresponding percentage changes in mean yield and standard deviation of the yield for all crops for which yield shifts were incorporated into the FASOM model are presented in Appendix B.

Table 4-1. Percent Changes in Mean Yield Incorporated into FASOM, Barley

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	22.0	13.7	17.8	17.8	21.8	13.7	17.8	17.1
Arizona	-48.6	-40.3	-32.2	5.7	24.8	47.9	64.4	109.4
Arkansas	42.0	32.9	28.9	29.1	42.0	32.9	28.9	29.1
CaliforniaN	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
CaliforniaS	40.9	24.4	46.3	134.2	52.0	78.1	72.4	186.3
Colorado	-15.0	-21.7	-15.7	-22.6	24.9	17.8	27.6	5.9
Connecticut	5.2	2.1	-1.5	2.5	4.4	0.1	-1.5	2.4
Delaware	18.6	13.6	51.7	25.0	28.6	23.1	64.6	35.6
Florida	9.7	5.1	14.7	13.4	9.7	5.1	14.7	13.5
Georgia	53.9	44.9	57.4	28.9	54.3	45.3	57.8	29.3
Idaho	0.6	-7.0	-6.7	3.2	29.3	27.9	20.4	18.5
IllinoisN	23.2	42.5	40.9	9.6	23.9	43.3	41.8	10.2
IllinoisS	46.3	37.4	57.3	32.3	48.1	39.1	59.3	33.9
IndianaN	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IndianaS	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IowaW	51.2	58.0	59.3	10.6	53.2	60.1	61.4	12.1
IowaCent	45.2	46.0	46.9	7.1	51.3	52.1	52.8	11.5
IowaNE	49.0	49.0	49.1	15.5	49.1	49.1	49.1	15.5
IowaS	7.1	2.0	-0.5	-2.3	6.2	1.8	-0.5	-2.3
Kansas	9.8	6.2	6.8	4.8	7.9	5.6	5.9	3.7
Kentucky	49.9	42.6	60.7	30.3	50.1	42.8	60.9	30.4
Louisiana	14.9	20.5	25.1	22.9	14.2	20.5	26.0	22.7
Maine	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Maryland	22.1	16.6	44.7	17.1	29.1	23.2	53.1	23.8
Massachusetts	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
Michigan	18.9	43.2	44.0	23.0	21.5	46.0	46.3	25.7
Minnesota	38.3	38.0	35.2	12.1	53.3	52.6	49.4	24.2
Mississippi	46.6	35.3	42.1	24.3	46.9	35.5	42.3	24.5
Missouri	46.7	40.9	55.6	29.6	46.8	40.9	55.6	29.6
Montana	-18.8	-7.4	-14.5	-17.8	21.9	44.6	32.7	20.8
Nebraska	13.3	24.1	18.5	-6.5	46.6	61.4	53.9	21.1
Nevada	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
New Jersey	11.0	18.5	56.5	16.0	15.2	23.0	62.4	20.3

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
NewMexico	71.7	63.5	69.3	122.7	6.1	-4.0	8.7	6.8
NewYork	46.5	44.3	52.3	30.4	50.3	47.9	56.0	33.6
NorthCarolina	42.8	36.8	53.0	32.6	45.1	39.0	55.6	34.8
NorthDakota	16.3	17.0	10.4	-10.2	56.4	57.4	48.1	20.9
OhioNW	66.1	64.6	90.9	53.2	67.5	66.0	92.6	54.5
OhioS	48.6	44.6	65.8	39.0	49.0	45.0	66.2	39.4
OhioNE	50.2	45.9	59.8	36.9	51.8	47.4	61.5	38.4
Oklahoma	13.3	8.3	12.7	8.8	12.1	7.8	11.9	9.7
Oregon	9.3	18.1	2.5	12.7	40.0	54.6	28.9	36.7
Pennsylvania	31.4	31.8	53.1	23.2	34.9	35.3	57.2	26.5
Rhode Island	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
SouthCarolina	45.2	40.9	63.3	38.3	45.5	41.2	63.6	38.6
SouthDakota	14.3	25.5	13.8	-2.3	49.3	65.2	49.4	28.3
Tennessee	42.2	34.6	55.5	29.1	42.8	35.1	56.1	29.6
TxHiPlains	45.1	18.3	20.1	16.0	7.7	1.7	4.8	3.8
TxRolingPl	40.6	33.0	33.4	33.9	68.1	59.0	57.9	60.1
TxCntBlack	67.4	53.0	67.0	38.2	67.9	53.4	67.5	38.6
TxEast	24.0	15.3	22.1	26.3	22.9	16.4	22.3	26.3
TxEdplat	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
TxCoastBe	12.4	0.0	20.6	20.9	12.4	-1.7	22.8	23.2
TxSouth	8.2	10.5	23.1	21.6	7.9	-2.9	19.1	17.1
TxTranspec	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
Utah	-31.8	-50.6	-41.2	-23.3	48.0	14.3	30.2	61.0
Vermont	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Virginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Washington	-26.6	-24.2	-25.9	-14.4	35.8	103.7	15.2	73.2
WestVirginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Wisconsin	19.4	35.5	33.8	11.3	22.8	38.9	37.1	14.8
Wyoming	-11.9	-12.0	-10.5	-13.1	41.2	49.5	49.9	30.3

Table 4-2. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Barley

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	17.3	-11.2	-20.7	8.6	17.4	-11.3	-20.7	11.6
Arizona	-45.0	-39.6	-38.8	-9.3	5.2	10.1	-11.5	-10.2
Arkansas	51.9	80.5	54.5	39.9	51.9	80.5	54.5	39.9
CaliforniaN	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
CaliforniaS	133.6	73.4	45.4	113.7	70.3	93.5	44.8	66.2
Colorado	45.2	77.4	69.6	6.3	51.7	69.1	47.6	9.3
Connecticut	74.3	106.4	19.7	-20.5	85.0	127.7	19.7	-20.2
Delaware	205.4	199.4	164.1	240.3	99.0	96.2	72.1	121.8
Florida	14.9	-2.2	0.7	-5.0	14.9	-2.1	0.6	-5.0
Georgia	78.3	46.4	94.8	53.3	77.9	46.1	94.4	52.9
Idaho	92.6	64.4	50.7	23.0	95.1	16.1	53.0	23.6
IllinoisN	47.9	115.8	63.6	69.8	44.4	110.8	59.8	65.8
IllinoisS	73.2	147.0	133.2	64.2	70.3	143.1	130.0	62.5
IndianaN	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IndianaS	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IowaW	81.7	179.4	48.3	72.5	67.9	158.1	37.0	59.4
IowaCent	104.7	180.4	84.9	128.6	69.7	132.4	52.3	91.0
IowaNE	26.9	85.7	43.8	49.4	26.6	85.2	43.5	49.0
IowaS	25.1	29.7	11.7	3.8	32.0	29.5	11.6	5.7
Kansas	-6.4	3.5	13.0	17.1	16.3	7.1	14.8	29.4
Kentucky	69.7	106.7	150.4	81.4	68.6	105.3	148.7	80.2
Louisiana	15.6	42.1	3.1	-13.6	18.1	42.3	8.1	-13.1
Maine	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Maryland	191.0	177.8	102.9	81.2	121.6	113.6	54.4	38.2
Massachusetts	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
Michigan	-3.8	102.3	82.2	21.5	-22.3	62.9	48.7	-1.8
Minnesota	153.6	142.8	85.0	91.1	97.4	100.6	45.8	48.2
Mississippi	63.6	70.1	25.2	38.3	64.2	70.8	25.7	38.8
Missouri	55.7	161.3	105.2	74.4	55.5	161.0	105.0	74.2
Montana	112.2	114.9	113.3	54.1	110.1	77.8	60.8	45.6
Nebraska	122.6	242.1	110.0	53.5	59.6	148.8	53.0	13.1
Nevada	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
NewJersey	128.4	107.1	50.7	89.8	82.9	65.9	20.7	52.0
NewMexico	-26.9	-70.0	-40.2	46.8	-8.3	27.9	-37.3	18.6
NewYork	190.2	138.7	160.5	111.7	140.0	97.7	116.2	73.8
NorthCarolina	123.7	96.7	118.5	70.7	117.3	93.1	112.5	66.0
NorthDakota	208.2	205.4	127.8	174.8	82.0	88.8	30.8	59.4
OhioNW	152.7	192.9	158.4	241.6	139.7	177.9	145.1	224.1
OhioS	139.3	164.4	111.7	192.4	137.8	162.8	110.3	190.6
OhioNE	136.3	149.0	102.9	170.0	119.5	131.3	88.5	150.8
Oklahoma	2.0	10.4	3.8	14.3	11.9	15.7	7.2	12.5
Oregon	279.0	157.3	107.4	98.4	210.3	62.8	83.6	107.2

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Pennsylvania	172.6	106.9	68.1	95.2	134.8	78.3	44.8	68.1
Rhode Island	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
SouthCarolina	106.7	58.3	240.0	74.8	107.1	58.6	240.6	75.2
SouthDakota	180.9	236.8	101.1	69.2	100.4	132.1	38.3	17.1
Tennessee	75.2	108.7	220.3	90.5	76.5	110.2	222.6	91.9
TxHiPlains	-39.9	-49.4	-22.0	-3.1	30.9	5.5	17.5	16.9
TxRolingPl	104.8	37.2	9.6	75.1	73.0	15.9	-3.3	47.9
TxCntBlack	83.1	13.3	9.4	81.4	83.5	13.6	9.7	81.8
TxEast	11.6	-24.7	1.3	17.7	11.8	-18.6	2.0	17.7
TxEdplat	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
TxCoastBe	-3.0	-1.2	-4.5	6.3	-3.0	2.0	2.1	6.1
TxSouth	10.9	58.3	-36.8	-22.0	9.8	95.5	52.4	11.2
TxTranspec	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
Utah	62.9	75.6	23.4	14.9	58.3	69.4	60.4	21.2
Vermont	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Virginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Washington	-65.3	13.9	-67.4	-54.3	61.7	37.4	-4.3	46.1
WestVirginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Wisconsin	75.5	147.6	178.3	105.6	32.0	88.8	120.9	52.7
Wyoming	65.1	149.0	134.5	20.4	118.1	102.7	117.5	26.8

Incorporating the simulated changes in mean yield and standard deviation for each of crops with EPIC-simulated values or values calculated based on proxy crops and regions into FASOM, we generated simulated changes in equilibrium market conditions associated with these shifts in yield distributions that affect expected returns and variability of returns associated with alternative production activities.

Figure 4-10 shows the simulated changes in average market prices under each climate scenario relative to the simulated baseline price levels. There are a mixture of increasing and decreasing mean prices for each crop across the scenarios simulated. Figure 4-11 presents simulated changes in the standard deviation of market prices under each climate scenario. As for the simulated changes in mean prices, there are both increases and decreases in the standard deviation of the simulated price distribution. In general, minor crops concentrated in particular geographic regions tend to have larger simulated changes in average price as well as standard deviation of the price.

Figures 4-12 through 4-28 present the simulated changes in regional (presented by FASOM market region) and national acreage by crop under each of the climate scenarios examined. These results indicate substantial potential shifts in regional as well as national crop mix.

Figure 4-10. Simulated Changes in Average Market Price Relative to the Baseline

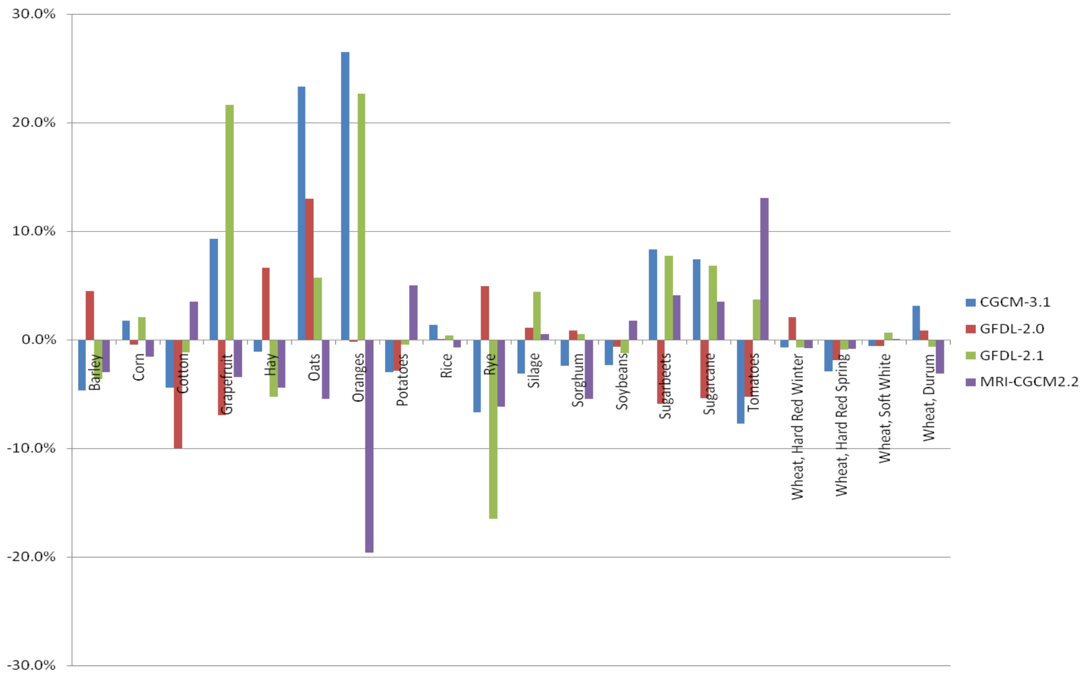


Figure 4-11. Simulated Changes in the Standard Deviation of Price Relative to the Baseline

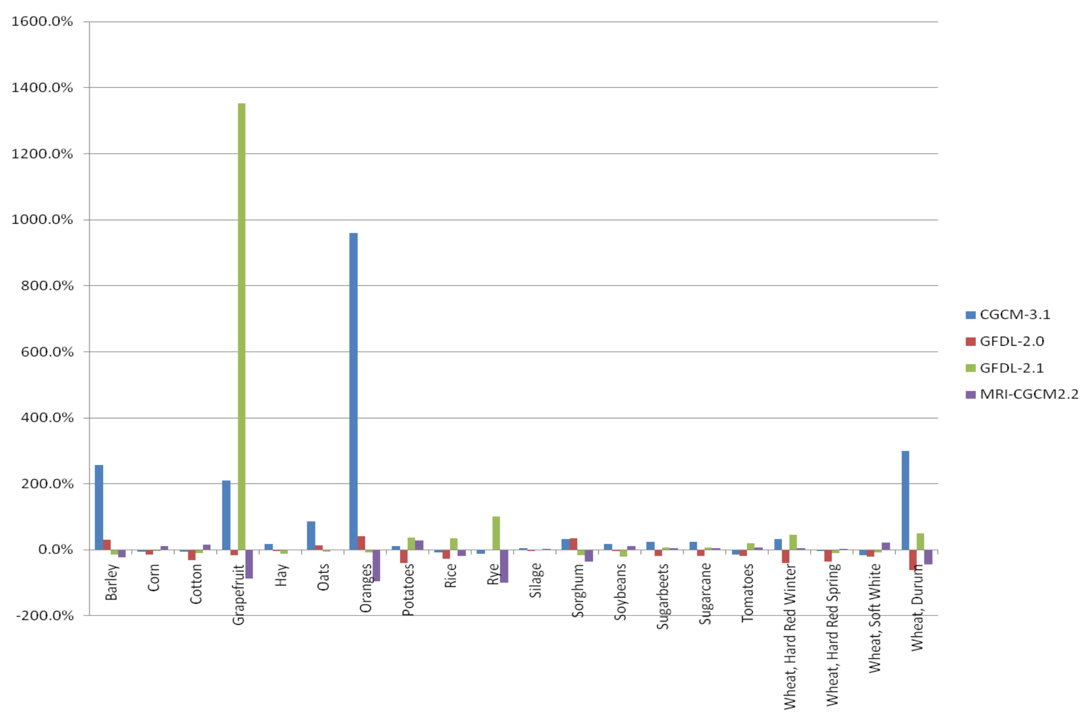


Figure 4-12. Simulated Changes in Regional Acreage Relative to the Baseline, Barley (Acres)

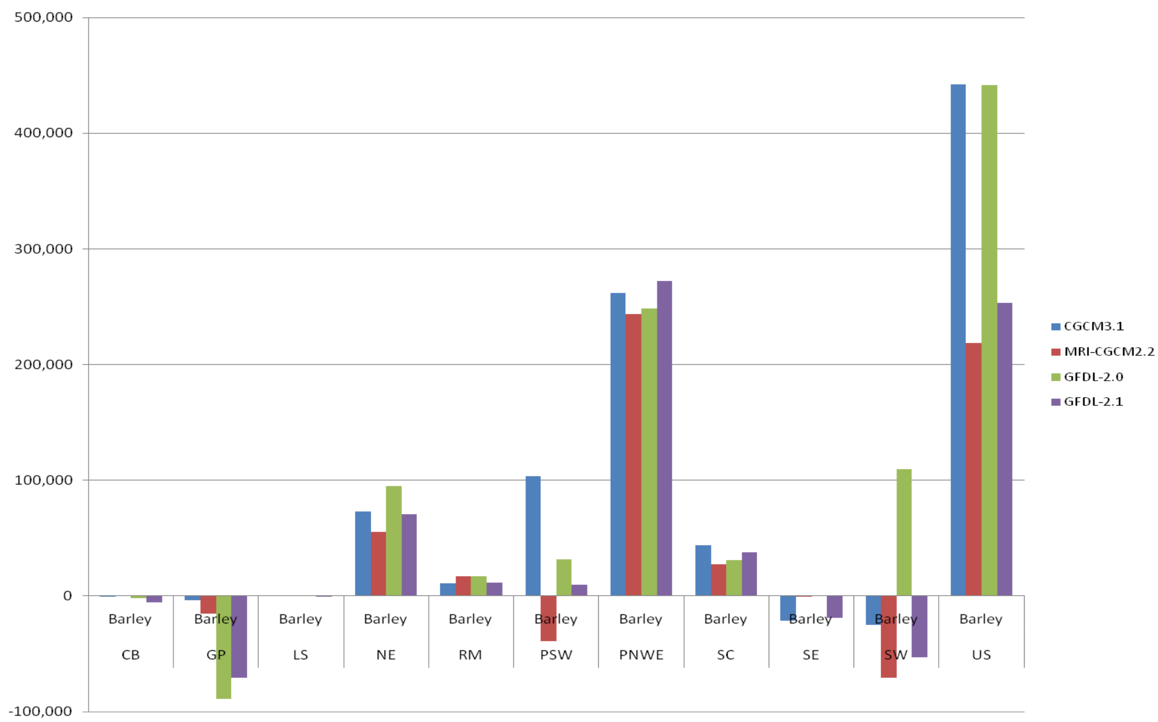


Figure 4-13. Simulated Changes in Regional Acreage Relative to the Baseline, Corn (Acres)

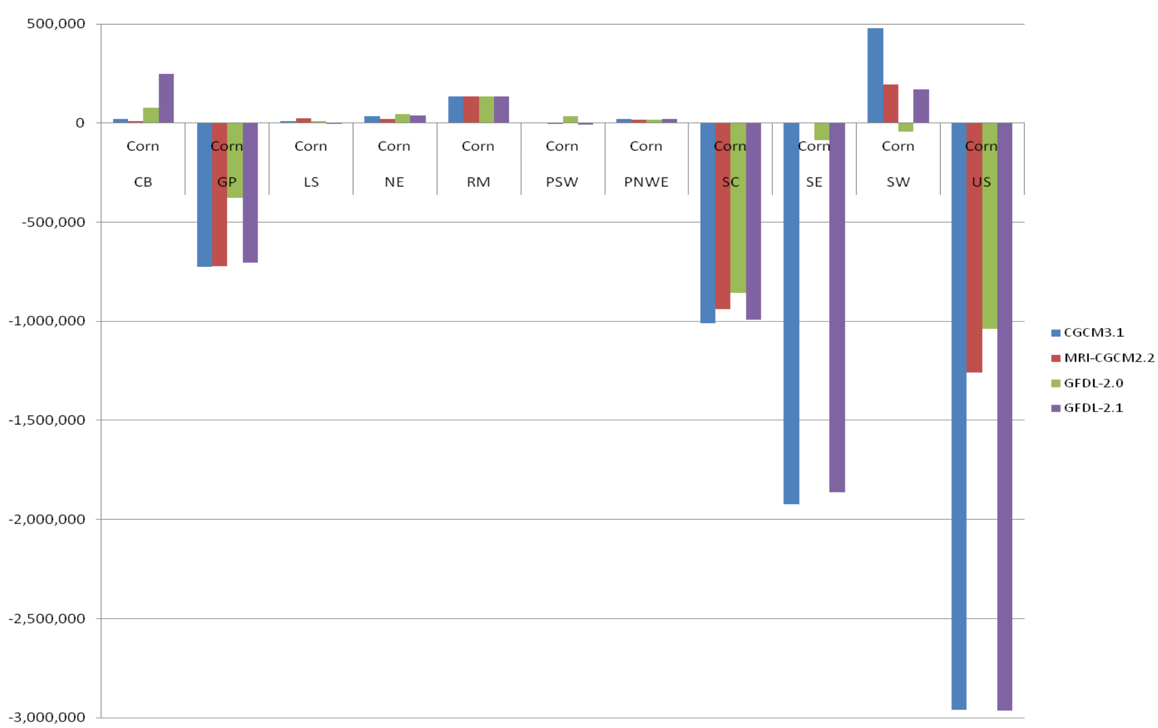


Figure 4-14. Simulated Changes in Regional Acreage Relative to the Baseline, Cotton (Acres)

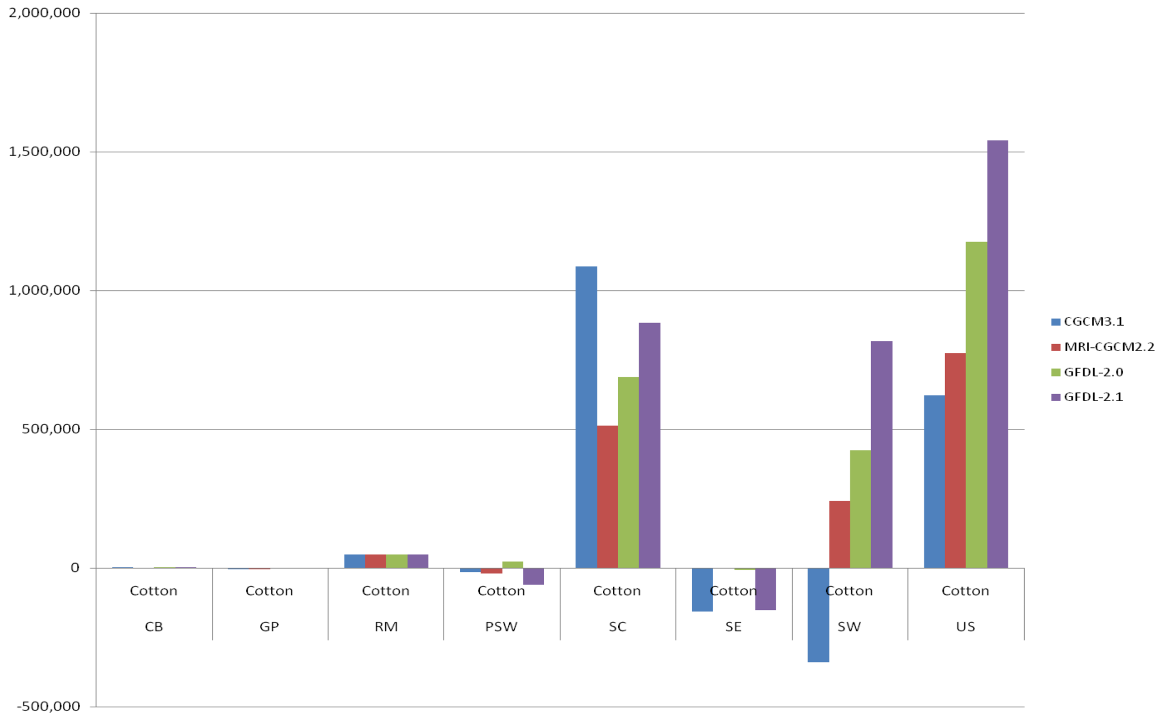


Figure 4-15. Simulated Changes in Regional Acreage Relative to the Baseline, Grapefruit (Acres)

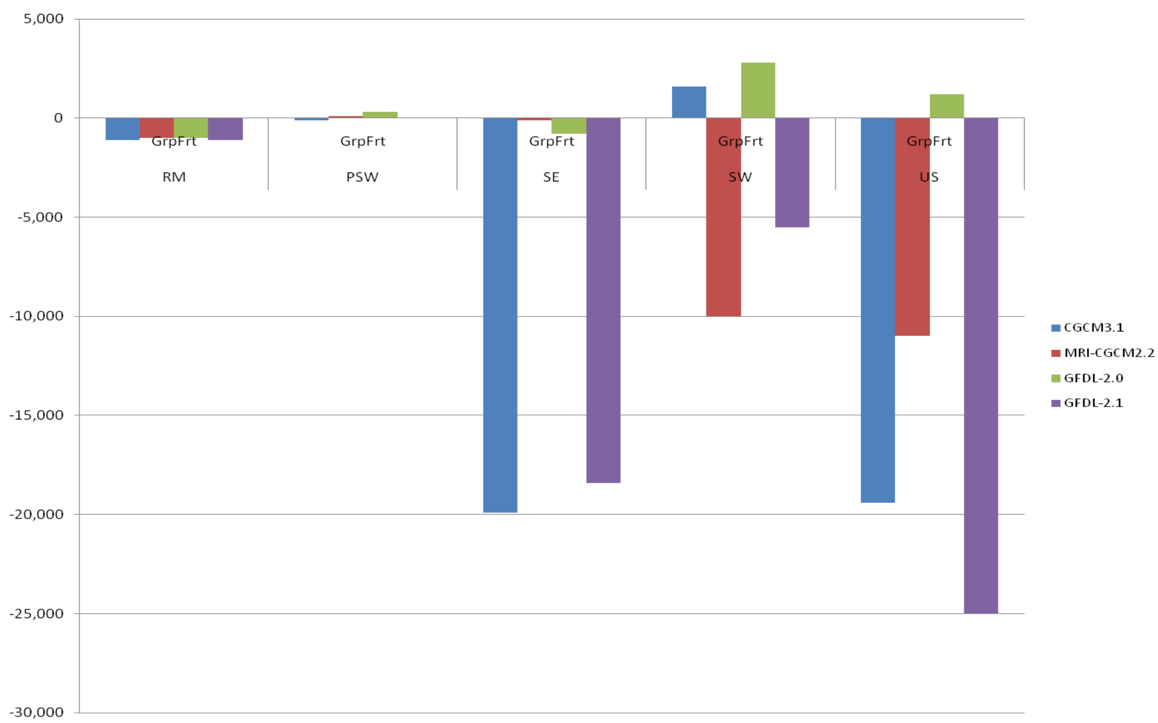


Figure 4-16. Simulated Changes in Regional Acreage Relative to the Baseline, Hay (Acres)

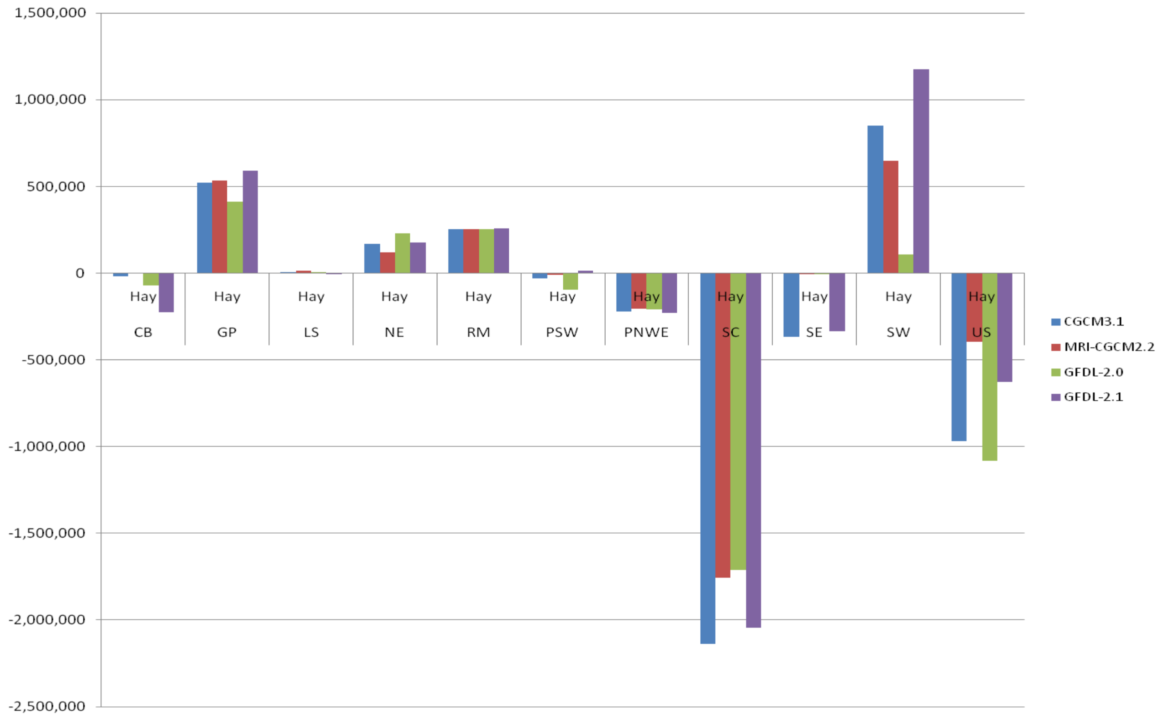


Figure 4-17. Simulated Changes in Regional Acreage Relative to the Baseline, Oats (Acres)

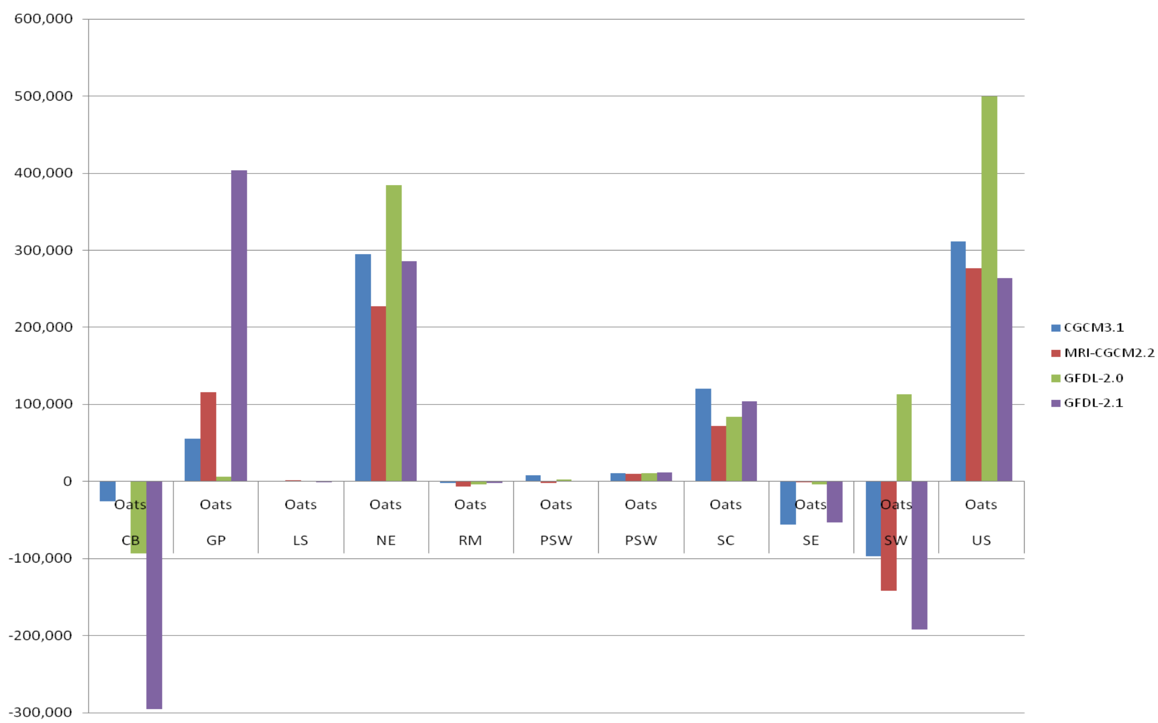


Figure 4-18. Simulated Changes in Regional Acreage Relative to the Baseline, Oranges (Acres)

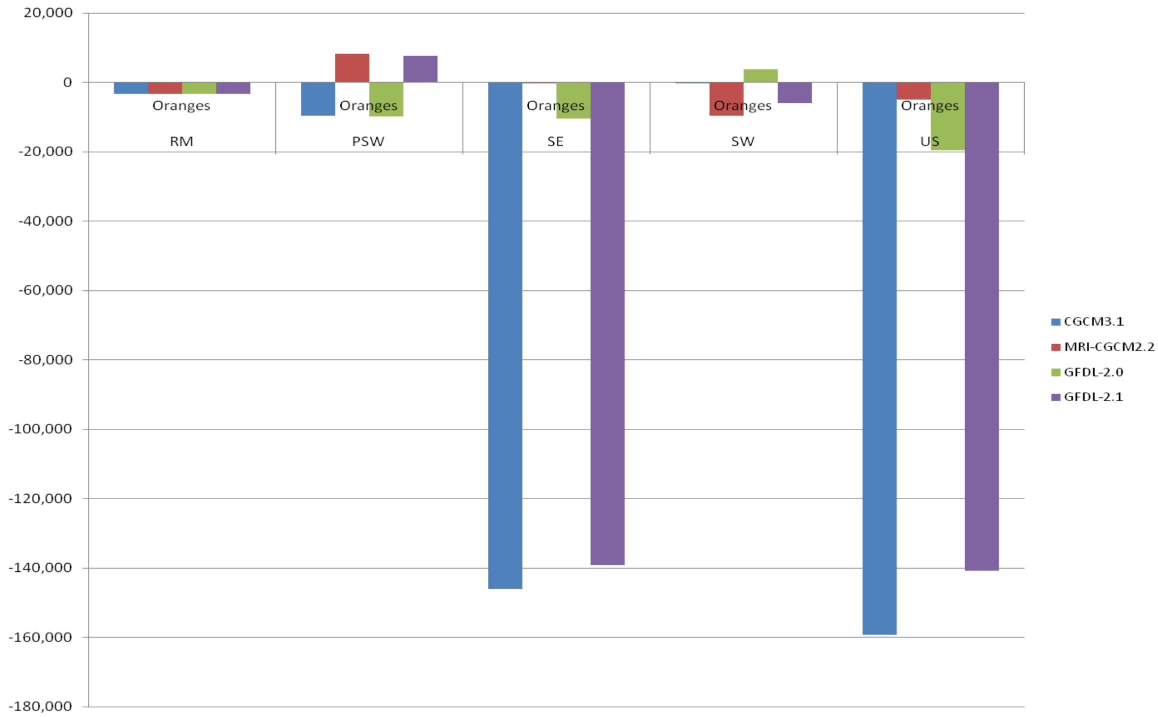


Figure 4-19. Simulated Changes in Regional Acreage Relative to the Baseline, Potatoes (Acres)

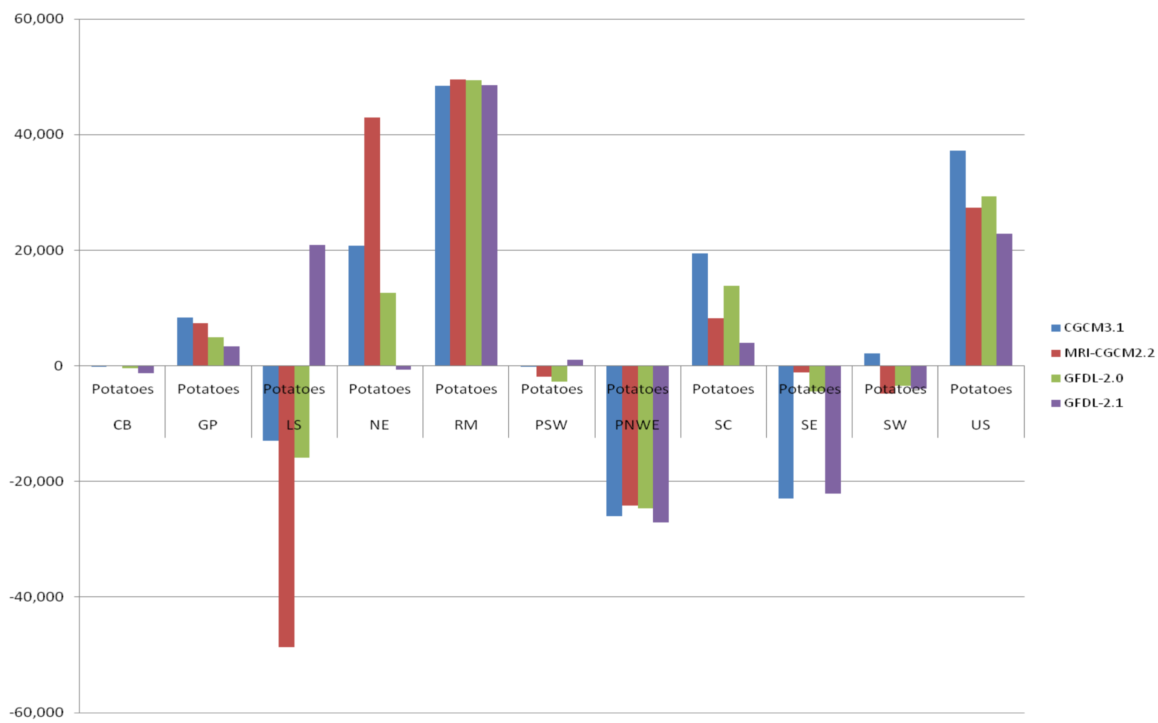


Figure 4-20. Simulated Changes in Regional Acreage Relative to the Baseline, Rice (Acres)

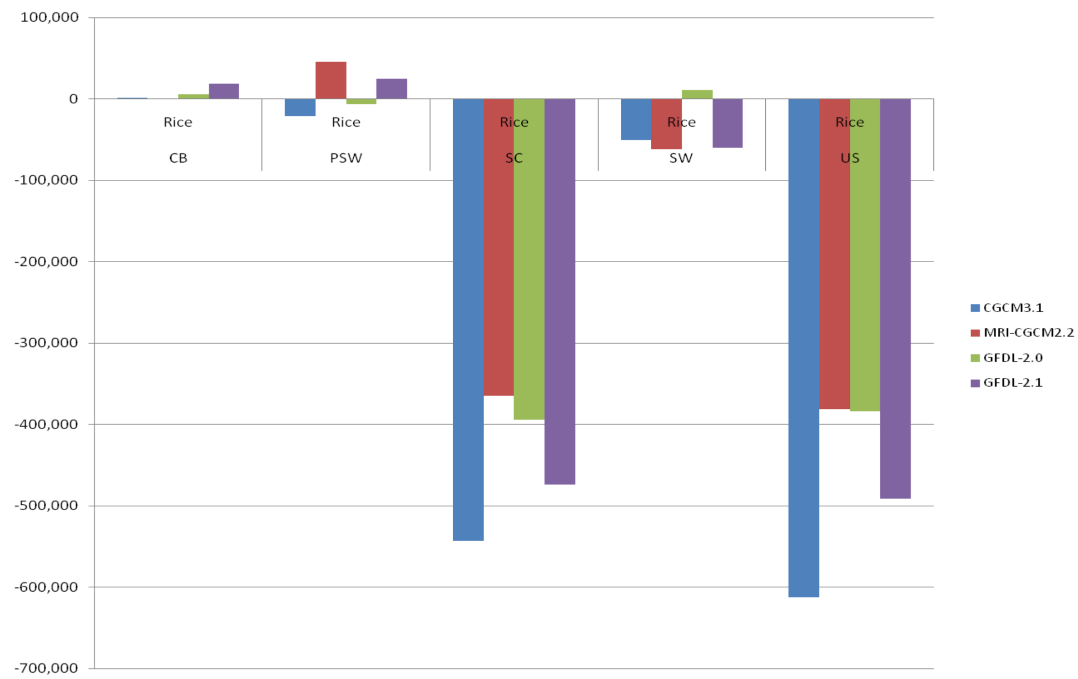


Figure 4-21. Simulated Changes in Regional Acreage Relative to the Baseline, Rye (Acres)

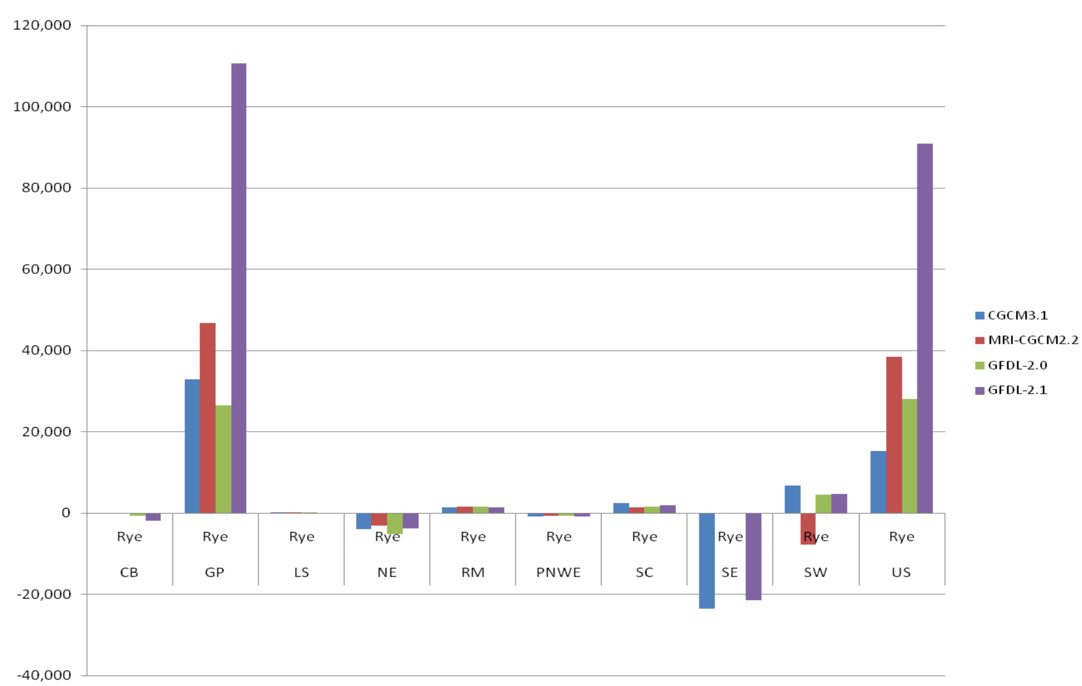


Figure 4-22. Simulated Changes in Regional Acreage Relative to the Baseline, Silage (Acres)

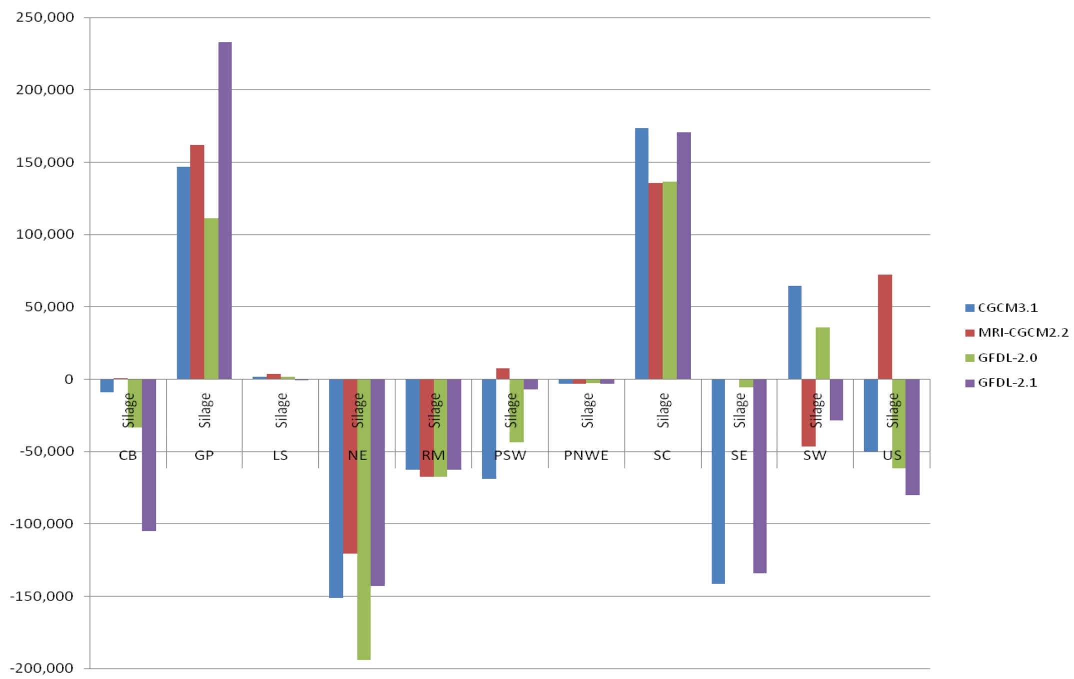


Figure 4-23. Simulated Changes in Regional Acreage Relative to the Baseline, Sorghum (Acres)

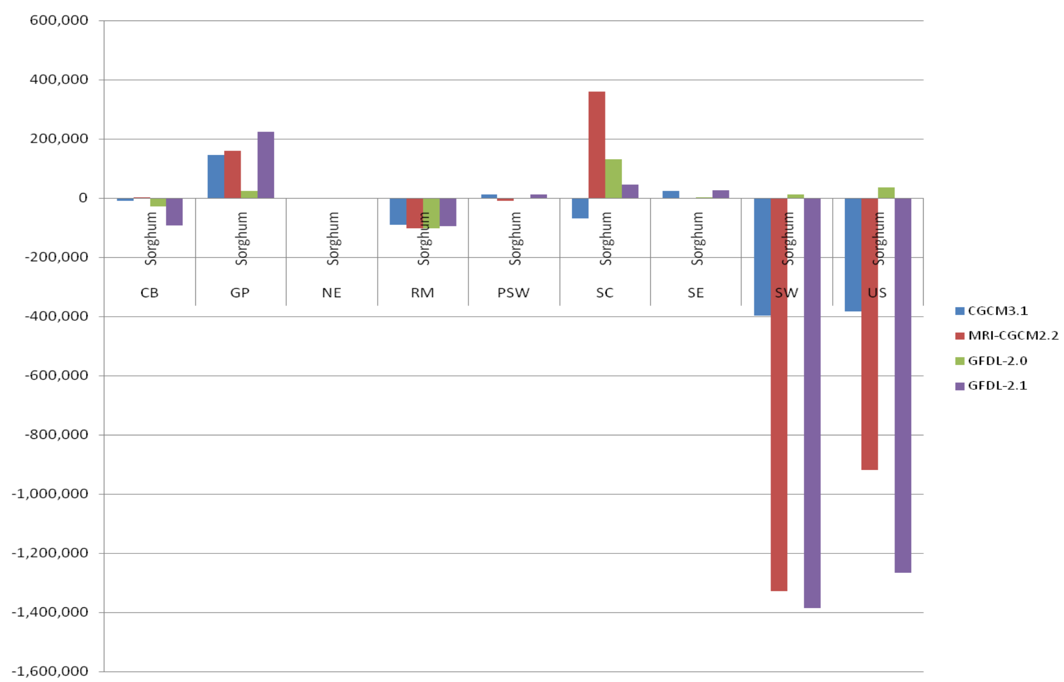


Figure 4-24. Simulated Changes in Regional Acreage Relative to the Baseline, Soybeans (Acres)

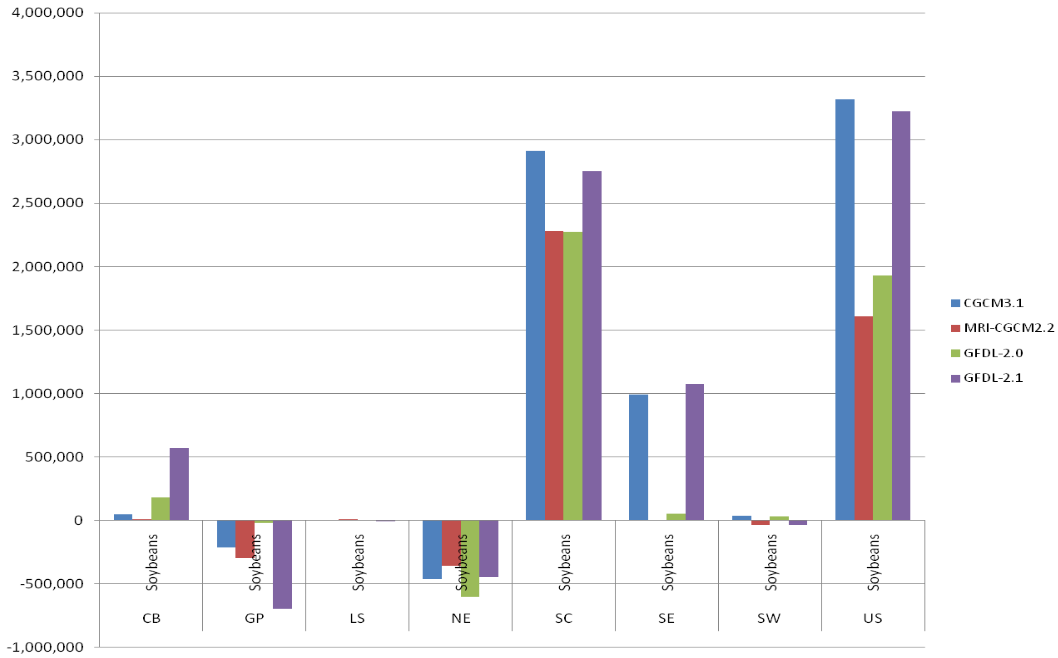


Figure 4-25. Simulated Changes in Regional Acreage Relative to the Baseline, Sugarbeets (Acres)

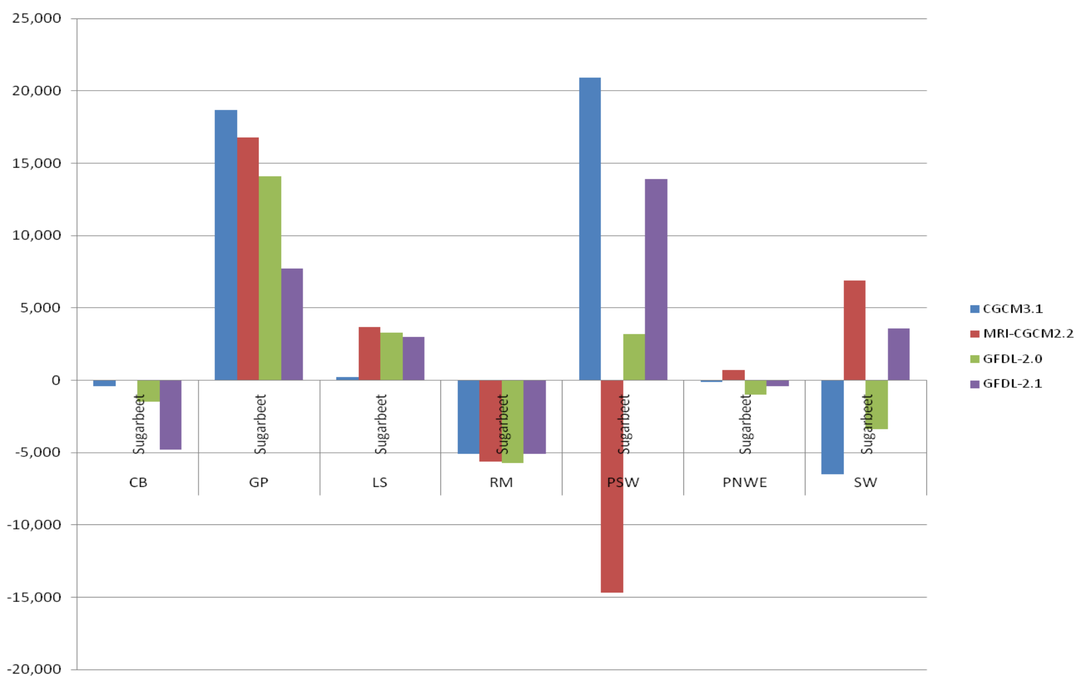


Figure 4-26. Simulated Changes in Regional Acreage Relative to the Baseline, Sugarcane (Acres)

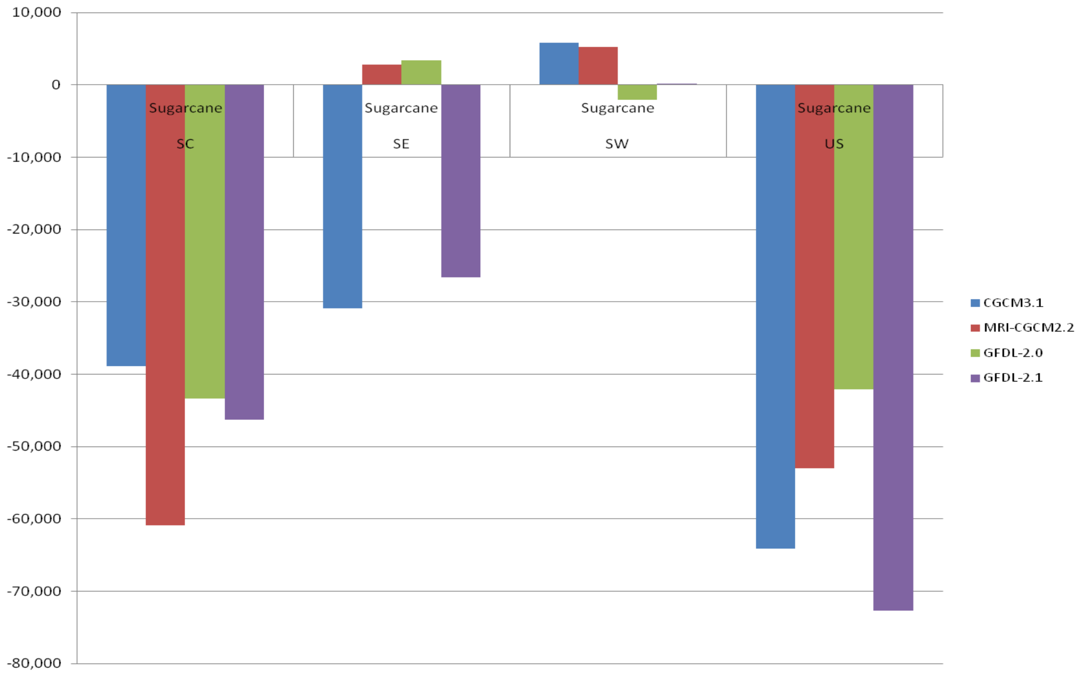


Figure 4-27. Simulated Changes in Regional Acreage Relative to the Baseline, Tomatoes (Acres)

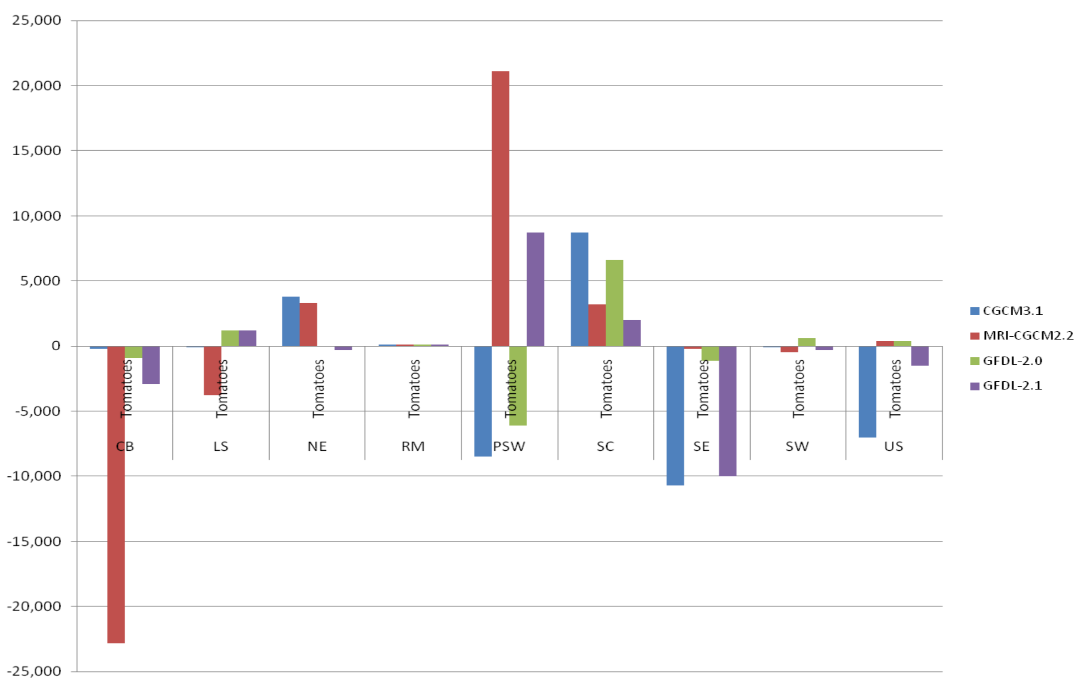
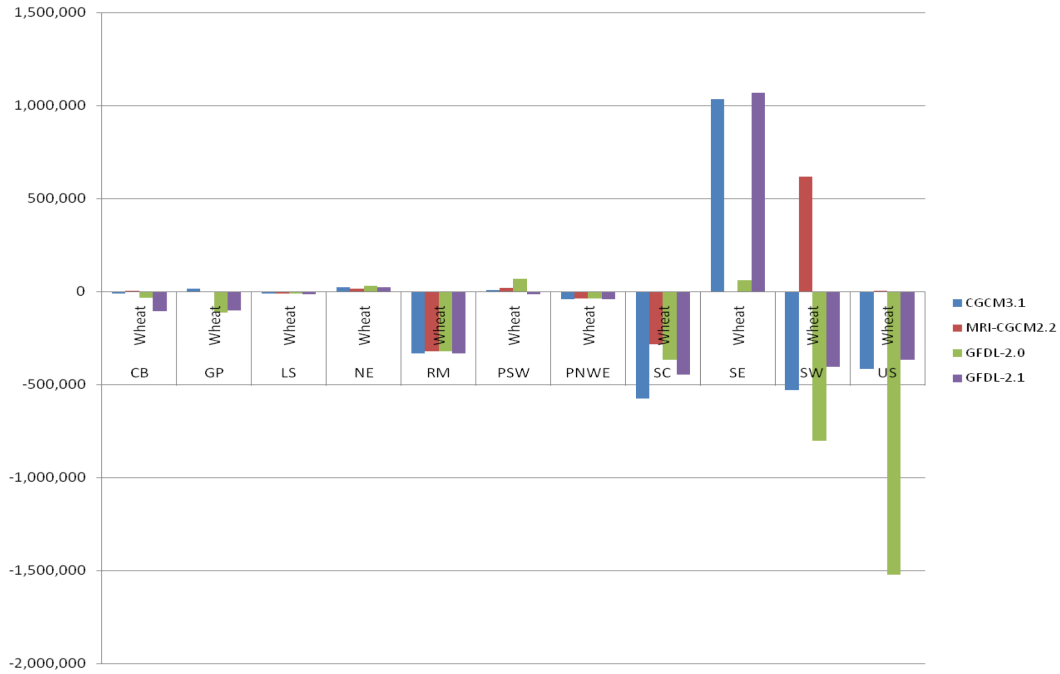


Figure 4-28. Simulated Changes in Regional Acreage Relative to the Baseline, Wheat (Acres)



The combination of yield effects for crop/region/irrigation status combinations associated with each climate scenario (input values included in Appendix B) with the regional shifts in crop acreage and changes in irrigation practices as producers react to changing market conditions lead to the simulated changes in national average crop yields shown in Figure 4-29. In these simulations, average national yields for barley, hay, oats, rye, and hard red winter wheat increase under all four primary climate scenarios examined. Simulated average national yields for cotton, grapefruit, oranges, potatoes, soft white wheat, and durum wheat, on the other hand, decrease under all four primary climate scenarios examined. For the remainder of the crops examined, including corn, rice, silage, sorghum, soybeans, sugarbeets, sugarcane, tomatoes, and hard red spring wheat, the sign of the change in simulated average national yield depends on the climate scenario. Generally, simulated yield effects for these crops were more likely to be positive under the CGCM-3.1 and GFDL-2.0 scenarios and more likely to be negative under the GFDL-2.1 and MRI-CGCM2.2 scenarios.

Given the changes in yields and acreage distribution across crops, there are potentially substantial changes in regional agricultural commodity production. Figures 4-30 through 4-46 summarize simulated changes in regional crop production for each of the primary climate scenarios considered.

Figure 4-29. Simulated Equilibrium Changes in National Average Yield Relative to the Baseline

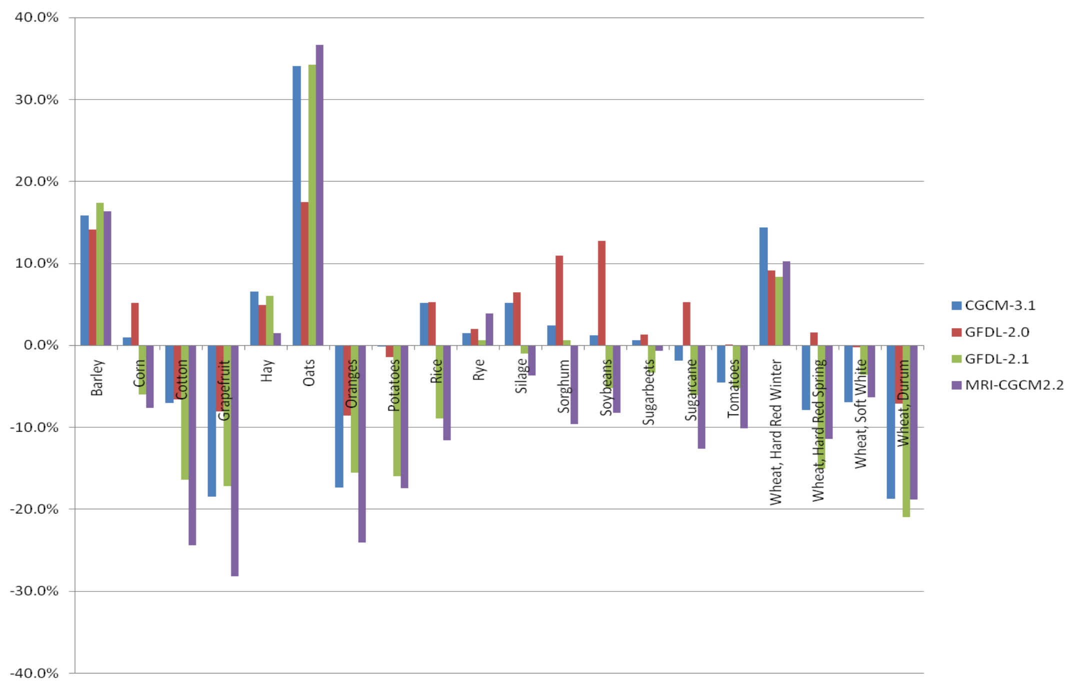


Figure 4-30. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Barley (bushels)

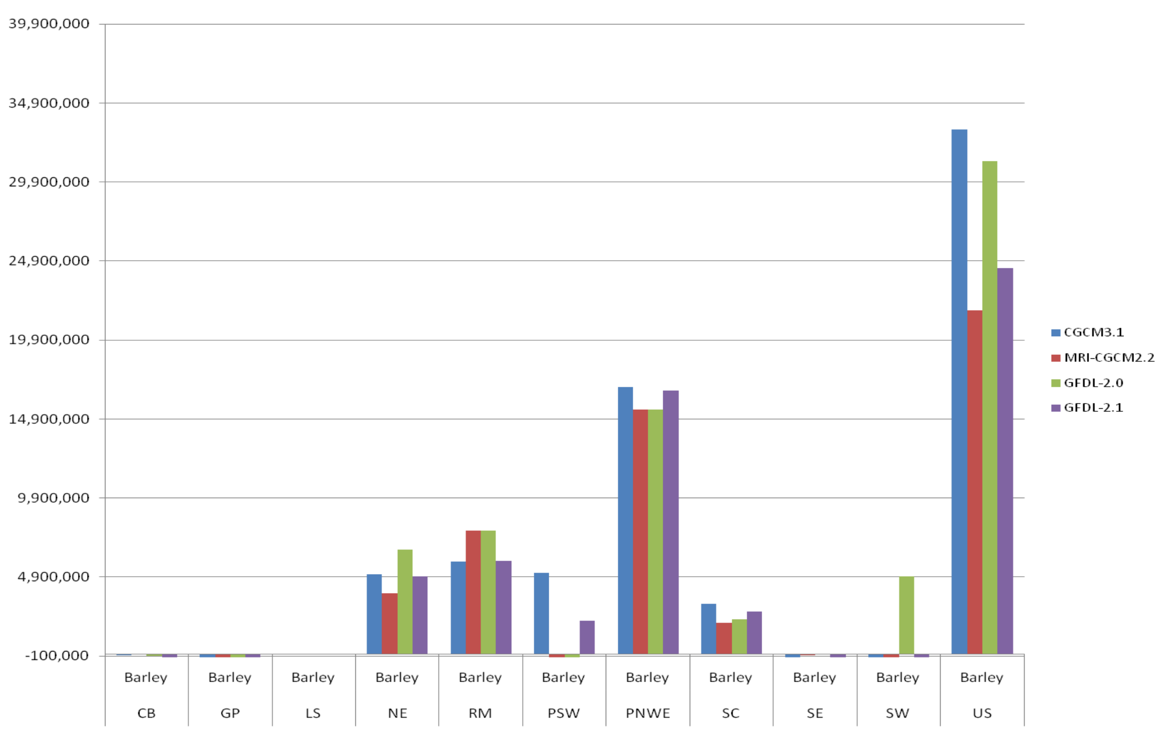


Figure 4-31. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Corn (bushels)

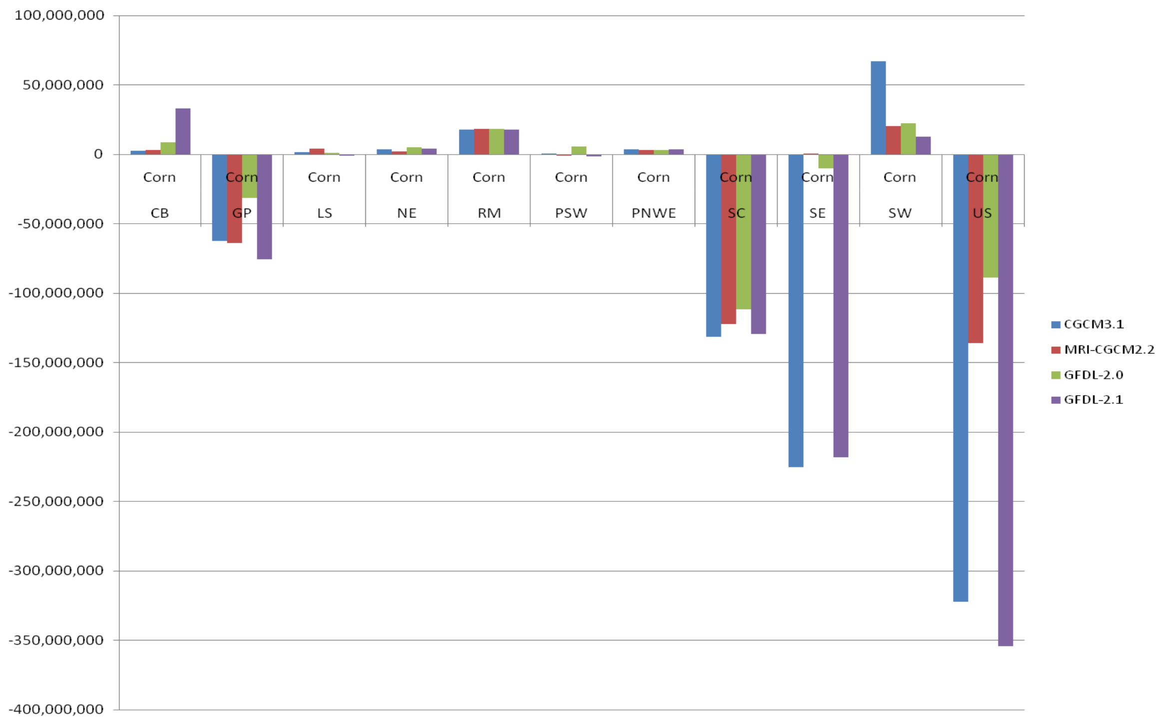


Figure 4-32. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Cotton (480-lb bales)

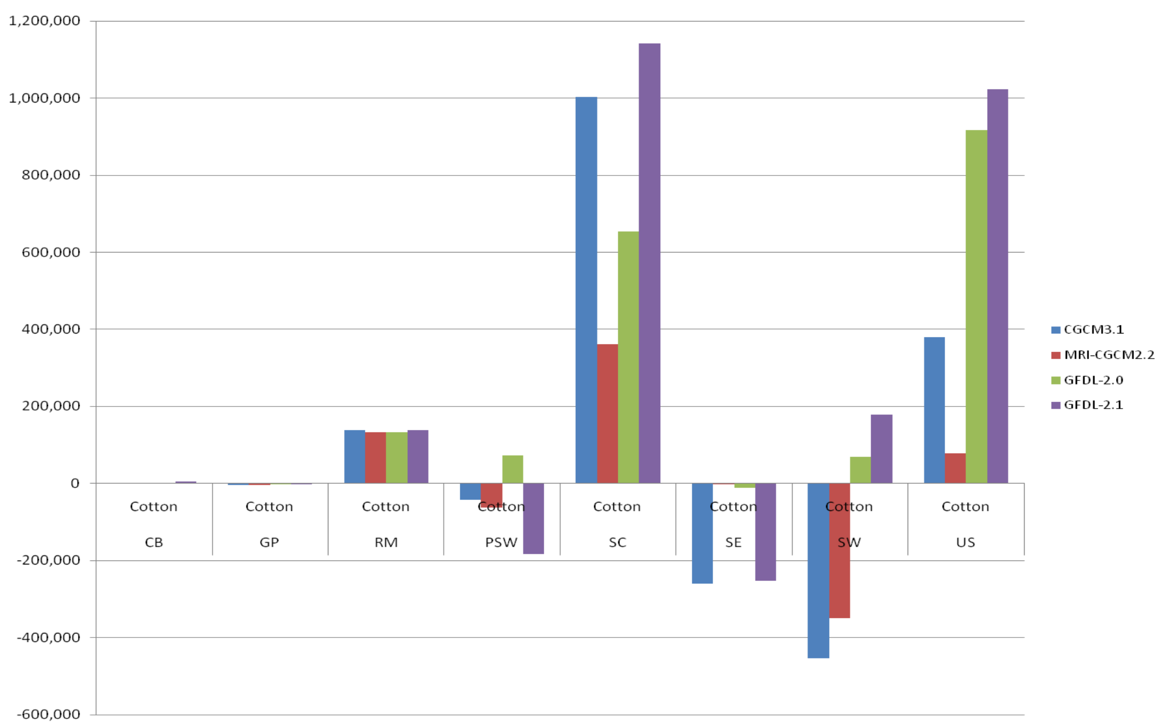


Figure 4-33. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Grapefruit (pounds)

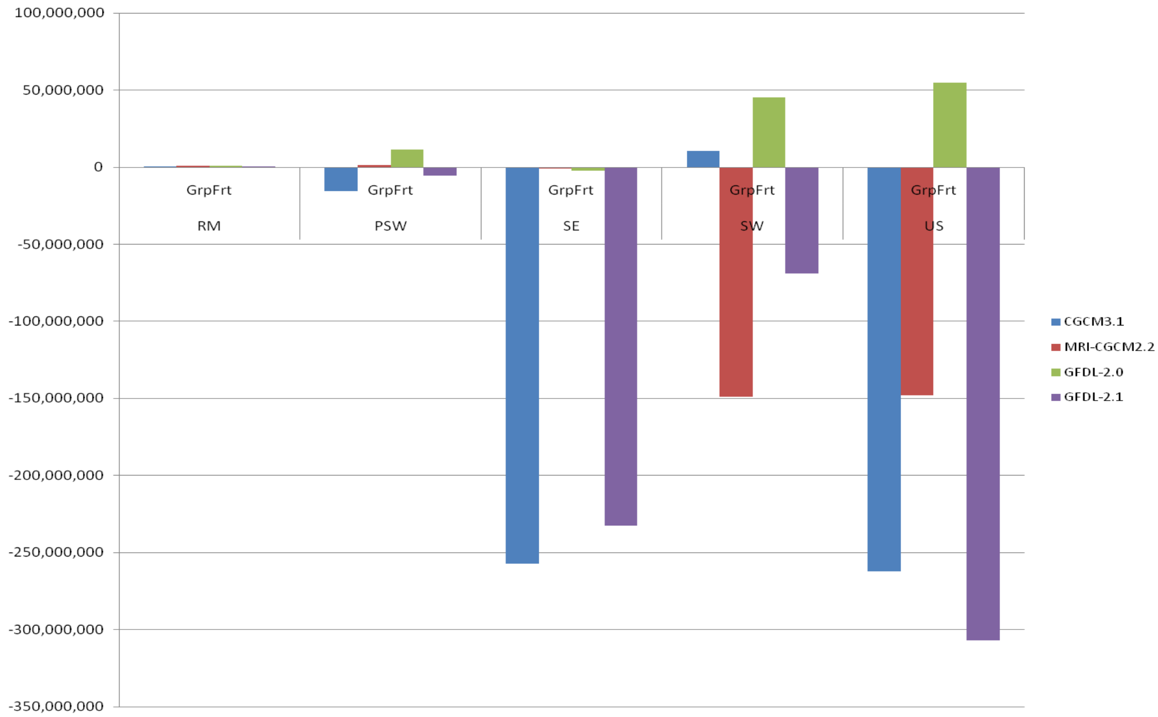


Figure 4-34. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Hay (tons)

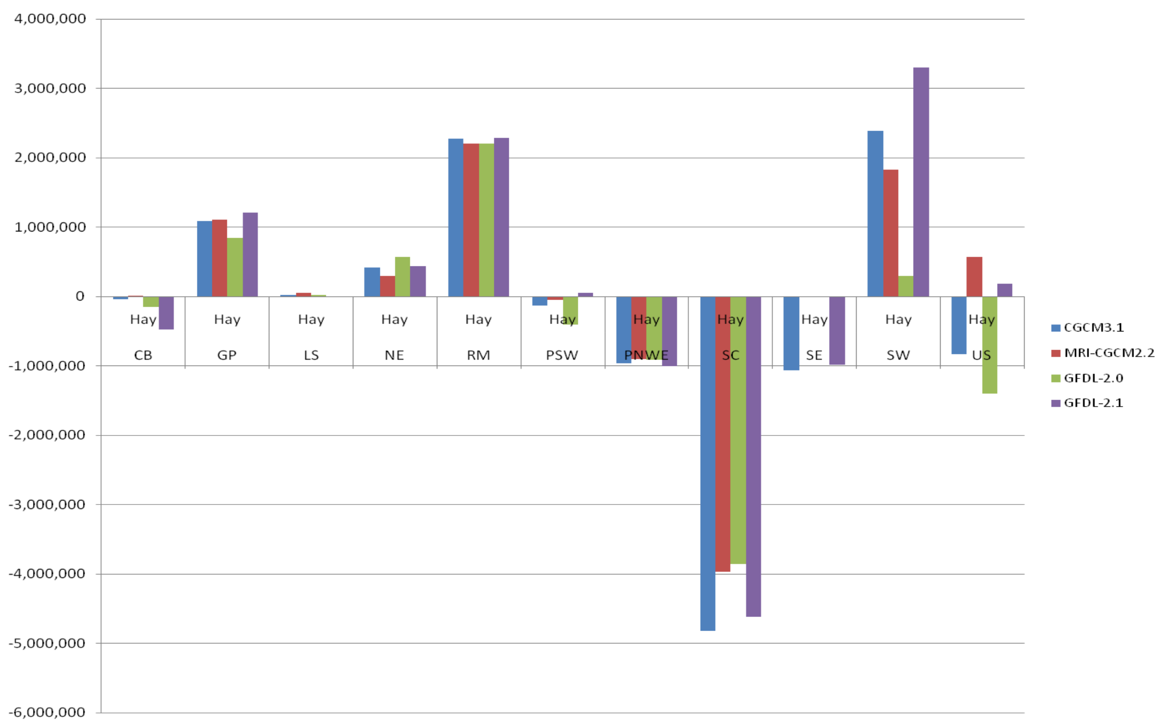


Figure 4-35. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Oats (bushels)

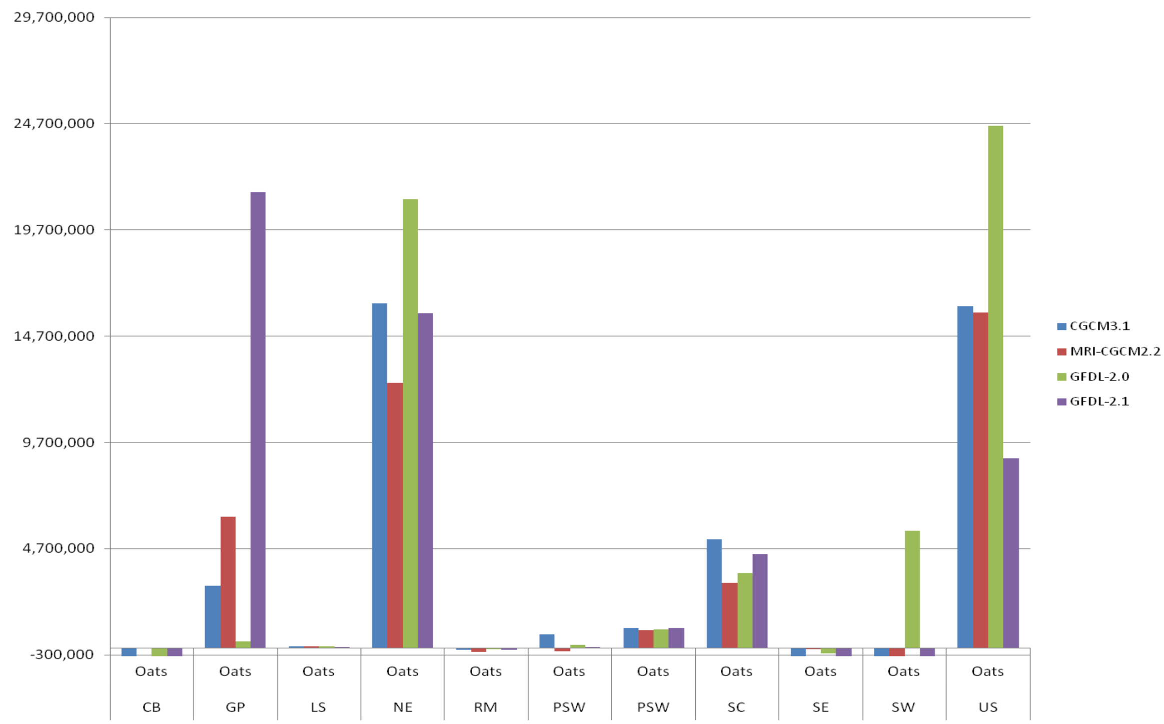


Figure 4-36. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Oranges (pounds)

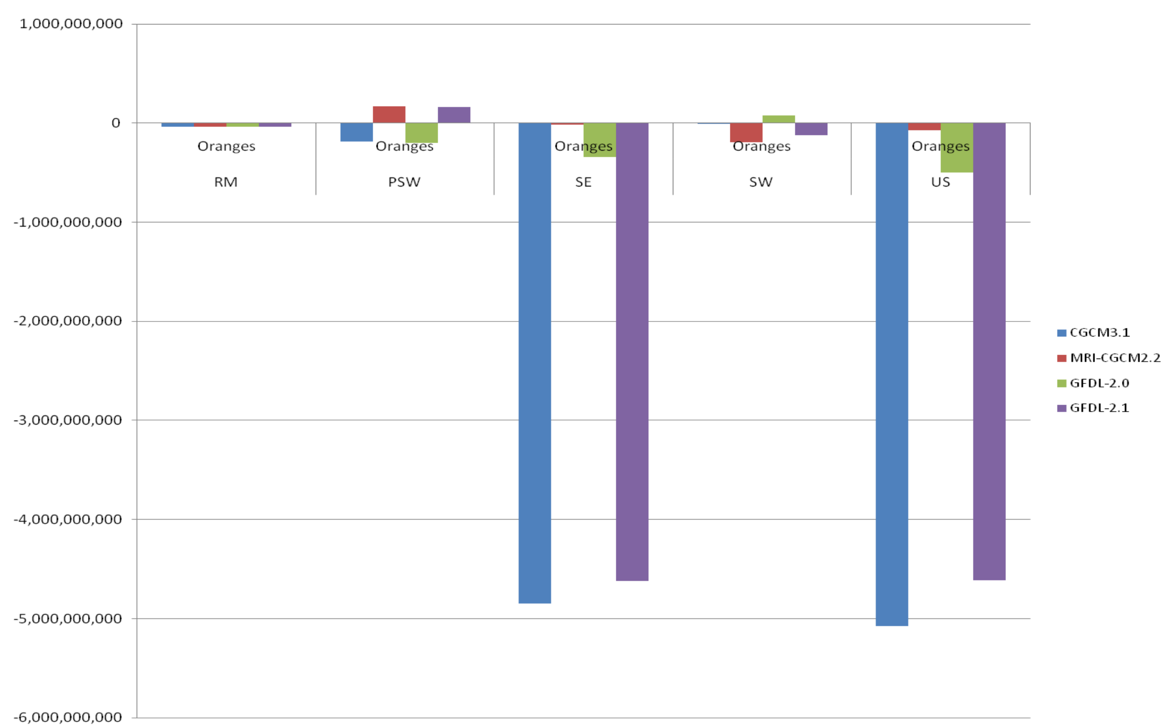


Figure 4-37. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Potatoes (cwt)

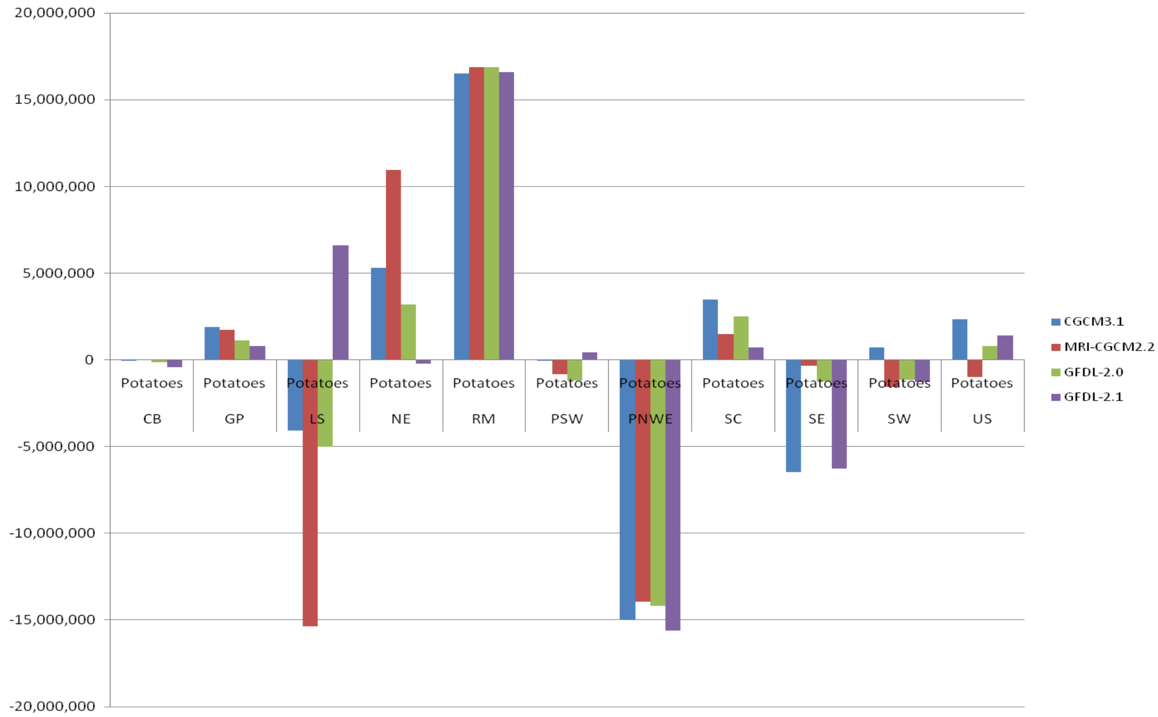


Figure 4-38. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Rice (cwt)

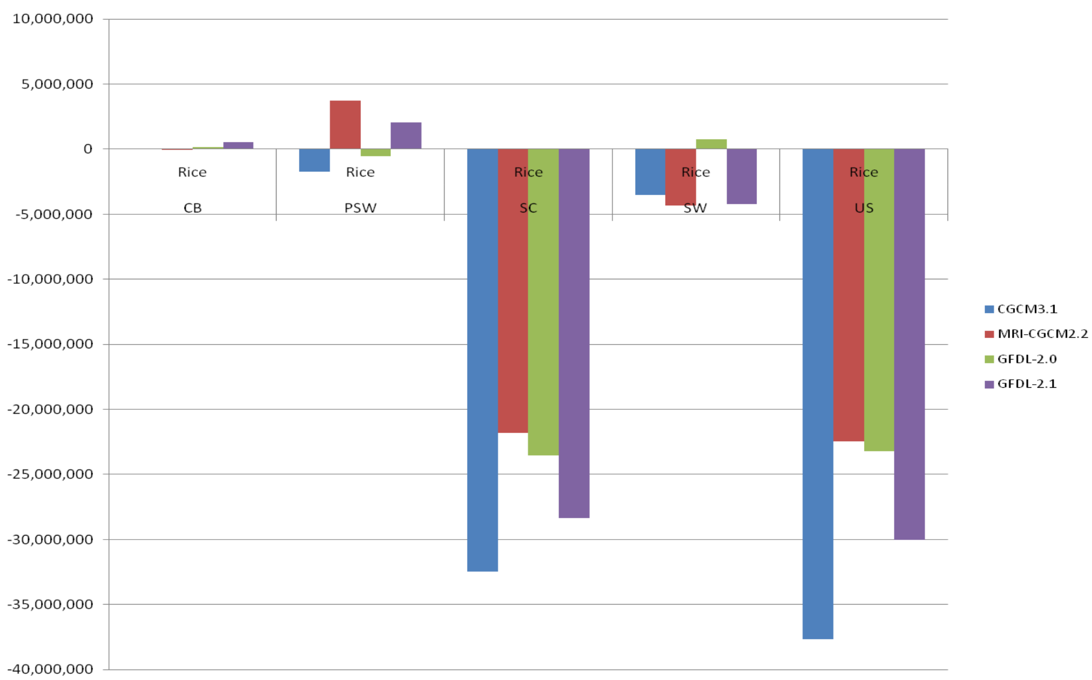


Figure 4-39. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Rye (bushels)

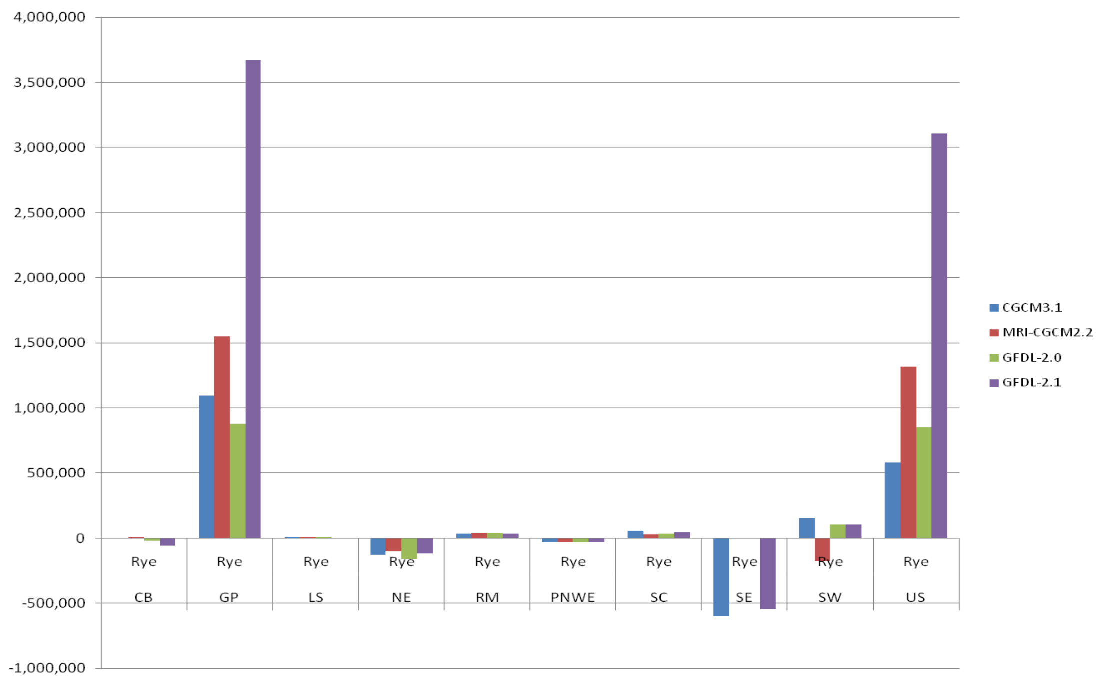


Figure 4-40. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Silage (tons)

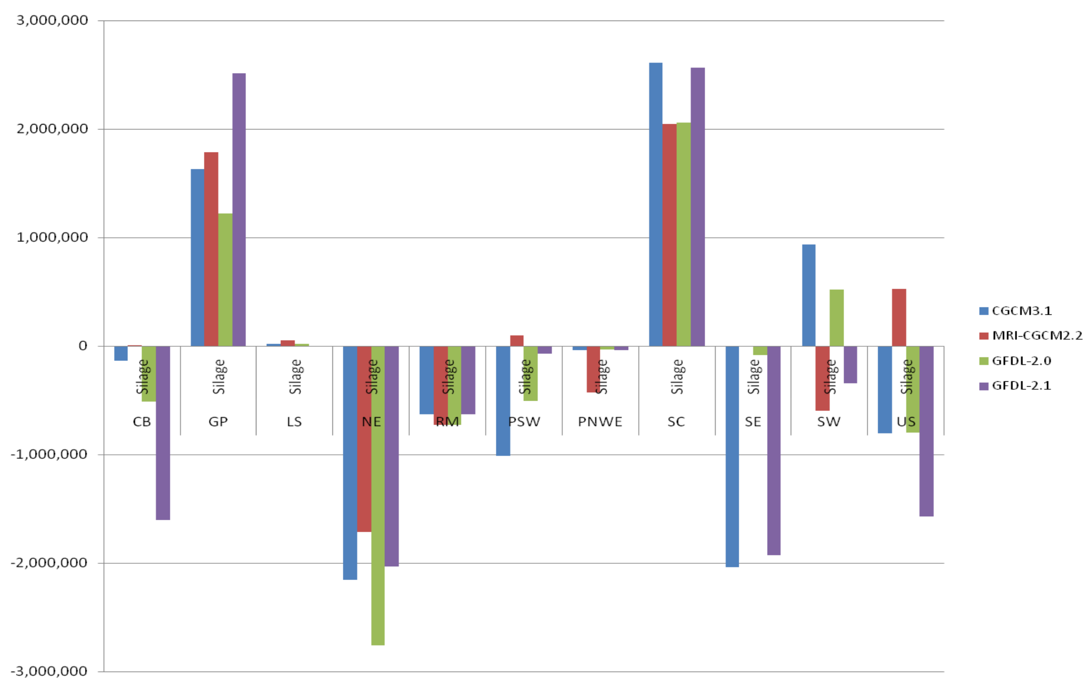


Figure 4-41. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Sorghum (cwt)

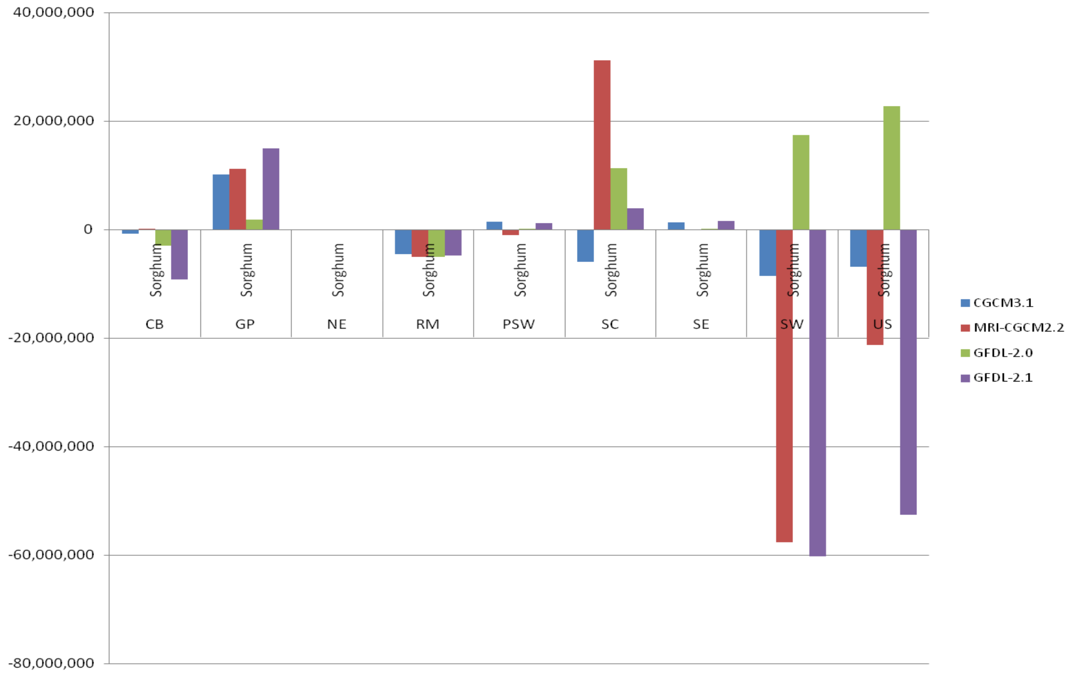


Figure 4-42. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Soybeans (bushels)

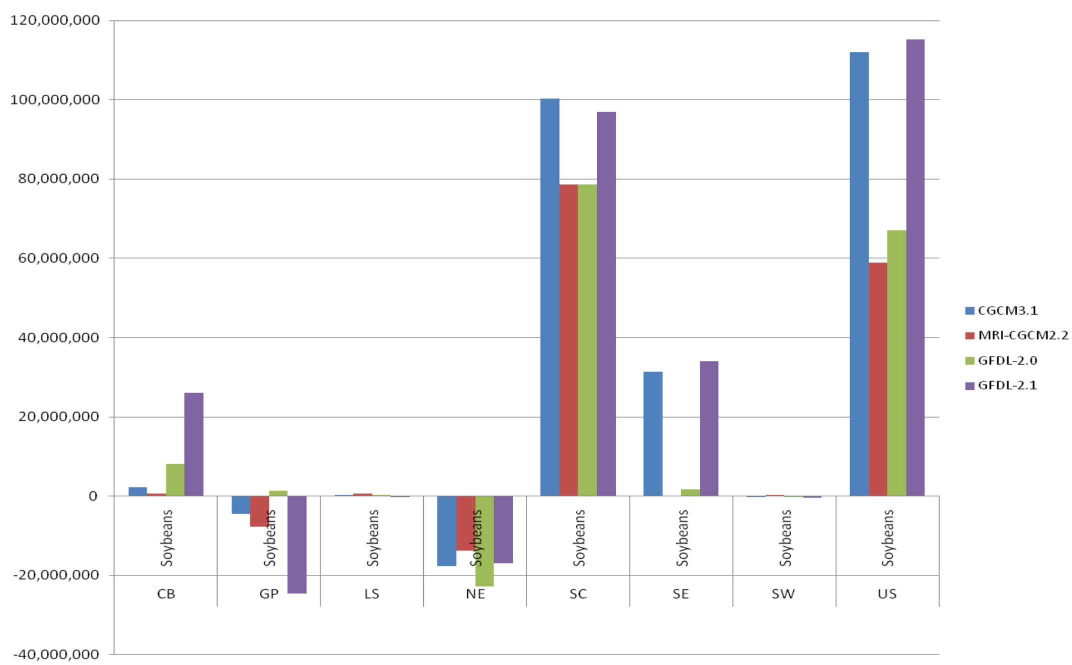


Figure 4-43. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Sugarbeets (tons)

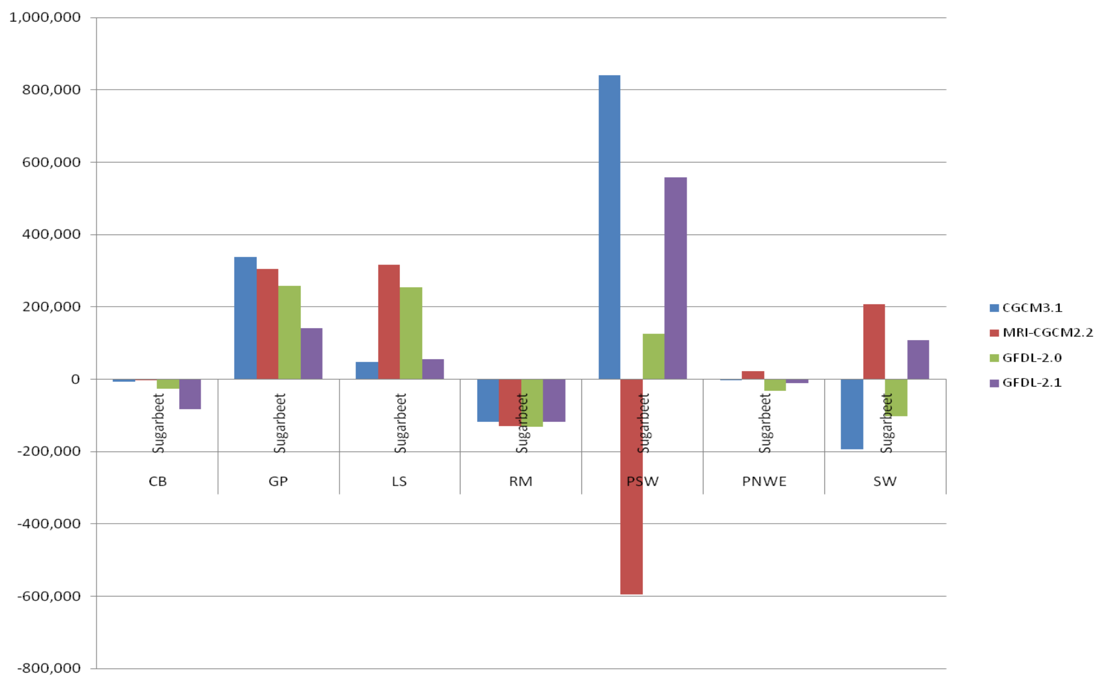


Figure 4-44. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Sugarcane (tons)

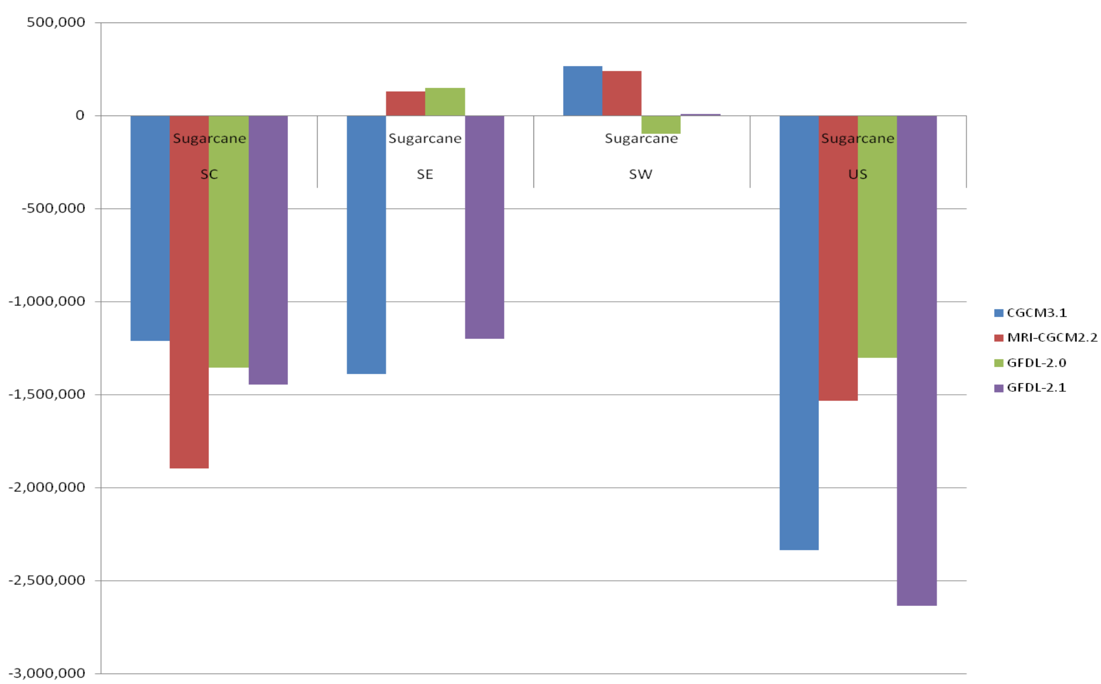


Figure 4-45. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Tomatoes (cwt)

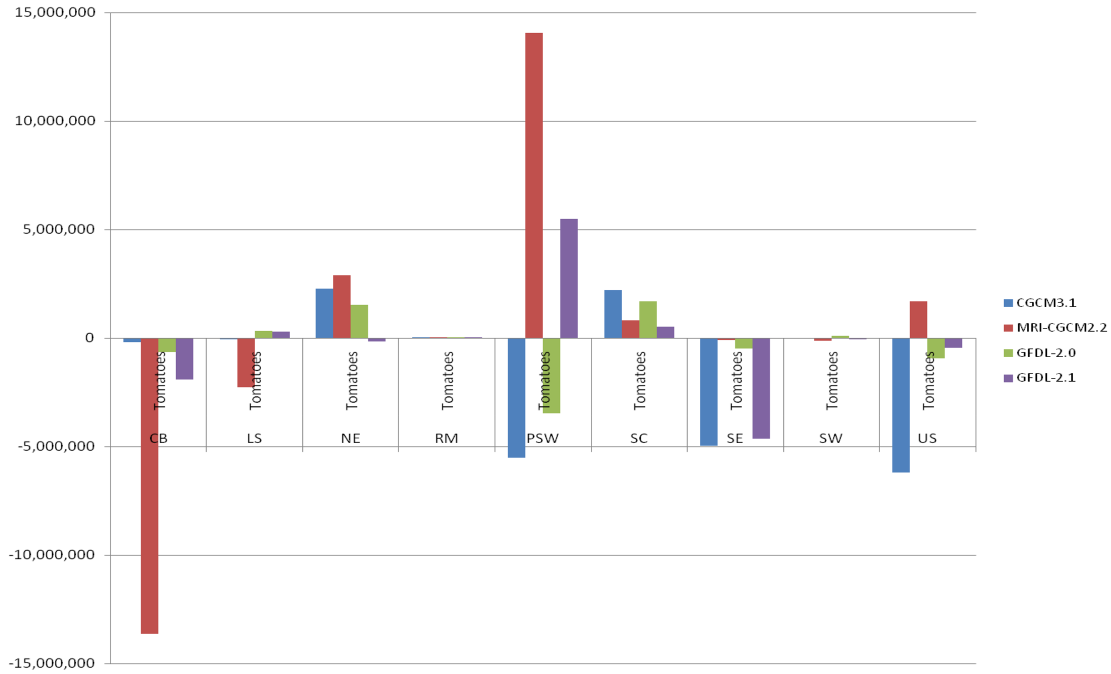
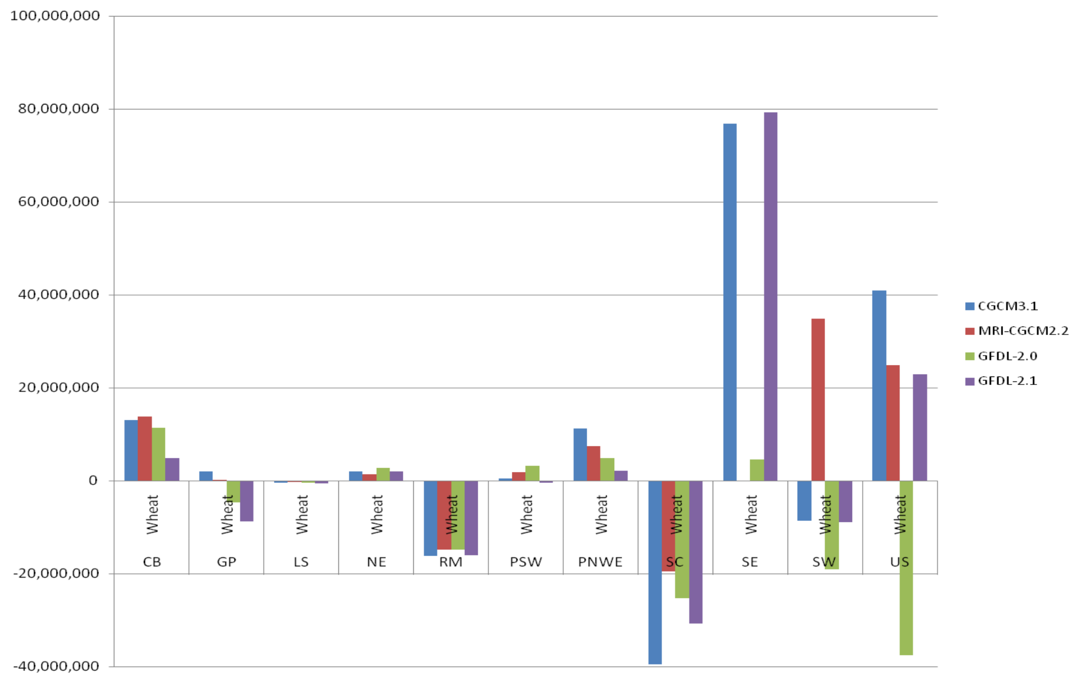


Figure 4-46. Simulated Equilibrium Changes in Regional Commodity Production Relative to the Baseline, Wheat (bushels)



4.3 Financial Impacts

We applied the SRA model to the baseline loss cost ratios generated using the methods described in Section 3. Table 4-3 compares our simulated rates of return by reinsurance fund to the historical returns provided by RMA. Our returns generally match up well, particularly for years closest to the 2006 base year, as expected. Our simulations are based on the 2006 book of business being applied to simulated loss cost ratios that provide an estimate of what loss cost ratios would have been for a given crop/district combination for a given insurance product. The book of business has changed substantially over time, e.g., there has been an enormous growth in the share of liabilities and premiums in revenue insurance. Thus, the more distant the historical year from 2006, the more they are expected to differ because the historical allocation of insurance liabilities and premiums across regions, insurance products, coverage levels, and reinsurance funds would look very different. Our model is simulating what the returns to the 2006 book of business would have been had in been in place in years with yield and price outcomes like the historical years included in the sample.

Tables 4-4 through 4-7 summarize the simulated rates of return and standard deviations of the rates of return by state and reinsurance fund and by organization and reinsurance fund for the baseline. Tables 4-8 through 4-23 summarize results for each of the four climate scenarios simulated.

Table 4-3. Simulated Baseline Returns vs. Actual Historical Returns (Gains as a Percentage of Retained Premiums)

Reinsurance Fund	Avg Return 1998-2007	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Actual Returns											
Other Comm.	15.6	13.5	10.5	10.0	14.4	3.9	12.7	26.6	24.2	11.3	31.0
Other Develop.	1.8	-1.6	0.7	-1.3	-2.8	-7.7	3.3	7.5	9.7	8.7	17.8
CAT Comm.	31.3	29.0	35.0	33.7	35.0	29.4	35.3	25.1	26.4	31.1	33.2
CAT Develop.	18.0	16.6	19.3	20.8	19.8	16.8	19.8	16.7	-0.5	20.0	18.2
Revenue Commercial	26.1	31.1	22.8	22.3	18.6	-10.1	18.0	25.3	38.0	27.7	35.1
Revenue Developmental	11.5	15.9	0.6	9.9	3.4	-13.3	1.7	13.7	19.4	17.2	24.3
Assigned Risk	0.6	-0.9	-2.0	-1.3	-1.7	-3.1	-0.1	0.8	3.4	0.7	4.5
Totals	20.1	17.5	14.8	14.9	14.6	-2.1	14.5	22.0	30.1	22.3	31.5
Simulated Baseline Returns											
Other Comm.	16.5	4.6	13.0	14.2	13.5	8.1	20.5	25.8	25.5	8.9	31.3
Other Develop.	2.9	8.6	-0.9	-2.1	-6.1	-5.7	6.8	0.7	5.3	6.6	15.6
CAT Comm.	31.1	20.1	34.4	32.8	35.4	29.5	35.5	26.9	28.8	32.6	34.6
CAT Develop.	16.4	7.3	20.2	15.9	19.9	19.8	20.6	19.9	-1.1	20.7	20.5
Revenue Commercial	28.3	36.4	29.3	32.3	24.7	-0.7	25.7	29.8	40.7	29.3	35.1

Reinsurance Fund	Avg Return 1998-2007	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Revenue Developmental	11.1	14.9	5.6	12.2	7.6	-5.2	3.2	9.6	21.0	17.8	24.5
Assigned Risk	1.0	-0.6	2.1	-1.3	-0.2	-0.3	0.7	0.4	4.1	1.1	3.9
Totals	23.2	25.8	23.0	25.2	20.2	2.3	22.1	25.4	33.2	23.1	31.6
Difference between Simulated and Actual											
Other Comm.	0.9	-8.9	2.5	4.2	-0.9	4.2	7.8	-0.8	1.3	-2.4	0.2
Other Develop.	1.1	10.2	-1.6	-0.8	-3.3	2.0	3.5	-6.8	-4.4	-2.2	-2.1
CAT Comm.	-0.2	-8.9	-0.7	-0.9	0.4	0.2	0.2	1.8	2.4	1.5	1.4
CAT Develop.	-1.6	-9.4	0.9	-4.8	0.2	3.0	0.8	3.3	-0.5	0.8	2.3
Revenue Commercial	2.2	5.4	6.5	10.0	6.1	9.3	7.7	4.5	2.7	1.6	0.0
Revenue Developmental	-0.4	-1.1	5.0	2.3	4.2	8.1	1.5	-4.1	1.7	0.6	0.1
Assigned Risk	0.4	0.3	4.1	0.0	1.5	2.8	0.8	-0.4	0.7	0.3	-0.6
Totals	3.1	8.2	8.2	10.3	5.6	4.3	7.6	3.4	3.1	0.8	0.1

Table 4-4. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, Baseline

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	33.14%	9.71%	14.27%	8.77%	-1.31%	12.94%	0.98%	12.31%
AZ	4.96	36.64%	24.91%	13.62%	19.32%	-4.55%	-5.25%	-0.28%	20.21%
AR	38.49	36.22%	11.93%	11.32%	20.42%	1.94%	-6.46%	1.64%	21.32%
CA	170.88	35.68%	24.14%	32.02%	19.41%	0.29%	18.40%	2.82%	26.49%
CO	52.38	30.91%	8.71%	8.33%	18.68%	-11.22%	-0.59%	-0.66%	7.06%
CT	1.58	33.86%	0.70%	24.32%	N/A	-4.71%	N/A	-1.99%	8.80%
DE	5.37	35.56%	27.53%	36.30%	N/A	7.38%	17.07%	3.51%	34.64%
FL	84.61	29.98%	-21.62%	32.25%	19.30%	-20.69%	0.47%	-4.95%	-3.26%
GA	50.00	34.90%	6.27%	11.61%	19.05%	-1.73%	6.94%	0.17%	9.48%
ID	33.77	37.12%	32.26%	19.19%	18.21%	18.27%	13.09%	0.93%	28.56%
IL	351.96	36.22%	39.97%	36.60%	22.03%	13.54%	15.61%	3.24%	32.13%
IN	164.81	36.59%	39.50%	33.45%	20.75%	17.84%	19.86%	4.42%	30.42%
IA	349.08	36.59%	33.73%	35.75%	13.18%	9.19%	21.10%	4.07%	34.70%
KS	197.82	23.24%	15.22%	18.05%	13.82%	16.70%	12.40%	2.75%	15.92%
KY	31.87	34.34%	15.14%	31.58%	19.96%	-7.36%	4.83%	0.44%	26.13%
LA	26.39	34.48%	16.59%	16.76%	15.27%	2.75%	-6.36%	1.64%	19.61%
ME	3.08	37.38%	19.92%	N/A	N/A	16.02%	N/A	2.84%	23.32%
MD	15.75	31.84%	20.67%	33.12%	N/A	9.60%	19.90%	5.02%	30.63%
MA	1.32	22.98%	-13.50%	15.42%	21.47%	-3.98%	N/A	-2.07%	-0.47%
MI	54.71	35.94%	29.88%	22.87%	19.95%	3.09%	6.37%	3.31%	20.30%
MN	296.66	33.71%	31.87%	34.35%	20.21%	-2.11%	13.02%	1.83%	32.74%
MS	30.72	36.74%	12.97%	10.48%	20.82%	-1.40%	-7.78%	1.58%	14.37%
MO	115.85	36.07%	33.64%	30.01%	12.99%	10.09%	15.17%	3.96%	29.79%
MT	65.15	20.85%	24.35%	20.21%	15.87%	16.42%	12.86%	2.96%	19.84%
NE	262.10	32.58%	32.27%	30.77%	20.44%	6.93%	15.08%	3.36%	29.41%
NV	0.45	33.73%	37.55%	N/A	N/A	2.18%	N/A	-3.38%	27.56%
NH	0.29	17.47%	0.66%	N/A	N/A	9.26%	N/A	-2.14%	2.93%
NJ	2.73	28.34%	-6.16%	42.18%	20.71%	-35.84%	13.41%	0.53%	25.26%

(continued)

Table 4-4. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, Baseline (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	35.89%	23.94%	28.74%	11.11%	1.18%	11.50%	1.98%	25.08%
NY	11.02	30.28%	13.47%	31.01%	N/A	5.37%	22.31%	-1.15%	17.74%
NC	57.85	33.25%	8.02%	24.19%	21.56%	-7.78%	-4.67%	-1.64%	16.29%
ND	252.89	29.16%	28.59%	18.64%	18.25%	5.16%	6.80%	1.92%	16.28%
OH	112.00	30.84%	31.15%	31.81%	20.76%	15.79%	14.92%	4.12%	28.27%
OK	43.37	21.78%	10.85%	10.72%	11.70%	4.18%	-1.54%	0.49%	9.99%
OR	10.23	37.30%	20.90%	-8.10%	19.98%	-14.37%	-1.19%	0.19%	22.57%
PA	24.01	29.70%	9.91%	28.37%	21.33%	2.85%	17.11%	3.10%	21.05%
RI	0.06	32.98%	46.84%	N/A	N/A	23.70%	N/A	N/A	41.55%
SC	19.35	19.44%	-8.63%	21.64%	3.99%	8.63%	18.31%	-2.16%	7.02%
SD	222.61	23.16%	23.90%	14.03%	7.63%	7.58%	6.46%	-0.25%	13.74%
TN	25.93	29.05%	-4.54%	20.09%	-0.45%	1.24%	4.17%	-1.17%	15.45%
TX	180.75	32.42%	-2.33%	20.77%	17.07%	1.79%	4.94%	1.34%	12.31%
UT	1.00	34.49%	25.96%	31.43%	9.03%	-12.85%	23.04%	1.36%	20.63%
VT	0.81	27.45%	20.30%	9.50%	N/A	-12.08%	N/A	-2.34%	20.79%
VA	21.64	34.94%	5.94%	17.23%	16.68%	4.36%	-3.20%	-1.36%	14.25%
WA	38.67	36.90%	28.17%	15.67%	17.04%	7.46%	3.93%	1.13%	26.10%
WV	1.26	34.79%	19.82%	40.98%	N/A	13.03%	N/A	-1.11%	30.56%
WI	72.54	34.04%	23.72%	21.39%	21.22%	9.20%	6.97%	1.74%	19.24%
WY	6.04	26.98%	28.11%	23.14%	-4.17%	0.45%	8.92%	3.10%	21.03%
All States	**3,541.95**	**33.98%**	**19.02%**	**27.74%**	**18.79%**	**0.64%**	**11.48%**	**1.72%**	**23.49%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-5. Standard Deviation of Expected Net Gains by State and Fund, Baseline

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	7.63%	25.93%	27.03%	13.03%	12.97%	14.34%	2.97%	21.94%
AZ	4.96	0.46%	11.65%	27.72%	1.71%	14.83%	20.12%	2.59%	8.72%
AR	38.49	1.73%	34.67%	31.09%	4.15%	18.34%	18.16%	3.50%	16.33%
CA	170.88	4.93%	15.09%	26.89%	5.66%	10.13%	16.56%	1.32%	10.63%
CO	52.38	11.00%	22.33%	30.42%	10.12%	8.80%	16.94%	2.48%	23.41%
CT	1.58	14.13%	24.84%	33.26%	N/A	15.03%	N/A	1.57%	10.79%
DE	5.37	4.87%	22.59%	26.24%	N/A	18.64%	17.51%	4.43%	24.19%
FL	84.61	20.40%	29.00%	20.65%	5.19%	16.22%	16.58%	1.63%	18.21%
GA	50.00	6.99%	23.65%	28.18%	6.74%	11.63%	14.92%	2.71%	18.89%
ID	33.77	0.44%	16.49%	20.58%	8.77%	8.90%	13.58%	2.52%	13.51%
IL	351.96	1.77%	15.80%	21.88%	0.18%	14.70%	21.50%	5.23%	19.99%
IN	164.81	1.64%	14.08%	21.43%	2.66%	13.45%	15.83%	3.70%	19.03%
IA	349.08	2.11%	25.36%	22.05%	20.37%	17.00%	11.06%	4.03%	21.31%
KS	197.82	24.86%	29.19%	27.47%	10.19%	15.54%	16.24%	3.71%	24.11%
KY	31.87	7.09%	24.97%	21.66%	6.54%	13.09%	18.24%	1.98%	19.92%
LA	26.39	4.94%	26.67%	28.37%	8.42%	19.84%	18.72%	3.08%	19.74%
ME	3.08	0.39%	32.55%	N/A	N/A	17.46%	N/A	4.08%	19.05%
MD	15.75	14.29%	28.04%	22.75%	N/A	15.94%	13.33%	2.01%	22.29%
MA	1.32	20.44%	17.99%	33.40%	0.92%	13.04%	N/A	1.51%	13.00%
MI	54.71	1.46%	16.95%	23.30%	1.40%	10.13%	26.05%	4.07%	15.92%
MN	296.66	7.58%	18.38%	24.28%	5.82%	11.92%	15.74%	1.97%	22.24%
MS	30.72	0.66%	28.37%	30.40%	5.07%	16.05%	18.81%	3.30%	15.57%
MO	115.85	1.38%	15.48%	18.62%	12.97%	14.12%	15.18%	2.70%	15.83%
MT	65.15	28.60%	26.32%	33.15%	9.26%	16.51%	22.12%	3.89%	26.90%
NE	262.10	10.09%	19.48%	21.44%	2.78%	12.65%	15.70%	2.45%	20.35%
NV	0.45	13.65%	18.22%	N/A	N/A	26.21%	N/A	3.48%	14.59%
NH	0.29	22.70%	26.95%	N/A	N/A	22.50%	N/A	1.74%	25.37%
NJ	2.73	15.59%	28.04%	12.96%	4.61%	33.08%	23.21%	3.28%	13.92%

(continued)

Table 4-5. Standard Deviation of Expected Net Gains by State and Fund, Baseline (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	2.31%	19.03%	17.58%	9.84%	12.80%	16.02%	2.95%	11.17%
NY	11.02	15.92%	22.24%	27.27%	N/A	8.48%	22.37%	1.72%	17.23%
NC	57.85	6.54%	22.33%	21.34%	0.37%	9.06%	17.12%	1.63%	18.27%
ND	252.89	14.04%	18.14%	23.82%	6.75%	12.23%	16.39%	2.97%	17.65%
OH	112.00	10.48%	22.49%	22.37%	3.85%	17.53%	18.95%	3.33%	20.76%
OK	43.37	11.20%	24.13%	29.42%	12.06%	13.84%	18.46%	3.06%	24.73%
OR	10.23	0.71%	27.19%	43.91%	7.50%	17.54%	24.06%	4.72%	9.70%
PA	24.01	17.70%	21.88%	31.41%	1.25%	13.35%	15.71%	3.12%	25.06%
RI	0.06	12.68%	3.37%	N/A	N/A	19.09%	N/A	N/A	6.70%
SC	19.35	20.36%	23.38%	34.90%	15.40%	9.81%	16.77%	2.03%	23.81%
SD	222.61	24.58%	26.48%	33.84%	19.12%	17.21%	19.48%	3.27%	30.39%
TN	25.93	10.91%	25.48%	27.45%	10.67%	16.87%	18.71%	2.01%	20.34%
TX	180.75	11.51%	23.60%	23.13%	6.13%	14.80%	18.12%	3.15%	17.22%
UT	1.00	5.51%	32.21%	29.48%	23.59%	24.65%	15.12%	1.94%	16.73%
VT	0.81	18.44%	28.28%	34.99%	N/A	21.76%	N/A	4.63%	25.39%
VA	21.64	1.48%	21.79%	33.48%	7.16%	10.43%	20.73%	2.30%	26.37%
WA	38.67	0.49%	20.55%	33.89%	11.08%	14.72%	24.18%	2.46%	14.19%
WV	1.26	7.16%	18.49%	11.98%	N/A	10.00%	N/A	2.44%	11.97%
WI	72.54	6.28%	28.81%	32.25%	2.27%	17.95%	20.45%	4.00%	26.76%
WY	6.04	23.66%	21.14%	26.53%	26.81%	12.62%	16.58%	3.44%	16.86%
All States	**3,541.95**	**3.30%**	**9.51%**	**14.52%**	**4.17%**	**6.24%**	**10.64%**	**1.84%**	**11.17%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. “N/A” denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-6. Expected Net Gain as a Percentage of Retained Premiums by Organization and Fund, Baseline

Organization	Retained Premiums (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	35.47%	12.78%	29.91%	N/A	N/A	N/A	2.81%	24.64%
2	4.03	35.17%	16.72%	27.87%	18.57%	10.84%	7.86%	-0.47%	19.88%
3	52.13	37.24%	35.49%	38.14%	20.97%	13.75%	15.50%	3.37%	30.78%
4	980.87	33.03%	14.76%	26.78%	N/A	3.14%	N/A	1.17%	23.36%
5	39.91	35.96%	25.61%	25.82%	19.55%	2.42%	11.49%	0.98%	19.04%
6	117.97	35.19%	33.06%	31.88%	12.73%	6.63%	12.96%	3.13%	29.07%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	35.07%	23.75%	29.14%	9.74%	-1.72%	14.52%	1.88%	24.64%
9	119.67	34.44%	23.77%	25.30%	12.83%	8.37%	12.67%	1.57%	23.07%
10	454.84	34.85%	20.91%	31.46%	21.83%	4.91%	9.61%	1.82%	23.30%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	31.89%	22.55%	27.43%	12.19%	14.83%	18.63%	2.61%	22.68%
13	102.89	33.82%	12.74%	25.07%	16.23%	-1.99%	7.23%	1.83%	17.18%
14	828.01	34.20%	21.92%	25.73%	19.40%	-10.95%	9.68%	1.41%	23.96%
15	86.95	35.20%	26.57%	26.51%	20.78%	9.75%	14.21%	2.86%	24.97%
16	91.85	36.07%	31.36%	29.45%	N/A	-9.05%	22.47%	2.24%	28.69%
17	147.52	32.82%	5.49%	27.83%	-30.26%	-0.54%	8.26%	1.53%	14.49%
All Organizations	**3,541.95**	**33.98%**	**19.02%**	**27.74%**	**18.79%**	**0.64%**	**11.48%**	**1.72%**	**23.49%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. “N/A” denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-7. Standard Deviation of the Expected Net Gains by Organization and Fund, Baseline

Organization	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	2.39%	17.97%	15.13%	N/A	N/A	N/A	2.02%	12.16%
2	4.03	4.07%	18.16%	20.42%	7.45%	10.09%	15.40%	2.62%	13.94%
3	52.13	0.61%	15.50%	19.86%	2.77%	12.97%	23.27%	5.19%	17.88%
4	980.87	4.37%	9.44%	13.53%	N/A	10.29%	N/A	1.89%	10.73%
5	39.91	1.52%	13.44%	14.91%	2.00%	9.11%	11.27%	1.93%	10.45%
6	117.97	2.95%	16.38%	17.52%	11.75%	10.85%	12.62%	2.49%	15.85%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	2.97%	9.60%	15.54%	5.04%	7.12%	20.75%	2.15%	11.98%
9	119.67	3.45%	11.24%	15.79%	6.68%	6.69%	10.42%	1.94%	12.83%
10	454.84	3.23%	11.40%	16.61%	0.44%	7.81%	11.51%	2.03%	12.01%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	9.14%	18.69%	20.52%	9.84%	13.00%	9.74%	2.49%	14.60%
13	102.89	6.13%	11.23%	15.70%	4.39%	9.83%	10.78%	2.23%	10.95%
14	828.01	3.22%	10.37%	15.66%	4.92%	8.51%	9.94%	1.60%	12.10%
15	86.95	2.29%	10.44%	15.81%	1.48%	13.35%	10.98%	1.94%	12.94%
16	91.85	1.98%	10.52%	15.64%	N/A	8.31%	9.32%	2.91%	12.55%
17	147.52	4.91%	12.53%	12.05%	22.52%	7.34%	10.48%	2.00%	7.44%
All Organizations	**3,541.95**	**3.30%**	**9.51%**	**14.52%**	**4.17%**	**6.24%**	**10.64%**	**1.84%**	**11.17%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-8. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, GFDL-CM2.0

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	35.01%	6.74%	-3.82%	20.65%	-2.80%	0.82%	-1.43%	1.43%
AZ	4.96	37.30%	21.25%	2.80%	21.79%	-11.59%	-12.83%	-1.28%	16.64%
AR	38.49	31.66%	-33.31%	-28.36%	19.11%	-28.07%	-30.03%	-1.11%	-1.70%
CA	170.88	37.00%	31.58%	22.69%	21.63%	6.40%	17.50%	3.59%	31.76%
CO	52.38	30.53%	9.80%	-0.53%	18.76%	-5.47%	-2.03%	-0.87%	1.86%
CT	1.58	36.13%	13.03%	26.13%	N/A	-1.35%	N/A	-1.17%	14.46%
DE	5.37	34.67%	18.54%	27.25%	N/A	3.42%	7.25%	2.47%	25.84%
FL	84.61	34.14%	-2.73%	32.44%	20.97%	-10.96%	0.00%	-2.82%	8.03%
GA	50.00	35.99%	2.79%	7.98%	19.50%	-4.66%	5.70%	-0.21%	6.82%
ID	33.77	37.06%	28.73%	4.80%	15.01%	17.34%	11.00%	0.09%	23.73%
IL	351.96	36.99%	29.86%	27.81%	21.60%	3.85%	13.98%	3.04%	24.81%
IN	164.81	35.88%	36.00%	25.23%	20.75%	13.23%	17.28%	3.60%	23.64%
IA	349.08	35.97%	29.86%	31.93%	14.37%	0.49%	10.79%	3.51%	30.62%
KS	197.82	21.03%	8.84%	15.02%	13.35%	7.19%	8.94%	2.05%	12.68%
KY	31.87	33.37%	7.23%	26.15%	18.85%	-12.67%	0.33%	-0.41%	20.68%
LA	26.39	31.12%	-9.60%	-25.01%	18.26%	-13.30%	-17.75%	-1.73%	-4.00%
ME	3.08	37.43%	20.98%	N/A	N/A	16.77%	N/A	3.09%	23.98%
MD	15.75	36.13%	18.91%	22.73%	N/A	6.17%	9.63%	3.40%	22.33%
MA	1.32	33.17%	3.90%	17.68%	21.95%	5.96%	N/A	-1.24%	12.08%
MI	54.71	36.97%	38.33%	29.50%	21.92%	15.04%	8.50%	3.92%	25.70%
MN	296.66	34.14%	33.26%	26.06%	18.54%	4.40%	-0.25%	0.42%	25.98%
MS	30.72	35.24%	-19.93%	-27.67%	19.67%	-28.80%	-30.03%	-1.11%	-6.94%
MO	115.85	35.37%	22.22%	20.32%	5.39%	2.90%	10.74%	2.43%	21.17%
MT	65.15	21.54%	19.19%	25.10%	17.01%	5.75%	14.49%	2.77%	20.51%
NE	262.10	32.29%	29.71%	27.78%	20.33%	5.00%	12.48%	3.10%	26.57%
NV	0.45	33.65%	37.46%	N/A	N/A	0.46%	N/A	-3.82%	27.18%
NH	0.29	31.32%	19.80%	N/A	N/A	11.55%	N/A	-0.37%	21.23%
NJ	2.73	34.23%	-3.62%	39.52%	21.81%	-38.06%	13.41%	-1.15%	27.98%

(continued)

Table 4-8. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, GFDL-CM2.0 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	35.63%	23.97%	26.74%	15.00%	22.00%	15.92%	4.06%	25.23%
NY	11.02	28.37%	11.81%	12.70%	N/A	5.88%	20.92%	-0.66%	14.56%
NC	57.85	34.73%	3.56%	12.06%	21.36%	-8.87%	-13.24%	-2.19%	8.80%
ND	252.89	29.39%	25.39%	5.83%	18.01%	2.44%	-1.42%	0.83%	7.97%
OH	112.00	37.29%	33.07%	30.58%	21.21%	15.96%	15.74%	4.31%	27.72%
OK	43.37	33.40%	15.32%	10.80%	10.62%	4.82%	-3.50%	0.96%	11.34%
OR	10.23	35.98%	28.70%	5.86%	11.98%	-16.32%	7.46%	2.56%	25.04%
PA	24.01	32.61%	22.38%	25.32%	21.41%	11.39%	15.10%	3.29%	22.93%
RI	0.06	35.87%	47.54%	N/A	N/A	23.70%	N/A	N/A	43.04%
SC	19.35	28.30%	9.28%	10.67%	15.69%	9.97%	10.57%	-1.69%	11.35%
SD	222.61	24.72%	25.90%	24.32%	7.96%	11.80%	14.27%	0.77%	22.69%
TN	25.93	33.19%	-17.07%	2.44%	20.20%	-7.23%	-9.37%	-1.03%	5.00%
TX	180.75	35.57%	5.89%	24.65%	18.45%	4.25%	9.46%	1.94%	16.46%
UT	1.00	31.58%	14.28%	21.76%	2.41%	-22.36%	17.62%	-0.76%	13.42%
VT	0.81	28.69%	22.64%	10.68%	N/A	-9.16%	N/A	-2.09%	22.88%
VA	21.64	36.30%	20.11%	4.77%	19.65%	6.22%	-14.31%	-0.69%	8.64%
WA	38.67	37.26%	25.99%	4.08%	15.93%	7.19%	-4.63%	1.48%	22.46%
WV	1.26	35.62%	28.50%	40.22%	N/A	22.47%	N/A	0.18%	34.11%
WI	72.54	34.72%	23.83%	16.53%	21.22%	7.34%	0.12%	0.18%	15.63%
WY	6.04	26.70%	15.69%	17.30%	-13.92%	-6.45%	5.47%	2.13%	12.45%
All States	**3,541.95**	**34.83%**	**19.50%**	**22.85%**	**20.61%**	**1.26%**	**8.03%**	**1.45%**	**20.35%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-9. Standard Deviation of Expected Net Gains by State and Fund, GFDL-CM2.0

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	4.09%	30.03%	28.35%	3.61%	13.25%	13.65%	2.23%	23.49%
AZ	4.96	0.24%	21.22%	28.79%	0.51%	18.51%	20.76%	2.84%	12.90%
AR	38.49	8.48%	30.75%	27.81%	6.36%	14.04%	14.29%	3.16%	16.81%
CA	170.88	0.77%	18.34%	33.15%	0.83%	16.51%	16.55%	2.60%	11.91%
CO	52.38	11.73%	24.53%	38.27%	10.07%	8.80%	20.08%	3.11%	29.02%
CT	1.58	5.60%	26.13%	32.06%	N/A	14.83%	N/A	1.72%	10.18%
DE	5.37	7.39%	26.84%	31.39%	N/A	18.29%	21.21%	4.41%	28.96%
FL	84.61	9.53%	31.68%	21.15%	1.87%	18.20%	15.94%	2.68%	17.93%
GA	50.00	4.29%	29.44%	28.78%	4.48%	14.29%	15.52%	2.74%	21.65%
ID	33.77	0.48%	17.07%	25.99%	12.90%	9.55%	14.17%	2.38%	14.91%
IL	351.96	0.46%	21.57%	24.71%	0.43%	17.32%	21.58%	5.26%	22.39%
IN	164.81	3.14%	17.71%	24.13%	3.15%	14.57%	16.58%	3.75%	21.29%
IA	349.08	2.51%	28.12%	24.34%	20.47%	16.58%	13.24%	4.13%	23.58%
KS	197.82	27.56%	32.12%	29.43%	14.76%	14.92%	16.86%	3.59%	25.86%
KY	31.87	8.47%	27.96%	23.73%	8.66%	15.57%	17.58%	2.44%	21.77%
LA	26.39	9.64%	24.53%	25.10%	3.06%	17.95%	18.48%	2.52%	18.62%
ME	3.08	0.37%	32.59%	N/A	N/A	17.06%	N/A	4.16%	19.08%
MD	15.75	3.88%	30.17%	27.79%	N/A	14.76%	15.34%	2.58%	26.25%
MA	1.32	14.09%	20.24%	33.49%	0.20%	12.37%	N/A	1.70%	12.46%
MI	54.71	0.58%	16.78%	22.20%	0.18%	11.88%	25.94%	4.05%	15.61%
MN	296.66	6.87%	18.28%	26.45%	7.80%	11.78%	15.45%	2.12%	23.95%
MS	30.72	2.41%	29.23%	28.18%	6.91%	13.06%	11.73%	2.83%	14.14%
MO	115.85	1.84%	19.75%	21.86%	17.78%	14.14%	15.87%	2.86%	18.72%
MT	65.15	26.89%	27.09%	33.53%	7.82%	13.48%	21.89%	3.73%	27.19%
NE	262.10	12.44%	22.16%	25.38%	2.73%	13.07%	17.57%	2.62%	23.94%
NV	0.45	14.20%	18.20%	N/A	N/A	27.07%	N/A	3.91%	14.53%
NH	0.29	21.80%	27.35%	N/A	N/A	23.05%	N/A	2.13%	25.52%
NJ	2.73	7.22%	29.32%	15.90%	0.61%	32.58%	23.21%	3.02%	10.30%

(continued)

Table 4-9. Standard Deviation of Expected Net Gains by State and Fund, GFDL-CM2.0 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	3.65%	26.93%	23.30%	9.74%	11.55%	16.79%	3.22%	16.16%
NY	11.02	18.83%	27.42%	29.68%	N/A	11.75%	24.86%	2.15%	20.56%
NC	57.85	5.07%	22.43%	21.51%	0.38%	9.12%	16.67%	1.75%	18.34%
ND	252.89	11.88%	20.52%	24.25%	6.71%	12.89%	15.28%	2.83%	17.92%
OH	112.00	0.44%	23.24%	23.90%	2.75%	18.03%	18.91%	3.28%	21.89%
OK	43.37	3.97%	23.65%	27.91%	12.74%	13.70%	18.19%	3.26%	23.44%
OR	10.23	1.77%	26.36%	45.82%	16.29%	17.75%	24.58%	5.06%	10.37%
PA	24.01	13.83%	25.90%	32.95%	2.50%	14.87%	16.69%	3.35%	26.96%
RI	0.06	4.85%	1.22%	N/A	N/A	19.09%	N/A	N/A	2.48%
SC	19.35	17.21%	25.58%	36.93%	14.75%	11.90%	18.19%	2.39%	25.57%
SD	222.61	22.31%	25.48%	32.57%	18.79%	17.90%	20.15%	3.55%	29.46%
TN	25.93	7.69%	29.88%	31.23%	3.76%	19.81%	18.09%	2.28%	22.34%
TX	180.75	4.50%	25.20%	22.74%	5.49%	15.21%	18.76%	3.31%	17.20%
UT	1.00	11.42%	41.36%	39.28%	30.13%	22.15%	21.30%	2.04%	21.93%
VT	0.81	15.96%	27.08%	35.30%	N/A	21.90%	N/A	4.72%	24.08%
VA	21.64	0.78%	26.31%	32.56%	6.60%	11.70%	18.88%	2.44%	26.60%
WA	38.67	0.47%	29.09%	42.83%	10.51%	22.04%	27.77%	4.06%	22.43%
WV	1.26	4.87%	18.77%	12.98%	N/A	6.50%	N/A	2.76%	12.33%
WI	72.54	4.78%	28.79%	32.33%	2.33%	17.96%	19.44%	3.68%	26.68%
WY	6.04	23.47%	28.86%	25.92%	24.80%	16.99%	17.26%	3.93%	20.86%
All States	**3,541.95**	**2.39%**	**11.95%**	**15.79%**	**1.56%**	**7.74%**	**10.37%**	**1.92%**	**12.35%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-10. Expected Net Gain as a Percentage of Retained Premiums by Organization and Fund, GFDL-CM2.0

Organization	Retained Premiums (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	32.71%	5.51%	17.84%	N/A	N/A	N/A	1.23%	15.18%
2	4.03	33.76%	12.00%	19.99%	18.02%	5.23%	8.49%	-1.19%	15.04%
3	52.13	37.04%	28.87%	24.58%	18.71%	11.20%	15.02%	3.32%	21.61%
4	980.87	35.38%	18.05%	21.42%	N/A	7.81%	N/A	0.94%	20.71%
5	39.91	34.62%	19.73%	18.18%	19.19%	1.95%	4.87%	0.51%	13.42%
6	117.97	33.71%	29.23%	27.49%	8.93%	6.99%	10.48%	2.80%	25.13%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	35.14%	22.88%	23.24%	18.61%	3.31%	14.11%	1.40%	20.84%
9	119.67	34.72%	21.89%	21.75%	13.61%	10.50%	11.90%	1.59%	20.30%
10	454.84	34.59%	22.76%	27.74%	21.27%	4.16%	5.03%	1.24%	20.40%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	29.08%	17.16%	24.60%	13.89%	6.16%	12.13%	1.59%	18.63%
13	102.89	35.05%	13.08%	23.60%	18.37%	2.19%	6.82%	2.01%	16.70%
14	828.01	34.58%	20.27%	21.32%	21.01%	-6.54%	7.66%	1.31%	20.88%
15	86.95	35.10%	25.70%	23.64%	21.12%	10.77%	14.76%	2.50%	22.75%
16	91.85	33.89%	26.26%	26.36%	N/A	-3.32%	23.14%	2.12%	25.58%
17	147.52	34.07%	8.46%	17.54%	17.31%	-4.11%	4.39%	1.66%	11.21%
All Organizations	**3,541.95**	**34.83%**	**19.50%**	**22.85%**	**20.61%**	**1.26%**	**8.03%**	**1.45%**	**20.35%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-11. Standard Deviation of the Expected Net Gains by Organization and Fund, GFDL-CM2.0

Organization	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	6.75%	20.49%	16.65%	N/A	N/A	N/A	1.90%	13.52%
2	4.03	4.80%	18.86%	21.33%	7.26%	9.00%	15.63%	2.61%	14.68%
3	52.13	0.58%	19.90%	24.74%	4.66%	14.75%	23.37%	5.20%	20.94%
4	980.87	1.84%	12.27%	14.61%	N/A	11.26%	N/A	1.98%	12.00%
5	39.91	3.29%	14.99%	16.25%	2.28%	10.09%	10.89%	2.06%	11.13%
6	117.97	4.29%	17.92%	19.10%	14.32%	11.42%	13.17%	2.53%	17.31%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	2.11%	11.64%	17.46%	4.07%	7.80%	20.86%	2.18%	13.39%
9	119.67	3.07%	11.98%	16.81%	4.62%	6.57%	10.15%	2.01%	13.67%
10	454.84	3.19%	13.90%	17.23%	1.25%	9.79%	10.73%	2.02%	12.57%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	11.19%	21.00%	21.14%	13.99%	12.68%	10.55%	2.44%	15.34%
13	102.89	2.97%	15.02%	16.94%	3.40%	11.11%	11.00%	2.35%	11.93%
14	828.01	2.67%	12.77%	16.92%	1.73%	10.47%	9.92%	1.74%	13.44%
15	86.95	2.35%	11.47%	17.43%	0.99%	13.89%	11.41%	2.01%	14.42%
16	91.85	4.81%	10.80%	16.79%	N/A	8.96%	9.21%	2.99%	13.61%
17	147.52	3.68%	15.25%	14.02%	7.82%	7.42%	10.34%	2.14%	8.80%
All Organizations	**3,541.95**	**2.39%**	**11.95%**	**15.79%**	**1.56%**	**7.74%**	**10.37%**	**1.92%**	**12.35%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-12. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, GFDL-CM2.1

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	34.83%	3.94%	-6.20%	20.42%	-3.74%	-0.69%	-1.76%	-0.75%
AZ	4.96	37.32%	26.50%	8.99%	21.82%	-7.86%	-8.46%	-0.39%	20.07%
AR	38.49	35.65%	6.78%	2.53%	19.49%	-6.06%	-14.43%	1.29%	17.22%
CA	170.88	37.00%	34.40%	26.47%	21.52%	6.85%	17.89%	4.12%	33.57%
CO	52.38	30.29%	9.93%	-0.93%	18.74%	-5.12%	-2.40%	-0.87%	1.64%
CT	1.58	36.12%	13.32%	24.78%	N/A	-1.16%	N/A	-1.11%	14.59%
DE	5.37	35.20%	27.85%	34.61%	N/A	5.83%	13.54%	3.11%	33.13%
FL	84.61	33.05%	-15.30%	33.27%	20.50%	-17.11%	0.66%	-4.07%	1.03%
GA	50.00	35.75%	-4.64%	7.14%	19.08%	-9.12%	5.17%	-0.59%	3.32%
ID	33.77	37.06%	28.79%	2.54%	15.21%	18.42%	8.64%	0.12%	23.37%
IL	351.96	37.32%	38.79%	35.86%	21.99%	16.46%	15.29%	3.21%	31.49%
IN	164.81	36.87%	40.52%	33.05%	20.65%	19.73%	19.23%	4.22%	30.08%
IA	349.08	36.66%	35.99%	37.96%	9.63%	9.51%	19.91%	4.09%	36.73%
KS	197.82	24.04%	13.22%	15.91%	9.32%	17.15%	11.60%	2.75%	14.15%
KY	31.87	34.43%	7.32%	29.69%	19.42%	-13.37%	2.96%	-0.66%	23.29%
LA	26.39	31.70%	1.95%	-8.32%	19.54%	-10.76%	-18.12%	-0.79%	5.40%
ME	3.08	37.42%	21.04%	N/A	N/A	16.77%	N/A	3.10%	24.02%
MD	15.75	36.61%	27.07%	31.21%	N/A	9.51%	18.14%	4.81%	30.32%
MA	1.32	33.10%	4.99%	15.82%	21.95%	6.98%	N/A	-1.19%	12.64%
MI	54.71	36.97%	38.64%	31.23%	21.93%	16.11%	9.14%	4.04%	26.59%
MN	296.66	34.66%	36.31%	31.88%	19.22%	7.75%	9.23%	2.06%	31.33%
MS	30.72	36.50%	4.57%	2.74%	21.08%	-8.80%	-12.28%	1.13%	9.52%
MO	115.85	35.67%	28.71%	27.28%	9.55%	6.13%	14.10%	3.50%	27.16%
MT	65.15	21.79%	21.71%	28.39%	16.61%	5.60%	16.34%	3.06%	23.12%
NE	262.10	32.00%	28.68%	28.26%	20.32%	3.45%	12.98%	3.05%	26.87%
NV	0.45	33.71%	37.03%	N/A	N/A	-4.15%	N/A	-3.49%	26.28%
NH	0.29	31.00%	21.19%	N/A	N/A	9.86%	N/A	-0.27%	22.38%
NJ	2.73	34.43%	1.41%	41.42%	21.82%	-31.81%	13.41%	-0.12%	29.53%

(continued)

Table 4-12. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, GFDL-CM2.1 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	35.77%	25.82%	29.95%	14.05%	21.67%	18.73%	4.39%	27.27%
NY	11.02	28.62%	16.25%	24.81%	N/A	8.34%	23.59%	-0.27%	18.14%
NC	57.85	35.15%	8.25%	20.92%	21.52%	-7.40%	-7.43%	-1.49%	14.89%
ND	252.89	31.53%	27.50%	22.84%	19.92%	5.13%	9.58%	2.21%	18.53%
OH	112.00	37.32%	35.28%	33.34%	20.76%	18.23%	16.15%	4.41%	29.98%
OK	43.37	34.14%	20.57%	15.08%	12.33%	7.24%	0.43%	0.81%	15.34%
OR	10.23	31.08%	26.67%	0.69%	8.99%	-17.87%	6.23%	2.29%	21.57%
PA	24.01	32.74%	23.21%	27.50%	21.71%	11.39%	16.91%	3.31%	24.45%
RI	0.06	35.92%	47.62%	N/A	N/A	23.70%	N/A	N/A	43.11%
SC	19.35	29.01%	11.30%	17.48%	18.47%	13.65%	15.02%	-1.33%	14.96%
SD	222.61	26.59%	29.62%	31.93%	7.80%	15.52%	19.68%	2.16%	29.52%
TN	25.93	34.04%	-6.65%	15.62%	19.72%	-0.50%	-0.01%	-1.02%	13.95%
TX	180.75	35.53%	7.14%	25.86%	18.69%	4.35%	11.03%	1.94%	17.41%
UT	1.00	33.03%	21.47%	35.39%	12.38%	-20.38%	24.77%	-0.45%	18.45%
VT	0.81	27.23%	20.55%	8.85%	N/A	-11.27%	N/A	-2.49%	20.95%
VA	21.64	36.44%	27.59%	19.44%	20.33%	10.12%	-2.66%	1.32%	20.34%
WA	38.67	37.30%	29.99%	12.06%	16.38%	12.33%	0.91%	2.43%	26.34%
WV	1.26	35.47%	26.18%	39.00%	N/A	20.91%	N/A	-0.58%	32.55%
WI	72.54	34.74%	21.46%	14.25%	21.28%	5.96%	2.73%	1.18%	14.15%
WY	6.04	26.18%	12.84%	20.91%	-21.54%	-3.89%	19.05%	2.34%	12.29%
All States	**3,541.95**	**35.13%**	**21.69%**	**28.62%**	**20.23%**	**2.66%**	**12.60%**	**1.96%**	**24.70%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-13. Standard Deviation of Expected Net Gains by State and Fund, GFDL-CM2.1

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	4.29%	29.25%	27.60%	4.02%	12.66%	13.66%	2.01%	22.81%
AZ	4.96	0.22%	19.39%	27.32%	0.49%	18.26%	20.55%	2.92%	12.15%
AR	38.49	2.85%	38.37%	32.33%	5.97%	18.78%	16.27%	3.66%	17.72%
CA	170.88	0.82%	16.84%	30.36%	1.37%	16.81%	16.52%	2.42%	10.91%
CO	52.38	12.42%	24.59%	37.60%	10.04%	8.87%	19.14%	3.00%	28.51%
CT	1.58	5.60%	26.10%	33.27%	N/A	14.65%	N/A	1.71%	10.07%
DE	5.37	6.97%	24.50%	27.99%	N/A	19.23%	18.31%	4.48%	25.76%
FL	84.61	12.67%	32.01%	20.90%	2.90%	18.39%	15.91%	2.30%	18.48%
GA	50.00	5.04%	28.00%	29.35%	5.28%	13.36%	15.87%	2.86%	21.12%
ID	33.77	0.46%	17.11%	24.31%	12.40%	9.68%	13.72%	2.51%	14.55%
IL	351.96	0.34%	17.97%	22.33%	0.21%	15.62%	21.54%	5.24%	20.41%
IN	164.81	1.10%	13.33%	21.72%	2.74%	13.79%	16.03%	3.72%	19.20%
IA	349.08	1.43%	24.01%	20.77%	22.87%	15.85%	11.78%	4.02%	20.10%
KS	197.82	24.66%	31.19%	28.66%	14.25%	15.49%	16.63%	3.71%	25.20%
KY	31.87	5.76%	27.07%	21.85%	7.33%	14.89%	18.07%	2.29%	20.24%
LA	26.39	9.57%	29.92%	32.03%	2.91%	20.13%	19.25%	3.10%	23.02%
ME	3.08	0.37%	32.57%	N/A	N/A	17.08%	N/A	4.16%	19.06%
MD	15.75	2.20%	28.67%	24.61%	N/A	14.80%	14.10%	2.17%	23.61%
MA	1.32	14.22%	20.38%	34.05%	0.20%	12.21%	N/A	1.69%	12.53%
MI	54.71	0.60%	16.25%	22.35%	0.18%	11.20%	25.95%	4.05%	15.53%
MN	296.66	6.49%	17.33%	24.74%	7.75%	11.46%	16.75%	2.21%	22.55%
MS	30.72	0.94%	34.40%	34.83%	3.79%	17.03%	18.20%	3.76%	18.21%
MO	115.85	1.93%	18.57%	20.37%	15.99%	14.43%	15.46%	2.83%	17.49%
MT	65.15	26.80%	26.75%	32.56%	8.29%	13.02%	21.17%	3.67%	26.47%
NE	262.10	13.47%	22.20%	25.04%	2.72%	13.08%	17.31%	2.58%	23.65%
NV	0.45	13.96%	18.18%	N/A	N/A	27.58%	N/A	3.78%	14.40%
NH	0.29	22.28%	27.20%	N/A	N/A	22.87%	N/A	2.12%	25.44%
NJ	2.73	6.59%	29.09%	13.64%	0.56%	32.30%	23.21%	3.26%	9.93%

(continued)

Table 4-13. Standard Deviation of Expected Net Gains by State and Fund, GFDL-CM2.1 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	3.89%	27.03%	23.51%	10.82%	11.98%	16.64%	3.34%	16.56%
NY	11.02	19.79%	27.88%	30.40%	N/A	11.79%	19.79%	2.32%	21.42%
NC	57.85	4.13%	22.94%	21.43%	0.33%	9.24%	17.38%	1.87%	18.56%
ND	252.89	9.49%	19.51%	23.88%	3.87%	13.12%	17.12%	2.98%	17.95%
OH	112.00	0.39%	20.79%	21.60%	3.77%	17.28%	18.54%	3.27%	19.95%
OK	43.37	3.40%	22.09%	26.89%	11.52%	13.55%	18.32%	3.20%	22.44%
OR	10.23	19.93%	27.34%	44.25%	19.98%	17.12%	23.98%	4.88%	15.97%
PA	24.01	13.62%	25.16%	31.72%	0.53%	14.30%	16.12%	3.27%	26.01%
RI	0.06	4.29%	0.88%	N/A	N/A	19.09%	N/A	N/A	2.04%
SC	19.35	16.61%	26.24%	36.33%	11.47%	11.58%	17.80%	2.48%	25.66%
SD	222.61	20.68%	23.58%	26.82%	18.84%	16.55%	17.90%	3.47%	24.49%
TN	25.93	7.06%	28.45%	30.09%	5.67%	18.80%	18.72%	2.30%	21.50%
TX	180.75	4.96%	24.61%	21.42%	4.53%	15.09%	18.03%	3.21%	16.41%
UT	1.00	7.54%	35.07%	27.36%	20.54%	21.69%	15.64%	1.74%	17.72%
VT	0.81	17.65%	26.93%	35.53%	N/A	22.07%	N/A	4.67%	24.24%
VA	21.64	0.73%	23.54%	31.95%	5.27%	11.90%	20.57%	3.11%	25.97%
WA	38.67	0.45%	27.63%	42.96%	10.49%	22.01%	28.33%	4.20%	21.78%
WV	1.26	5.32%	19.89%	14.85%	N/A	7.41%	N/A	2.74%	13.65%
WI	72.54	5.28%	29.28%	32.20%	2.33%	17.94%	19.52%	3.89%	26.75%
WY	6.04	23.76%	28.95%	24.43%	24.05%	16.76%	14.80%	3.88%	20.76%
All States	**3,541.95**	**2.30%**	**11.58%**	**14.20%**	**2.39%**	**7.97%**	**10.45%**	**1.91%**	**11.31%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-14. Expected Net Gain as a Percentage of Retained Premiums by Organization and Fund, GFDL-CM2.1

Organization	Retained Premiums (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	35.27%	15.90%	27.04%	N/A	N/A	N/A	2.49%	23.15%
2	4.03	35.00%	13.00%	25.14%	18.65%	6.05%	11.01%	-0.99%	18.40%
3	52.13	37.02%	36.36%	37.14%	18.11%	16.76%	15.41%	3.39%	30.17%
4	980.87	35.47%	19.13%	27.66%	N/A	3.43%	N/A	1.50%	25.10%
5	39.91	35.58%	22.19%	26.71%	19.47%	4.79%	12.72%	1.25%	19.28%
6	117.97	34.44%	33.73%	33.10%	10.94%	10.90%	15.64%	3.17%	30.29%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	35.51%	26.57%	29.84%	18.18%	4.36%	14.48%	2.09%	25.58%
9	119.67	35.34%	25.96%	25.99%	16.49%	11.05%	12.53%	1.92%	23.97%
10	454.84	35.19%	27.21%	31.78%	21.64%	6.69%	11.50%	2.12%	24.73%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	31.07%	20.35%	27.86%	10.39%	14.94%	17.67%	2.46%	22.48%
13	102.89	34.89%	10.77%	29.12%	17.87%	0.82%	11.02%	2.35%	20.14%
14	828.01	34.69%	22.85%	26.95%	20.58%	-8.88%	10.97%	1.68%	25.04%
15	86.95	35.22%	26.93%	26.72%	21.14%	10.25%	15.78%	2.88%	25.22%
16	91.85	35.82%	31.50%	31.25%	N/A	-2.71%	22.93%	2.38%	29.99%
17	147.52	34.68%	7.24%	27.41%	16.25%	-0.27%	7.86%	1.83%	14.92%
All Organizations	**3,541.95**	**35.13%**	**21.69%**	**28.62%**	**20.23%**	**2.66%**	**12.60%**	**1.96%**	**24.70%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-15. Standard Deviation of the Expected Net Gains by Organization and Fund, GFDL-CM2.1

Organization	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	2.98%	22.17%	15.83%	N/A	N/A	N/A	2.12%	13.20%
2	4.03	4.23%	17.93%	20.00%	6.72%	9.63%	15.56%	2.61%	13.78%
3	52.13	1.37%	17.53%	20.70%	5.49%	14.19%	23.28%	5.20%	18.43%
4	980.87	1.99%	11.88%	13.42%	N/A	10.78%	N/A	1.99%	11.17%
5	39.91	2.17%	14.70%	14.83%	2.11%	10.17%	11.58%	2.18%	10.85%
6	117.97	3.81%	15.40%	16.40%	13.87%	10.89%	12.33%	2.48%	14.88%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	2.07%	10.96%	15.26%	4.47%	7.84%	20.75%	2.17%	11.89%
9	119.67	2.58%	11.97%	15.34%	5.56%	6.69%	10.25%	2.02%	12.65%
10	454.84	2.75%	13.49%	16.03%	0.89%	10.08%	11.31%	2.12%	11.91%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	9.73%	19.67%	19.61%	13.32%	12.96%	10.01%	2.46%	14.19%
13	102.89	3.86%	14.18%	14.82%	3.92%	11.07%	10.72%	2.33%	10.66%
14	828.01	3.02%	12.37%	15.29%	2.71%	10.64%	9.57%	1.71%	12.34%
15	86.95	2.44%	11.53%	16.40%	0.82%	13.74%	10.86%	2.01%	13.64%
16	91.85	2.38%	10.77%	15.08%	N/A	8.68%	9.21%	2.89%	12.27%
17	147.52	3.44%	15.45%	12.37%	11.66%	8.28%	10.59%	2.15%	8.57%
All Organizations	**3,541.95**	**2.30%**	**11.58%**	**14.20%**	**2.39%**	**7.97%**	**10.45%**	**1.91%**	**11.31%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. “N/A” denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-16. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, CGCM3.1

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	35.22%	11.26%	3.18%	20.98%	-0.74%	4.87%	-0.57%	6.69%
AZ	4.96	37.44%	43.39%	34.02%	21.93%	17.66%	13.28%	4.27%	33.10%
AR	38.49	33.96%	-16.83%	-17.26%	18.97%	-21.57%	-24.49%	-0.12%	5.82%
CA	170.88	37.09%	38.56%	29.35%	21.68%	11.46%	18.34%	5.04%	36.42%
CO	52.38	31.08%	13.20%	6.37%	18.72%	-4.45%	-1.42%	-0.57%	6.88%
CT	1.58	36.16%	16.29%	29.89%	N/A	-0.11%	N/A	-0.96%	15.92%
DE	5.37	35.03%	20.64%	32.45%	N/A	1.37%	13.35%	2.98%	30.61%
FL	84.61	33.35%	-12.82%	16.00%	20.53%	-16.24%	-14.61%	-4.06%	1.89%
GA	50.00	35.49%	-14.62%	-2.54%	18.91%	-13.91%	-0.69%	-1.82%	-4.35%
ID	33.77	37.11%	32.93%	5.17%	16.78%	19.81%	9.82%	0.75%	26.50%
IL	351.96	37.30%	40.51%	36.78%	21.85%	18.02%	15.21%	3.20%	32.25%
IN	164.81	36.00%	37.66%	28.94%	21.18%	16.67%	18.68%	3.97%	26.74%
IA	349.08	36.16%	32.60%	35.09%	15.36%	2.07%	10.87%	3.59%	33.58%
KS	197.82	26.49%	23.40%	24.09%	15.50%	20.09%	15.37%	3.55%	21.41%
KY	31.87	32.97%	10.20%	27.50%	18.87%	-10.86%	1.68%	0.00%	22.20%
LA	26.39	31.76%	-2.31%	-11.51%	19.39%	-12.74%	-21.24%	-0.92%	2.84%
ME	3.08	37.43%	21.19%	N/A	N/A	16.85%	N/A	3.12%	24.11%
MD	15.75	36.35%	22.20%	25.94%	N/A	11.62%	10.64%	3.59%	25.38%
MA	1.32	33.21%	6.37%	22.40%	21.95%	7.27%	N/A	-1.03%	13.50%
MI	54.71	37.02%	39.72%	32.17%	21.94%	17.07%	8.84%	4.05%	27.18%
MN	296.66	34.07%	32.87%	25.13%	17.57%	4.03%	-2.82%	-0.01%	25.11%
MS	30.72	35.06%	-25.54%	-36.83%	19.45%	-31.84%	-34.24%	-1.84%	-11.05%
MO	115.85	35.54%	21.58%	22.28%	8.67%	1.27%	11.88%	2.60%	22.60%
MT	65.15	18.90%	8.63%	11.74%	16.22%	0.99%	5.55%	1.53%	9.62%
NE	262.10	33.42%	35.98%	32.93%	20.60%	11.07%	16.74%	4.01%	31.65%
NV	0.45	34.28%	37.36%	N/A	N/A	3.39%	N/A	-3.21%	27.86%
NH	0.29	31.41%	22.30%	N/A	N/A	13.98%	N/A	0.00%	23.40%
NJ	2.73	34.33%	-1.39%	40.16%	21.82%	-36.95%	13.41%	-0.93%	28.61%

(continued)

Table 4-16. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, CGCM3.1 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	35.49%	19.43%	23.23%	10.35%	19.70%	14.23%	3.52%	22.58%
NY	11.02	28.07%	10.05%	10.48%	N/A	5.53%	17.72%	-0.76%	13.38%
NC	57.85	34.73%	1.80%	7.54%	21.31%	-8.77%	-16.17%	-2.31%	5.96%
ND	252.89	29.56%	25.74%	4.57%	18.36%	3.08%	-2.92%	0.69%	7.21%
OH	112.00	37.17%	27.68%	26.94%	20.74%	11.06%	13.65%	3.82%	24.30%
OK	43.37	34.00%	21.60%	16.79%	12.51%	7.27%	-1.65%	0.48%	16.54%
OR	10.23	36.14%	30.22%	5.49%	12.57%	-14.77%	7.26%	2.48%	25.39%
PA	24.01	32.93%	22.32%	25.20%	21.32%	10.84%	15.59%	3.39%	22.87%
RI	0.06	35.96%	47.65%	N/A	N/A	23.70%	N/A	N/A	43.15%
SC	19.35	29.07%	13.49%	15.72%	16.59%	12.84%	14.57%	-1.22%	15.21%
SD	222.61	23.36%	23.84%	22.72%	7.43%	9.33%	12.05%	0.50%	21.07%
TN	25.93	34.97%	-4.39%	14.55%	20.69%	-0.31%	-6.75%	-0.65%	13.80%
TX	180.75	35.39%	-3.35%	15.14%	16.63%	-6.38%	-1.28%	-0.07%	8.59%
UT	1.00	33.61%	29.83%	40.42%	14.89%	-9.98%	26.82%	0.02%	23.10%
VT	0.81	29.65%	26.34%	16.30%	N/A	-5.60%	N/A	-1.21%	26.03%
VA	21.64	36.32%	20.09%	0.86%	19.57%	6.70%	-16.55%	-0.64%	5.98%
WA	38.67	37.27%	26.91%	-0.79%	16.10%	7.69%	-9.32%	1.27%	21.77%
WV	1.26	35.41%	23.31%	36.34%	N/A	20.41%	N/A	-0.82%	30.13%
WI	72.54	35.04%	26.62%	20.42%	21.28%	10.14%	1.24%	0.17%	18.60%
WY	6.04	27.18%	14.27%	35.41%	-23.06%	-6.62%	11.55%	2.02%	15.25%
All States	**3,541.95**	**35.08%**	**20.38%**	**25.11%**	**20.23%**	**0.84%**	**7.57%**	**1.28%**	**21.87%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-17. Standard Deviation of Expected Net Gains by State and Fund, CGCM3.1

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	3.72%	29.69%	29.24%	2.93%	13.74%	13.94%	2.60%	24.15%
AZ	4.96	0.16%	9.88%	17.25%	0.41%	14.47%	18.86%	2.64%	7.52%
AR	38.49	4.71%	33.56%	28.99%	6.63%	15.61%	15.09%	3.28%	16.27%
CA	170.88	0.51%	14.20%	28.42%	0.80%	16.10%	16.36%	2.00%	9.13%
CO	52.38	10.96%	23.69%	34.49%	10.06%	8.64%	18.48%	2.91%	26.47%
CT	1.58	5.40%	25.49%	29.19%	N/A	14.53%	N/A	1.67%	9.85%
DE	5.37	6.75%	24.86%	27.28%	N/A	19.35%	18.17%	4.40%	25.15%
FL	84.61	12.02%	33.25%	24.09%	3.06%	18.10%	15.27%	2.43%	18.93%
GA	50.00	5.60%	26.43%	27.85%	5.50%	12.84%	14.94%	2.67%	19.77%
ID	33.77	0.46%	16.68%	25.75%	11.61%	9.57%	13.95%	2.57%	14.42%
IL	351.96	0.32%	16.43%	21.85%	0.27%	14.61%	21.41%	5.24%	19.97%
IN	164.81	3.18%	17.56%	24.36%	2.53%	14.23%	16.34%	3.73%	21.35%
IA	349.08	1.68%	26.98%	22.63%	19.79%	16.16%	13.17%	4.12%	21.97%
KS	197.82	22.97%	30.79%	27.15%	14.28%	14.35%	15.97%	3.63%	24.00%
KY	31.87	9.92%	28.09%	23.66%	8.77%	15.32%	17.47%	2.36%	21.86%
LA	26.39	8.71%	28.47%	30.84%	2.84%	19.66%	18.56%	2.92%	21.89%
ME	3.08	0.37%	32.51%	N/A	N/A	17.02%	N/A	4.16%	19.03%
MD	15.75	2.89%	28.11%	25.32%	N/A	13.97%	14.30%	2.36%	24.01%
MA	1.32	13.86%	19.80%	30.94%	0.20%	12.05%	N/A	1.65%	12.14%
MI	54.71	0.54%	14.87%	21.56%	0.17%	10.54%	25.95%	4.05%	14.91%
MN	296.66	6.70%	18.15%	26.67%	8.65%	11.78%	15.21%	2.09%	24.07%
MS	30.72	2.22%	25.46%	23.27%	6.92%	11.68%	10.50%	2.32%	11.37%
MO	115.85	1.80%	18.64%	20.88%	15.45%	13.73%	15.53%	2.83%	17.86%
MT	65.15	29.58%	25.32%	33.11%	8.68%	12.20%	21.29%	3.47%	26.47%
NE	262.10	10.18%	17.66%	22.06%	2.52%	12.68%	15.61%	2.44%	20.67%
NV	0.45	12.57%	18.19%	N/A	N/A	29.93%	N/A	3.91%	14.79%
NH	0.29	21.62%	26.47%	N/A	N/A	22.64%	N/A	2.01%	24.75%
NJ	2.73	6.78%	28.45%	15.21%	0.56%	32.46%	23.21%	2.96%	9.79%

(continued)

Table 4-17. Standard Deviation of Expected Net Gains by State and Fund, CGCM3.1 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	4.21%	27.62%	25.18%	11.76%	12.75%	17.62%	3.39%	17.29%
NY	11.02	19.26%	28.34%	29.88%	N/A	11.99%	28.56%	2.18%	21.08%
NC	57.85	4.89%	22.25%	21.31%	0.46%	9.24%	16.10%	1.68%	18.12%
ND	252.89	11.48%	20.60%	24.28%	6.21%	13.14%	15.36%	2.67%	17.62%
OH	112.00	0.50%	24.68%	24.89%	3.74%	17.71%	19.40%	3.34%	22.77%
OK	43.37	3.34%	21.80%	26.58%	10.93%	13.55%	17.97%	3.11%	22.15%
OR	10.23	1.50%	27.30%	46.38%	15.81%	17.78%	24.80%	5.23%	10.49%
PA	24.01	12.45%	24.77%	31.71%	3.35%	14.74%	15.96%	3.17%	25.82%
RI	0.06	4.49%	0.86%	N/A	N/A	19.09%	N/A	N/A	2.11%
SC	19.35	16.45%	24.77%	36.17%	14.37%	11.73%	17.77%	2.41%	24.90%
SD	222.61	23.24%	25.77%	32.16%	19.17%	17.81%	19.88%	3.34%	29.11%
TN	25.93	4.99%	27.32%	29.74%	3.23%	17.97%	18.43%	2.23%	20.69%
TX	180.75	4.00%	23.38%	21.84%	5.81%	11.41%	15.96%	2.69%	15.86%
UT	1.00	5.62%	28.43%	24.93%	18.48%	20.13%	14.46%	1.46%	14.64%
VT	0.81	14.37%	26.32%	33.60%	N/A	21.84%	N/A	4.92%	23.25%
VA	21.64	0.79%	26.15%	31.94%	6.73%	11.76%	18.54%	2.47%	26.15%
WA	38.67	0.46%	28.10%	41.36%	10.48%	21.98%	26.99%	4.01%	21.38%
WV	1.26	5.34%	20.11%	16.75%	N/A	7.58%	N/A	2.73%	14.33%
WI	72.54	4.06%	28.11%	31.85%	2.32%	18.10%	19.59%	3.68%	26.22%
WY	6.04	22.33%	28.87%	18.87%	23.71%	17.39%	16.82%	3.82%	19.10%
All States	**3,541.95**	**2.05%**	**10.82%**	**14.55%**	**2.50%**	**7.46%**	**10.10%**	**1.79%**	**11.33%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. “N/A” denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-18. Expected Net Gain as a Percentage of Retained Premiums by Organization and Fund, CGCM3.1

Organization	Retained Premiums (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	34.18%	12.33%	21.72%	N/A	N/A	N/A	1.56%	18.91%
2	4.03	34.54%	17.92%	22.41%	17.56%	4.64%	4.91%	-1.37%	16.45%
3	52.13	37.31%	37.71%	38.81%	19.04%	17.41%	15.62%	3.40%	31.37%
4	980.87	35.45%	17.67%	22.56%	N/A	2.42%	N/A	0.75%	21.37%
5	39.91	34.74%	19.09%	19.70%	19.22%	2.97%	4.71%	0.81%	13.92%
6	117.97	34.04%	33.12%	31.63%	11.34%	9.64%	15.12%	2.95%	29.03%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	35.49%	27.27%	28.65%	17.67%	4.59%	14.56%	1.71%	24.91%
9	119.67	35.05%	23.82%	22.45%	15.95%	8.93%	10.28%	1.48%	21.02%
10	454.84	34.95%	28.48%	29.60%	21.69%	6.23%	4.39%	1.05%	22.05%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	31.66%	23.96%	29.20%	15.79%	16.15%	13.56%	2.50%	22.39%
13	102.89	34.76%	6.69%	23.10%	16.95%	-6.48%	1.27%	0.95%	14.03%
14	828.01	34.86%	21.13%	22.98%	20.59%	-8.60%	7.74%	1.18%	22.11%
15	86.95	35.23%	23.64%	25.34%	21.10%	9.96%	11.93%	2.31%	23.56%
16	91.85	35.00%	27.94%	28.03%	N/A	-5.05%	22.36%	1.19%	27.05%
17	147.52	34.17%	4.10%	20.07%	17.76%	-6.11%	3.24%	0.48%	10.54%
All Organizations	**3,541.95**	**35.08%**	**20.38%**	**25.11%**	**20.23%**	**0.84%**	**7.57%**	**1.28%**	**21.87%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-19. Standard Deviation of the Expected Net Gains by Organization and Fund, CGCM3.1

Organization	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	4.60%	19.86%	15.71%	N/A	N/A	N/A	1.88%	12.75%
2	4.03	4.37%	19.35%	20.51%	7.41%	9.30%	15.36%	2.49%	13.99%
3	52.13	0.51%	16.14%	19.66%	4.44%	13.01%	23.23%	5.19%	17.66%
4	980.87	1.84%	11.25%	13.43%	N/A	11.15%	N/A	1.87%	10.95%
5	39.91	3.10%	14.80%	15.56%	2.26%	9.95%	10.83%	2.06%	10.70%
6	117.97	3.65%	16.14%	17.34%	13.87%	10.73%	12.51%	2.49%	15.72%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	1.92%	9.90%	15.41%	4.41%	7.64%	20.72%	2.12%	11.94%
9	119.67	2.48%	11.19%	15.79%	5.08%	6.17%	9.78%	1.92%	12.83%
10	454.84	2.47%	12.00%	16.88%	0.55%	9.62%	10.53%	1.90%	12.14%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	8.86%	19.25%	19.36%	13.63%	11.97%	10.16%	2.37%	13.87%
13	102.89	3.65%	13.46%	16.05%	4.17%	8.78%	9.45%	2.05%	11.03%
14	828.01	2.33%	11.70%	15.69%	2.87%	10.41%	9.17%	1.61%	12.41%
15	86.95	2.26%	10.34%	16.13%	0.81%	13.53%	10.80%	1.82%	13.25%
16	91.85	3.00%	10.21%	15.92%	N/A	8.84%	9.37%	2.71%	12.81%
17	147.52	3.38%	14.34%	12.88%	7.10%	6.77%	9.75%	1.80%	7.87%
All Organizations	**3,541.95**	**2.05%**	**10.82%**	**14.55%**	**2.50%**	**7.46%**	**10.10%**	**1.79%**	**11.33%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-20. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, MRI-CGCM2.2

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	36.08%	19.80%	16.41%	21.40%	4.38%	14.26%	1.36%	16.71%
AZ	4.96	37.43%	42.23%	27.96%	21.93%	14.56%	7.42%	3.26%	31.20%
AR	38.49	34.79%	-7.99%	-9.77%	19.71%	-15.47%	-20.66%	0.28%	10.20%
CA	170.88	37.07%	37.64%	31.42%	21.56%	10.77%	20.16%	4.85%	35.82%
CO	52.38	30.98%	13.92%	2.70%	18.76%	-3.65%	-1.99%	-0.59%	4.76%
CT	1.58	36.22%	16.94%	26.84%	N/A	0.73%	N/A	-0.76%	16.36%
DE	5.37	35.55%	28.89%	35.69%	N/A	5.44%	15.73%	3.28%	34.21%
FL	84.61	34.29%	-2.62%	33.58%	21.04%	-10.72%	0.87%	-2.79%	8.18%
GA	50.00	36.16%	4.90%	11.28%	19.87%	-3.89%	7.62%	0.01%	8.88%
ID	33.77	37.16%	32.87%	11.70%	16.38%	20.34%	14.88%	1.29%	27.77%
IL	351.96	37.33%	39.92%	35.85%	22.01%	17.17%	15.47%	3.22%	31.56%
IN	164.81	36.92%	39.96%	32.19%	20.63%	19.06%	19.46%	4.31%	29.44%
IA	349.08	36.61%	34.10%	35.59%	13.45%	7.18%	18.43%	3.95%	34.45%
KS	197.82	24.41%	14.05%	15.43%	10.23%	17.03%	11.09%	2.68%	13.85%
KY	31.87	34.47%	9.62%	29.41%	19.59%	-12.11%	2.56%	-0.39%	23.50%
LA	26.39	34.77%	19.24%	10.57%	20.02%	2.71%	-4.73%	1.54%	18.72%
ME	3.08	37.43%	21.28%	N/A	N/A	16.92%	N/A	3.14%	24.16%
MD	15.75	36.75%	28.21%	31.65%	N/A	12.53%	17.59%	4.84%	30.84%
MA	1.32	33.30%	8.62%	18.44%	21.96%	9.11%	N/A	-0.86%	14.72%
MI	54.71	36.90%	36.38%	26.13%	21.92%	13.42%	7.90%	3.81%	23.82%
MN	296.66	34.72%	35.18%	30.81%	19.07%	5.53%	6.22%	1.44%	30.24%
MS	30.72	36.53%	9.44%	-1.80%	20.51%	-12.06%	-17.78%	1.43%	8.91%
MO	115.85	36.01%	30.78%	27.84%	11.57%	7.55%	14.41%	3.56%	27.84%
MT	65.15	21.19%	19.96%	19.72%	16.85%	8.16%	11.42%	2.53%	17.93%
NE	262.10	33.04%	35.23%	32.81%	20.55%	9.33%	16.84%	3.79%	31.47%
NV	0.45	34.43%	37.40%	N/A	N/A	5.60%	N/A	-3.28%	28.28%
NH	0.29	31.47%	24.15%	N/A	N/A	12.69%	N/A	0.18%	24.99%
NJ	2.73	34.58%	3.83%	41.72%	21.84%	-33.35%	13.41%	0.21%	30.13%

(continued)

Table 4-20. Expected Net Gain as a Percentage of Retained Premiums by State and Fund, MRI-CGCM2.2 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	35.13%	21.05%	22.81%	13.47%	16.85%	15.33%	3.26%	22.56%
NY	11.02	28.32%	14.37%	22.63%	N/A	7.87%	21.69%	-0.38%	16.90%
NC	57.85	35.19%	6.18%	15.26%	21.50%	-7.69%	-11.67%	-1.83%	11.35%
ND	252.89	29.89%	26.59%	12.99%	18.42%	4.47%	2.18%	1.24%	12.32%
OH	112.00	37.02%	21.48%	20.57%	20.93%	3.38%	8.82%	3.03%	18.41%
OK	43.37	33.78%	14.56%	7.72%	11.52%	3.54%	-3.51%	0.20%	9.13%
OR	10.23	36.23%	31.00%	8.05%	12.97%	-13.18%	8.34%	2.62%	25.88%
PA	24.01	33.30%	26.35%	29.20%	21.30%	12.31%	18.57%	3.80%	26.37%
RI	0.06	36.03%	47.69%	N/A	N/A	23.70%	N/A	N/A	43.19%
SC	19.35	29.70%	14.59%	17.15%	18.04%	14.57%	14.79%	-1.14%	16.31%
SD	222.61	24.80%	26.61%	25.51%	7.20%	12.93%	15.68%	0.96%	23.81%
TN	25.93	34.84%	-3.66%	15.66%	20.38%	0.81%	-0.88%	-0.85%	14.71%
TX	180.75	35.57%	8.72%	23.99%	18.80%	4.67%	9.33%	1.82%	16.67%
UT	1.00	31.06%	11.95%	17.33%	2.24%	-24.58%	14.10%	-0.81%	11.58%
VT	0.81	29.02%	24.15%	12.35%	N/A	-7.71%	N/A	-1.80%	24.15%
VA	21.64	36.42%	25.71%	14.12%	20.29%	8.90%	-7.49%	0.76%	16.26%
WA	38.67	37.28%	27.26%	0.13%	16.49%	8.19%	-7.36%	1.26%	22.18%
WV	1.26	35.63%	29.16%	40.80%	N/A	22.27%	N/A	0.02%	34.65%
WI	72.54	35.07%	24.65%	18.79%	21.21%	9.00%	4.11%	1.19%	17.61%
WY	6.04	28.10%	19.35%	31.24%	-9.46%	-1.46%	14.11%	2.43%	17.82%
All States	**3,541.95**	**35.49%**	**23.77%**	**26.87%**	**20.72%**	**3.91%**	**10.29%**	**1.83%**	**23.86%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. “N/A” denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-21. Standard Deviation of Expected Net Gains by State and Fund, MRI-CGCM2.2

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
AL	21.28	2.12%	27.56%	27.60%	1.83%	14.91%	13.70%	2.98%	22.68%
AZ	4.96	0.17%	11.24%	20.68%	0.42%	15.96%	20.24%	2.92%	8.47%
AR	38.49	3.68%	35.75%	30.63%	5.49%	16.68%	15.89%	3.47%	16.90%
CA	170.88	0.56%	14.96%	26.62%	1.31%	16.48%	15.82%	2.19%	9.64%
CO	52.38	11.25%	24.00%	35.06%	10.05%	8.89%	18.59%	2.97%	26.82%
CT	1.58	5.14%	25.84%	31.49%	N/A	14.62%	N/A	1.72%	10.09%
DE	5.37	5.70%	23.63%	25.75%	N/A	18.97%	17.30%	4.42%	23.76%
FL	84.61	8.97%	30.36%	20.43%	1.61%	17.90%	16.12%	2.61%	17.17%
GA	50.00	3.52%	29.35%	28.71%	4.08%	14.43%	15.27%	2.92%	21.58%
ID	33.77	0.42%	15.84%	23.71%	12.61%	9.47%	12.25%	2.53%	13.53%
IL	351.96	0.32%	16.94%	22.31%	0.20%	15.20%	21.52%	5.24%	20.36%
IN	164.81	0.95%	14.12%	22.20%	2.99%	14.08%	15.96%	3.71%	19.59%
IA	349.08	1.68%	25.30%	22.30%	21.08%	16.32%	12.28%	4.06%	21.57%
KS	197.82	24.33%	31.08%	28.37%	14.49%	15.46%	16.66%	3.72%	24.98%
KY	31.87	5.86%	27.10%	22.04%	6.94%	15.07%	17.88%	2.24%	20.46%
LA	26.39	4.64%	27.09%	31.24%	2.51%	21.48%	20.86%	3.27%	20.78%
ME	3.08	0.37%	32.49%	N/A	N/A	16.99%	N/A	4.17%	19.02%
MD	15.75	1.64%	27.03%	23.36%	N/A	14.64%	13.70%	2.08%	22.36%
MA	1.32	13.62%	20.07%	33.11%	0.19%	12.00%	N/A	1.72%	12.28%
MI	54.71	0.62%	18.48%	23.25%	0.16%	12.79%	25.98%	4.06%	16.36%
MN	296.66	6.39%	17.71%	25.02%	7.25%	11.66%	16.11%	2.15%	22.79%
MS	30.72	0.76%	30.10%	30.71%	5.21%	14.58%	16.23%	3.50%	15.48%
MO	115.85	1.50%	18.02%	20.31%	14.89%	14.56%	15.50%	2.83%	17.36%
MT	65.15	27.16%	26.89%	34.63%	7.73%	14.85%	22.48%	3.83%	27.87%
NE	262.10	10.31%	17.87%	21.82%	2.55%	12.50%	15.34%	2.42%	20.47%
NV	0.45	12.21%	18.19%	N/A	N/A	29.91%	N/A	3.89%	14.79%
NH	0.29	21.49%	26.55%	N/A	N/A	22.94%	N/A	2.14%	24.80%
NJ	2.73	6.36%	29.18%	12.92%	0.52%	32.77%	23.21%	3.30%	9.72%

(continued)

Table 4-21. Standard Deviation of Expected Net Gains by State and Fund, MRI-CGCM2.2 (continued)

State	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
NM	5.84	4.98%	27.90%	24.76%	11.81%	12.31%	16.78%	3.51%	17.12%
NY	11.02	20.12%	27.77%	30.57%	N/A	11.78%	22.94%	2.31%	21.44%
NC	57.85	3.92%	22.98%	21.77%	0.33%	9.41%	17.01%	1.86%	18.70%
ND	252.89	11.60%	20.66%	24.70%	6.20%	13.67%	15.96%	2.89%	18.22%
OH	112.00	0.58%	25.61%	25.19%	3.16%	16.86%	19.33%	3.32%	22.96%
OK	43.37	3.74%	23.96%	27.95%	12.17%	13.81%	18.40%	3.04%	23.51%
OR	10.23	1.29%	26.65%	46.14%	15.25%	17.73%	24.78%	5.22%	10.26%
PA	24.01	12.13%	25.41%	31.52%	3.33%	14.64%	15.90%	3.26%	25.93%
RI	0.06	4.01%	0.84%	N/A	N/A	19.09%	N/A	N/A	1.92%
SC	19.35	15.91%	24.64%	36.19%	12.66%	11.24%	17.82%	2.40%	24.81%
SD	222.61	22.27%	25.18%	31.04%	18.89%	17.53%	19.35%	3.55%	28.12%
TN	25.93	5.59%	27.60%	29.89%	3.92%	17.78%	18.53%	2.26%	20.93%
TX	180.75	4.65%	24.49%	21.50%	4.33%	15.02%	18.01%	3.18%	16.40%
UT	1.00	12.17%	43.54%	42.70%	30.11%	20.78%	25.10%	2.13%	23.20%
VT	0.81	15.04%	26.55%	34.82%	N/A	21.91%	N/A	4.85%	23.54%
VA	21.64	0.76%	24.66%	33.27%	5.23%	12.13%	19.90%	3.02%	26.99%
WA	38.67	0.46%	28.38%	41.07%	10.46%	21.95%	27.26%	3.96%	21.49%
WV	1.26	4.89%	18.83%	12.73%	N/A	6.64%	N/A	2.76%	12.35%
WI	72.54	4.61%	29.06%	32.25%	2.56%	18.50%	19.96%	3.90%	26.73%
WY	6.04	20.54%	29.96%	22.25%	30.21%	19.07%	16.38%	3.90%	20.23%
All States	**3,541.95**	**1.72%**	**11.19%**	**14.78%**	**1.37%**	**7.89%**	**10.52%**	**1.92%**	**11.58%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for a state. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-22. Expected Net Gain as a Percentage of Retained Premiums by Organization and Fund, MRI-CGCM2.2

Organization	Retained Premiums (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	34.71%	15.93%	25.61%	N/A	N/A	N/A	2.39%	22.15%
2	4.03	34.69%	16.07%	25.24%	18.70%	10.12%	9.99%	-0.10%	18.94%
3	52.13	37.34%	36.86%	37.03%	19.18%	16.97%	15.40%	3.39%	30.14%
4	980.87	35.73%	21.01%	24.90%	N/A	9.15%	N/A	1.29%	23.71%
5	39.91	35.44%	22.58%	22.06%	19.66%	4.13%	8.69%	0.86%	16.56%
6	117.97	34.64%	34.09%	32.02%	11.31%	10.29%	14.08%	3.05%	29.36%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	35.80%	28.18%	28.61%	18.85%	4.88%	14.46%	1.96%	25.04%
9	119.67	35.52%	27.29%	24.62%	17.41%	11.28%	11.93%	1.65%	23.19%
10	454.84	35.68%	30.74%	30.94%	21.75%	7.35%	7.20%	1.65%	23.76%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	31.09%	21.62%	26.49%	11.26%	15.62%	17.34%	2.56%	21.75%
13	102.89	35.25%	14.48%	27.22%	18.68%	1.81%	8.93%	2.26%	19.19%
14	828.01	35.27%	24.80%	25.28%	21.08%	-5.09%	9.21%	1.63%	24.48%
15	86.95	35.30%	28.10%	26.83%	21.23%	10.46%	15.69%	2.91%	25.49%
16	91.85	35.67%	30.63%	29.91%	N/A	-3.41%	22.47%	2.23%	28.89%
17	147.52	34.96%	12.69%	25.48%	17.34%	0.37%	7.06%	1.92%	15.51%
All Organizations	**3,541.95**	**35.49%**	**23.77%**	**26.87%**	**20.72%**	**3.91%**	**10.29%**	**1.83%**	**23.86%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Table 4-23. Standard Deviation of the Expected Net Gains by Organization and Fund, MRI-CGCM2.2

Organization	Retained Premium (million $)	CATCOM	BUYCOM	REVCOM	CATDEV	BUYDEV	REVDEV	ASSIGN	ALL
1	25.50	4.02%	20.35%	15.85%	N/A	N/A	N/A	2.03%	12.96%
2	4.03	4.32%	18.56%	20.05%	6.65%	9.79%	15.52%	2.71%	13.74%
3	52.13	0.51%	16.87%	20.71%	4.28%	14.29%	23.29%	5.20%	18.41%
4	980.87	1.55%	11.66%	13.86%	N/A	11.10%	N/A	2.01%	11.37%
5	39.91	2.24%	15.78%	15.47%	2.30%	10.91%	11.34%	2.15%	11.14%
6	117.97	3.57%	15.59%	17.32%	13.21%	11.09%	12.82%	2.51%	15.66%
7	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
8	393.04	1.53%	10.07%	15.75%	3.64%	7.97%	20.75%	2.20%	12.14%
9	119.67	2.16%	11.27%	15.88%	4.78%	6.71%	10.28%	2.04%	12.94%
10	454.84	1.74%	12.34%	16.63%	0.62%	10.09%	11.25%	2.09%	12.16%
11	0.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
12	96.77	9.50%	19.63%	20.59%	13.59%	12.79%	9.94%	2.48%	14.75%
13	102.89	2.87%	14.80%	15.70%	3.27%	10.98%	10.71%	2.30%	11.18%
14	828.01	2.04%	12.05%	16.00%	1.48%	10.45%	10.04%	1.73%	12.68%
15	86.95	2.27%	10.90%	16.07%	0.77%	13.83%	10.68%	1.93%	13.28%
16	91.85	2.43%	10.43%	15.78%	N/A	9.16%	9.41%	2.91%	12.71%
17	147.52	2.79%	14.82%	12.67%	8.13%	7.91%	10.29%	2.12%	8.37%
All Organizations	**3,541.95**	**1.72%**	**11.19%**	**14.78%**	**1.37%**	**7.89%**	**10.52%**	**1.92%**	**11.58%**

Note: The prefixes CAT, BUY, and REV refer to catastrophic coverage, buyup yield insurance, and revenue insurance plans, respectively. Suffixes COM and DEV refer to the Commercial and Developmental reinsurance pools, while the column ASSIGN includes all policies placed in the Assigned Risk reinsurance pool. The column ALL represents the total across all reinsurance pools for an organization. "N/A" denotes reinsurance pools for which there were no retained premiums in the baseline dataset used for this analysis.

Although the FASOM simulations included show substantial movements in regional crop acreage, we did not incorporate those changes in the primary cases examined because we were holding the book of business constant at 2006 levels. Thus, the changes in returns presented reflect simulated impacts with no behavioral response to the changing yields and prices that are simulated, which would tend to overstate negative impacts. However, even without allowing for any reallocation of liabilities and premiums in response to changing conditions, the changes in simulated net gains and standard deviation of net gains for AIPs under the climate change scenarios simulated using the SRA model are relatively small at the national level as shown in Figures 4-47 and 4-48. This is partially due to the readjustment of yield guarantees as projected yields change under different climate conditions. It also reflects the diverse impacts across scenarios, crops, and regions, where there are numerous cases where production of a given crop within a region may become less risky due, for instance, to increased precipitation. Thus, while there are reductions in simulated net gains in some regions, there are also increases in other regions that largely offset at the national level.

Figure 4-47. Overall Expected Net Gains to AIPs by Scenario, U.S.

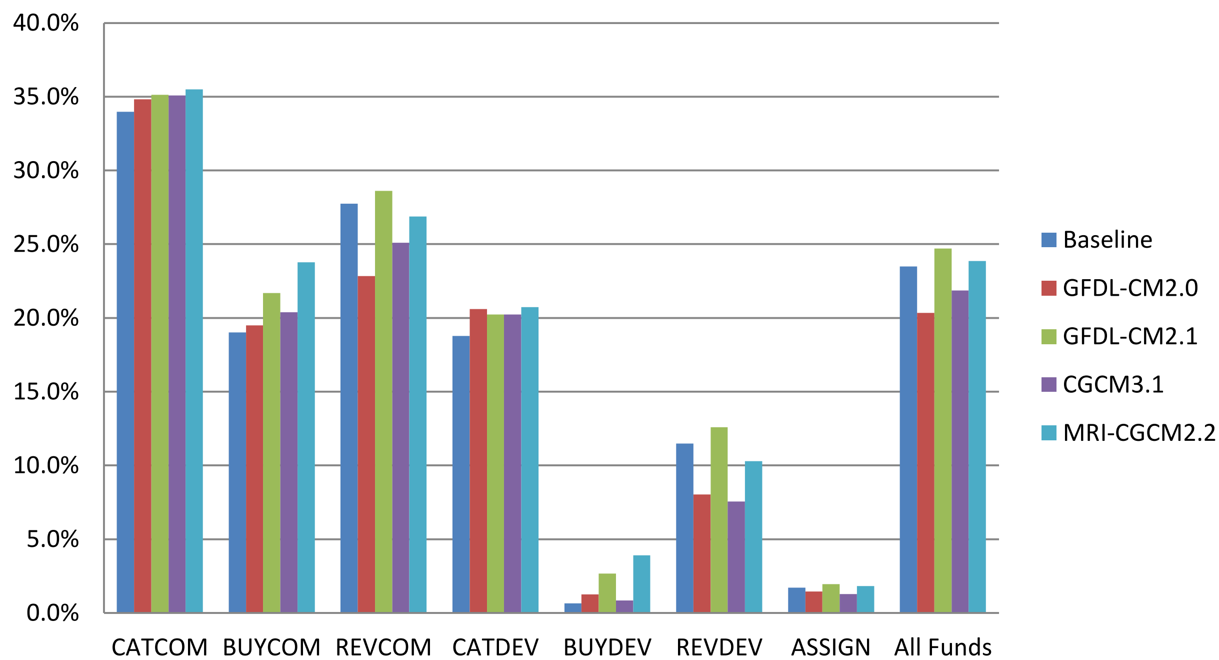
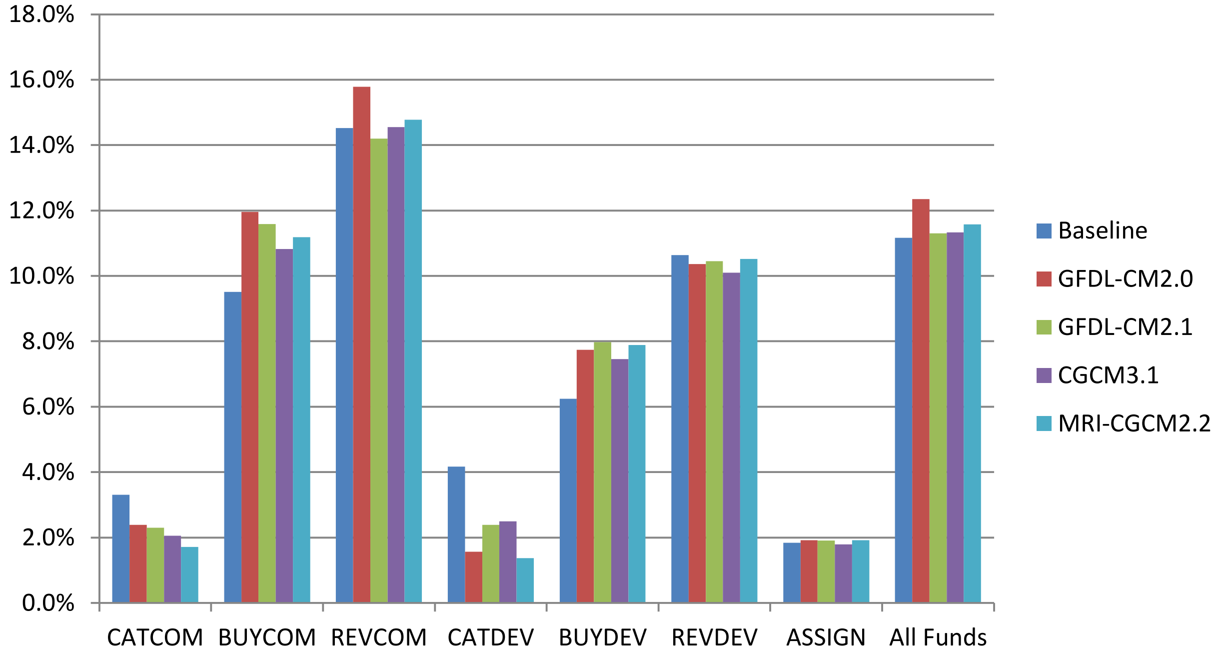


Figure 4-48. Overall Standard Deviation of Expected Net Gains to AIPs by Scenario, U.S.



Figures 4-49 and 4-50 show the differences in simulated returns under each of the climate scenarios relative to the baseline.

Figure 4-49. Simulated Change in Net Gains to AIPs Relative to the Baseline

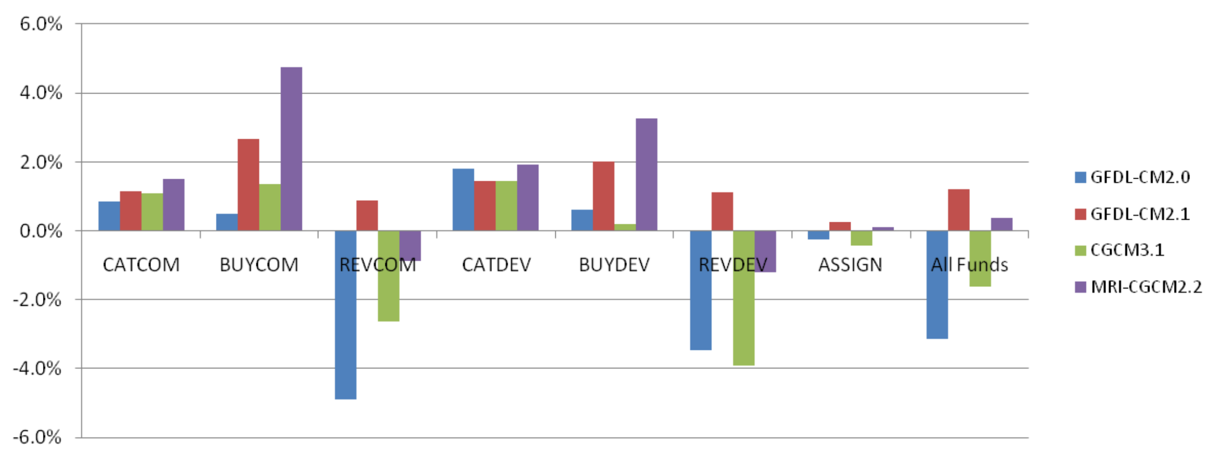
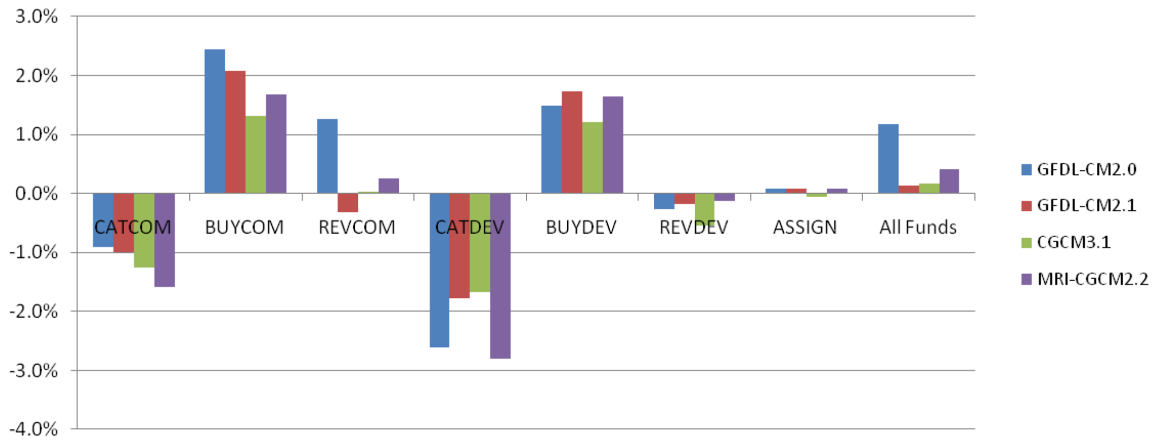


Figure 4-50. Simulated Change in Standard Deviation of Net Gains to AIPs Relative to the Baseline



Finding relatively small impacts across all crops at the national level is consistent with previous studies finding that agricultural impacts of climate change in the U.S. may be relatively small at the national level, but that this obscures the potential distributional effects within the U.S. However, it is also reflective of the risk protection provided to the AIPs by the SRA. The climate change scenarios have substantially larger impacts on the simulated net gains and standard deviation of gains to the FCIC than the AIPs, again holding the distribution of liabilities and premiums constant at base levels. Simulated average net gains for AIPs aggregated to the national level vary only from 3.1 percentage points below to 1.2 percentage points above the base simulated post-SRA return of 23.5%. Simulated average net gains to the FCIC, on the other hand, vary from 26.8 percentage points below to 14.4 percentage points above the base simulated return of 12.7% across the climate scenarios examined.

While the changes in simulated net gains to AIPs at the national level are relatively small, there are far greater deviations in the changes in simulated net gains to AIPs across individual states. Averaging across the four primary GCM scenarios analyzed, the change in simulated expected returns ranges from an increase of 20 percentage points to a reduction of 14 percentage points. In general, simulated net gains tend to be increasing in Northeastern and West Coast states and decreasing in most of the interior states of the U.S. as well as the Southcentral region. The largest percentage point declines in net gains are found in a band of states in the Southcentral and Southeast regions (Alabama, Arkansas, Georgia, Louisiana, Mississippi, and North Carolina) where there are large increases in temperature extremes, precipitation tends to be declining in the GCMs, and there is little irrigation. It is very important to recognize the uncertainties associated with climate modeling, however, particularly in downscaling climate model results to the regional level, due to the highly complex nature of the climate system and the evolving scientific understanding of interconnections between climate and terrestrial systems. Figure 4-51 shows simulated baseline net gains under the baseline across states, while Figures 4-52 through 4-55 present the simulated difference in net gain for each climate scenario relative to the baseline.

Figure 4-51. Simulated Net Gains to AIPs by State, Baseline

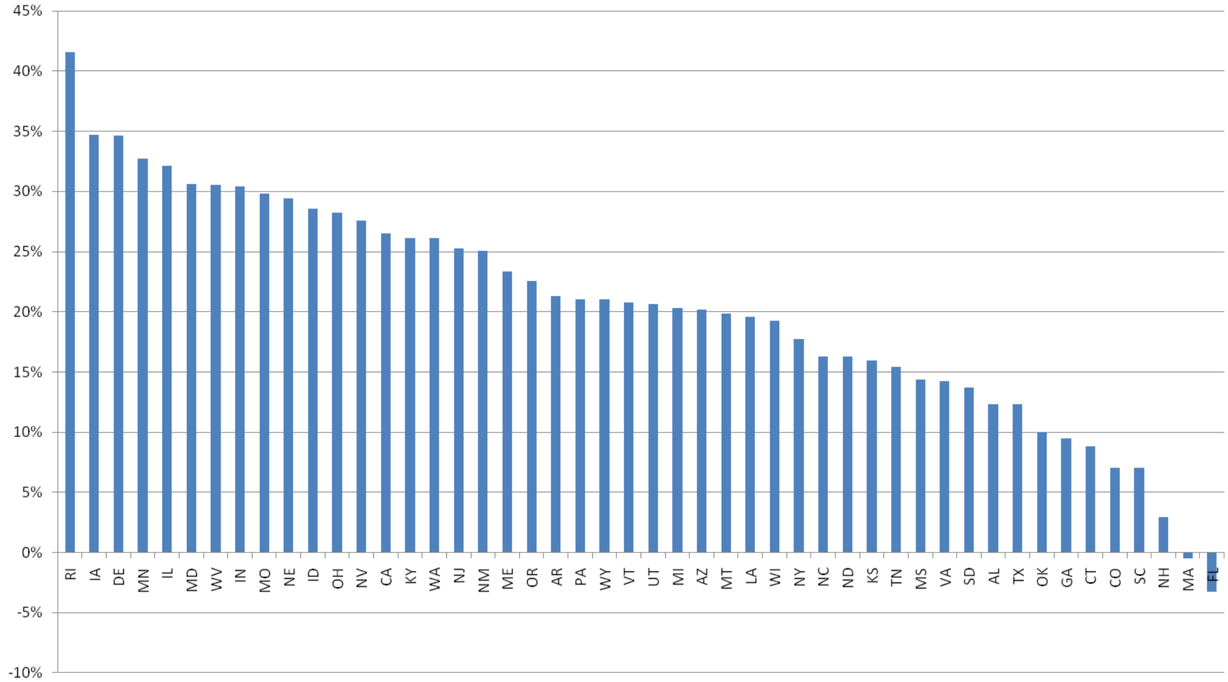


Figure 4-52. Simulated Net Gains to AIPs by State Relative to Baseline, GFDL-2.0

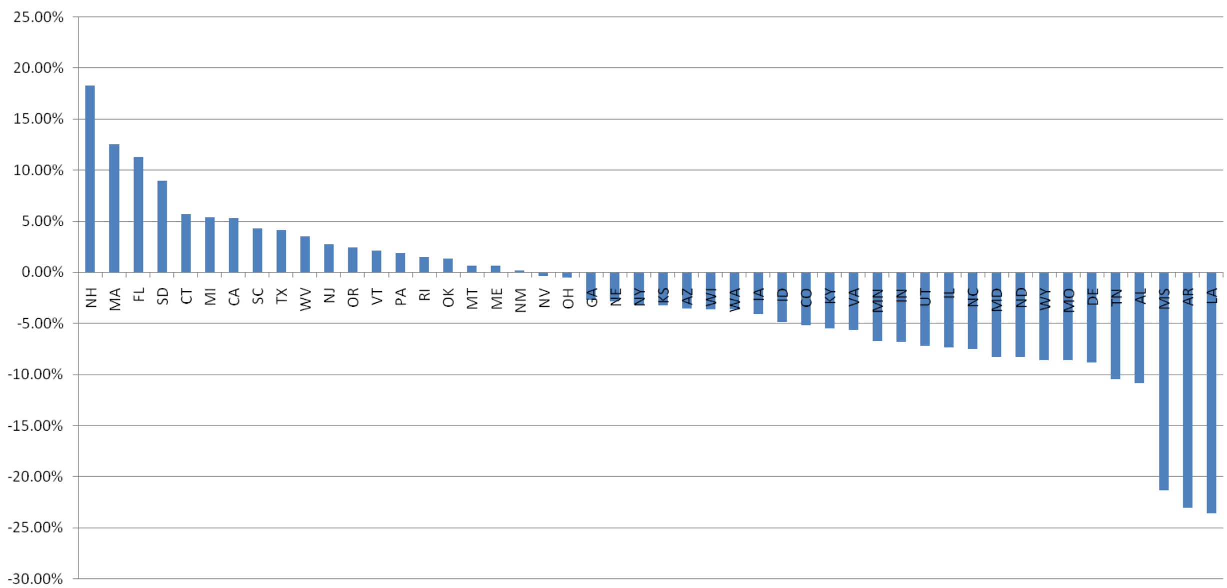


Figure 4-53. Simulated Net Gains to AIPs by State Relative to Baseline, GFDL-2.1

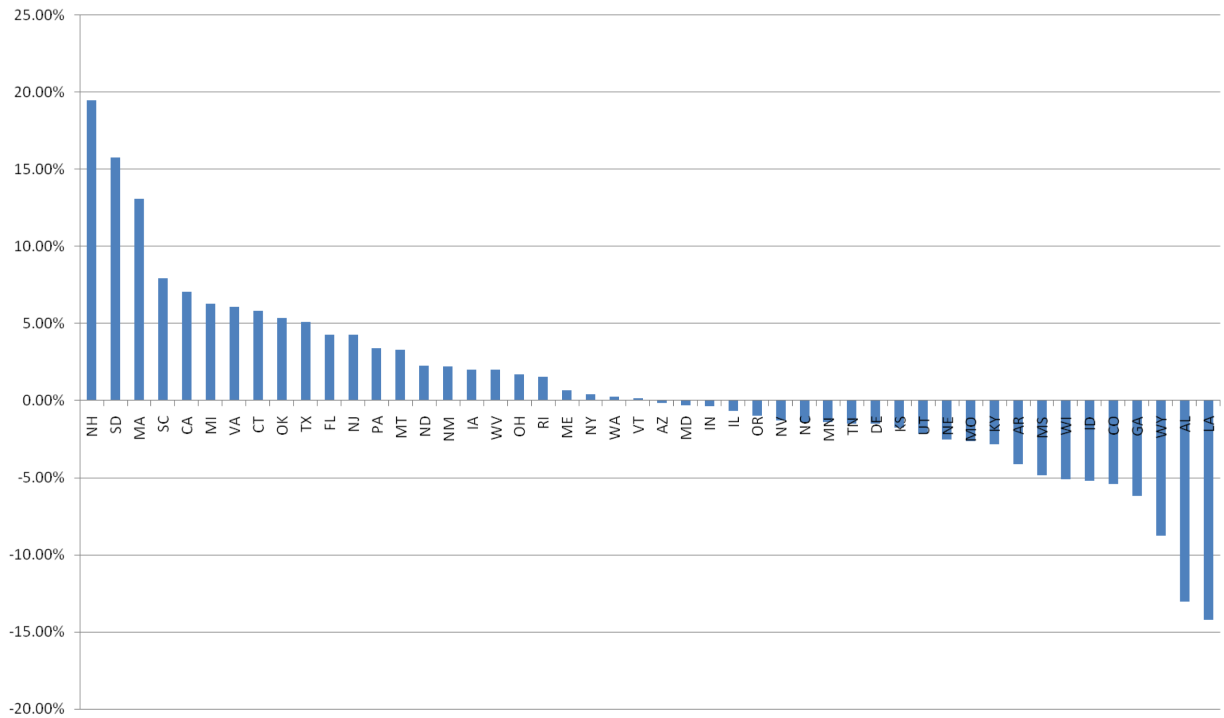


Figure 4-54. Simulated Net Gains to AIPs by State Relative to Baseline, CGCM3.1

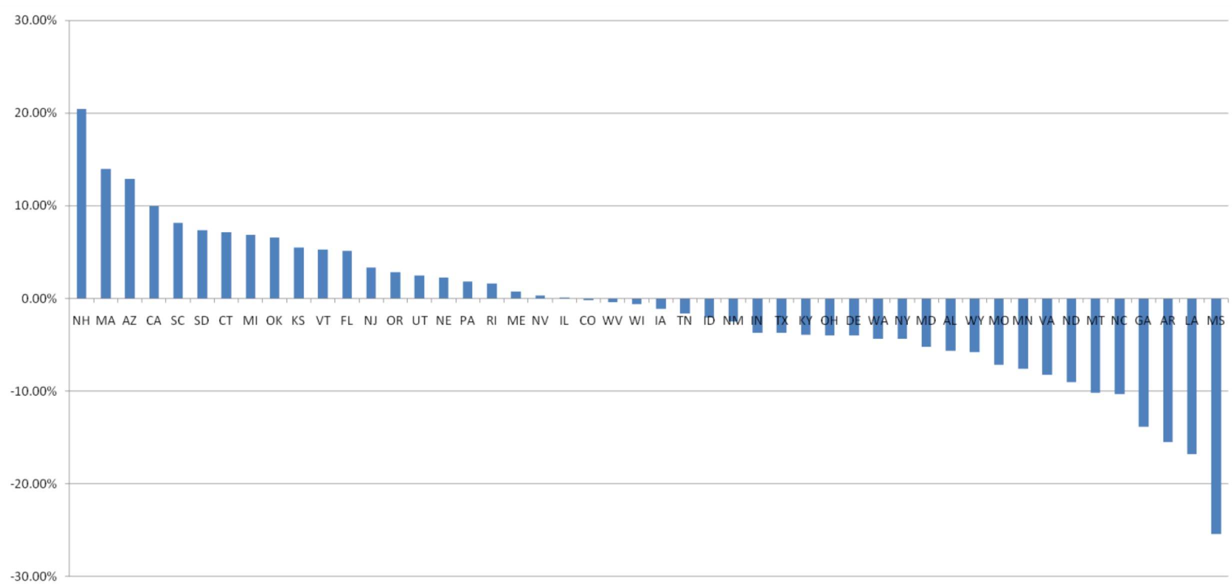
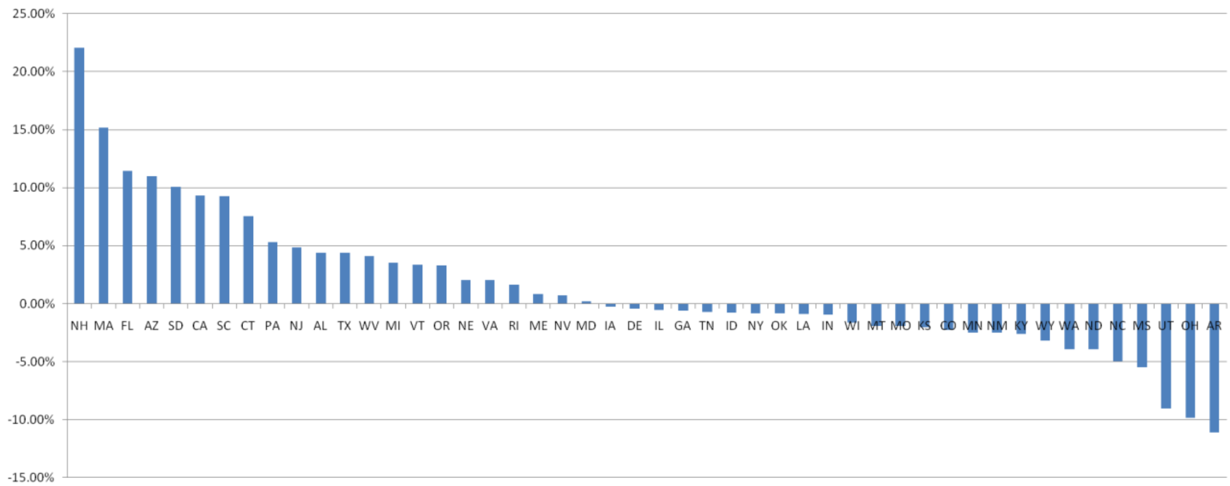
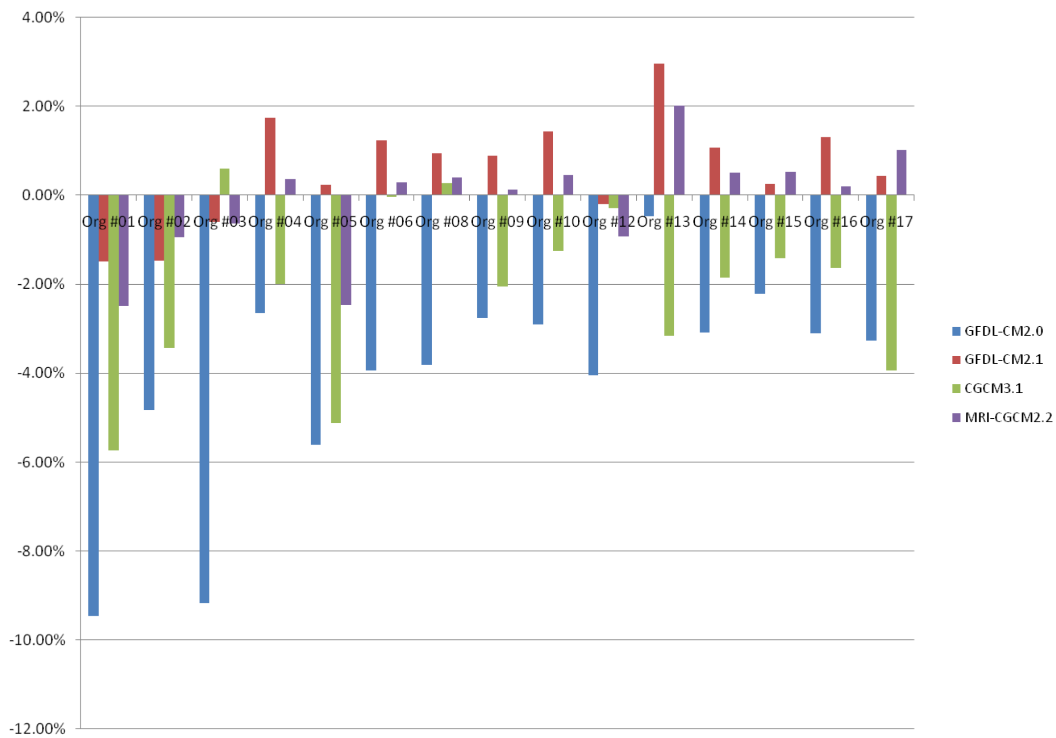


Figure 4-55. Simulated Net Gains to AIPs By State Relative to Baseline, MRI-CGCM2.2



There are also some differences in the changes in simulated returns under our climate scenarios across AIPs due to differences in the portfolios that they hold. Some tend to be focused more in regions with larger simulated reductions in net gains, for instance, while others may be more diversified across regions and crops. Figure 4-56 summarizes the simulated changes in net gains relative to the baseline by AIP.

Figure 4-56. Simulated Net Gains to AIPs by Organization Relative to Baseline



Summary and Implications for U.S. Crop Insurance

In this report, we provide an assessment of the potential long-term implications of climate change on the U.S. crop insurance portfolio. Agricultural producers have always faced numerous production and price risks, but forecasts of more rapid changes in climatic conditions in the future have raised concerns that these risks will increase in the future relative to historical conditions. In addition to implications for landowner decisions regarding land use, crop mix, and production practices, changing agricultural risks could potentially affect the performance of the crop insurance program. Thus, we assess the potential implications of climate change on the financial returns to both the FCIC and the AIPs under the current SRA and identify potential considerations for the specification of the SRA and other aspects of the crop insurance program that may help to mitigate financial impacts. However, the state of the available science has not yet reached a point where climate change impacts on agriculture can be identified in sufficient detail and accuracy to determine the quantitative changes in the crop insurance program that would be needed to mitigate these potential impacts.

Although the modeling system applied builds on existing models that have been used for climate change assessments and reflects what we consider reasonable and appropriate assumptions, it is very important to recognize the considerable uncertainties surrounding the results of this study or any study assessing the potential impacts of climate change on agricultural production. First, there is considerable variation in the publicly available climate projections data between GCMs, including both differences in the magnitude of temperature changes as well as in the magnitude and direction of changes in precipitation for regions of the U.S. These differences in projected climate conditions lead to differences in simulated changes in crop yields, with many cases where crop yields and yield variability simulated by EPIC for a given crop/region combination may be increasing or decreasing depending on the GCM used. We selected the GCMs used in this study based on data availability as well as their ability to provide a range of potential outcomes representative of the range of climate projections developed for the IPCC, but there are a number of other GCMs that have been used for climate projections, each of which would provide a somewhat different picture of future climate conditions across the U.S. Second, while we are building upon existing models that have been used extensively in the climate change literature, there are numerous assumptions regarding parameters, distributions, and model structure embedded in these models (as well as any other existing models) that may potentially have an effect on the overall outcome of the study.

In addition, the primary results presented above are assuming future climate impacts are applied to the simulated experience over a 36-year period from 1972-2007 and the 2006 baseline crop insurance book of business. There are numerous behavioral adjustments that would be expected under changing climate conditions, but attempting to model all of these responses was outside the scope of the current project. For instance, producers would be expected to respond to changing climate conditions by changing planting dates and cultivars (planting dates change in EPIC model simulations based on degree days). Also, changes in expected net returns and variability of those returns for alternative crops would lead not only to potential changes in crop mix and irrigation status, which we did model using FASOM, but also producer selection of insurance products and coverage levels. Also, while changes in crop mix, irrigation, and other production practices was modeled using FASOM, the book of business was held constant for these simulations so those mitigating changes in crop mix and practices are not reflected. In addition, to the extent that changing climatic conditions are negatively affecting yields over time, there will be greater incentives to conduct research on drought-tolerant, heat-tolerant, and other crop varieties better suited to the changing conditions, which would tend to reduce climate impacts on crop yields. Similarly, to the extent that AIPs believe AIPs would also be expected to make changes to their crop insurance portfolios in response to changing expected net gains and variability of net gains for different crops and states and to alter their retention rates within constraints imposed by the SRA. Another consideration is that climate impacts taking place outside the U.S. could have major effects on trade patterns and global commodity prices that would also influence producer decisions.

5.1 Projected Changes in Weather and Crop Yields

As described earlier, there is general consensus in the scientific literature that human-induced climate change has taken place and will continue to do so over the next century. Much of the literature examining potential climate change impacts on crop production has focused on projected changes in regional crop yields with higher temperatures and changes in precipitation, frequently incorporating the positive effects of CO_2 fertilization as well. There is typically more agreement between models on the temperature increases than for changes in precipitation, which is reflected in the GCMs we are using for this project. Another key consideration is that while temperature increases may increase yields for some crops in some regions at least up to a certain threshold, temperatures exceeding threshold highs can begin to cause very negative impacts. In addition, many of the GCMs used in the IPCC reports find increasing intensity in precipitation, which is projected to increase the probability of both flooding and droughts in different regions. In addition to potential increases in heat waves, droughts, and floods, there are concerns about potential increases in the frequency of tropical storms, tornadoes, and hailstorms, although it is very difficult to model impacts on those extreme events and there is little quantitative information available.

In Section 2 and Appendix A, we summarize some of the key changes in temperatures and precipitation simulated using the GCMs applied in this study. As a result of these changes in future growing conditions, growing regions may shift over time so we modified the EPIC model to generate information on yield potential for areas outside the historical growing regions, as discussed in Section 3. Changing production regions will tend to increase the demand for development of insurance program materials for new regions. In Section 4, we present EPIC model results showing the simulated changes in yields for dryland and irrigated production for major crops across all areas of the U.S. with substantial agricultural production. Because we are using daily weather files in the EPIC simulations, the simulated crop yields should be reflecting changes in heat waves as well as dry or wet periods that are incorporated within the weather files. We also summarize some of the simulated changes in regional crop acreage and prices from FASOM, which indicates substantial potential shifts in crop production.

5.2 Financial Impacts on FCIC and AIPs

Applying the modeling system described above, we find large effects on crop yields under the climate change scenarios modeled, both positive and negative. In general, yields increase in northern areas relative to southern areas for major crops other than wheat, but the patterns of simulated yield changes for a given climate scenario are complex and depend heavily on the individual crop, irrigation status, interactions with changes in precipitation that affect water availability, regional soils, and many other factors. There are also considerable differences in the yield change patterns between GCM scenarios. While each of the GCMs considered projected increases in average national maximum and minimum daily temperatures, they differ in the magnitude of these effects. Also, consistent with the greater uncertainties associated with projecting precipitation than temperature using GCMs, the precipitation patterns differ across models not only in magnitude but in direction of the change in precipitation for the U.S. overall as well as for key production regions.

As a result of these changing yields, equilibrium crop acreage allocation and production patterns change as producers switch crops in response to changes in relative expected profitability and risk. There are also changes in the simulated loss cost ratios due to changes in the yield and price distributions. However, even without allowing for any reallocation of liabilities and premiums in response to changing conditions, the changes in simulated net gains and standard deviation of net gains for AIPs under the climate change scenarios simulated using the SRA model are relatively small at the national level. This is partially due to the readjustment of yield guarantees as projected yields change under different climate conditions. It also reflects the diverse impacts across scenarios, crops, and regions, where there are numerous cases where production of a given crop within a region may become less risky due, for instance, to increased precipitation. Thus, while there are reductions in simulated net gains in some regions, there are also increases in other regions that largely offset at the national level. This is consistent with previous studies finding that agricultural impacts of climate change in the U.S. may be relatively small at the national level, but that this obscures the potential distributional effects within the U.S. However, it is also reflective of the risk protection provided to the AIPs by the SRA. The climate change scenarios have substantially larger impacts on the simulated net gains and standard deviation of gains to the FCIC than the AIPs, again holding the distribution of liabilities and premiums constant at base levels. Simulated average net gains for AIPs aggregated to the national level vary only from 3.1 percentage points below to 1.2 percentage points above the base simulated post-SRA return of 23.5%. Simulated average net gains to the FCIC, on the other hand, vary from 26.8 percentage points below to 14.4 percentage points above the base simulated return of 12.7% across the climate scenarios examined.

While the changes in simulated net gains to AIPs at the national level are relatively small, there are far greater deviations in the changes in simulated net gains to AIPs across individual states. Averaging across the four primary GCM scenarios analyzed, the change in simulated expected returns ranges from an increase of 20 percentage points to a reduction of 14 percentage points. In general, simulated net gains tend to be increasing in Northeastern and West Coast states and decreasing in most of the interior states of the U.S. as well as the Southcentral region. The largest percentage point declines in net gains are found in a band of states in the Southcentral and Southeast regions (Alabama, Arkansas, Georgia, Louisiana, Mississippi, and North Carolina) where there are large increases in temperature extremes, precipitation tends to be declining in the GCMs, and there is little irrigation. It is very important to recognize the uncertainties associated with climate modeling, however, particularly in downscaling climate model results to the regional level, due to the highly complex nature of the climate system and the evolving scientific understanding of interconnections between climate and terrestrial systems.

In addition, the primary results presented above are assuming future climate impacts are applied to recent historical conditions and the 2006 baseline crop insurance book of business. There are numerous behavioral adjustments that would be expected under changing climate conditions, but attempting to model all of these responses was outside the scope of the current project. For instance, producers would be expected to respond to changing climate conditions by changing planting dates and cultivars (planting dates change in EPIC model simulations based on degree days). Also, changes in expected net returns and variability of those returns for alternative crops would lead not only to potential changes in crop mix and irrigation status, which we did model using FASOM, but also producer selection of insurance products and coverage levels. In addition, to the extent that changing climatic conditions are negatively affecting yields over time, there will be greater incentives to conduct research on drought-tolerant, heat-tolerant, and other crop varieties better suited to the changing conditions, which would tend to reduce climate impacts on crop yields. Similarly, to the extent that AIPs believe AIPs would also be expected to make changes to their crop insurance portfolios in response to changing expected net gains and variability of net gains for different crops and states and to alter their retention rates within constraints imposed by the SRA. Another consideration is that climate impacts taking place outside the U.S. could have major effects on trade patterns and global commodity prices that would also influence producer decisions.

5.3 Current Risk-Sharing Terms of the SRA

The SRA model has been updated during the course of this project to reflect the current risk-sharing terms of the SRA, i.e., the retention rates and shares of gains and losses going to AIPs under different loss ratios and reinsurance pools. In addition, it is relatively simple to modify the assumed shares for each category of loss ratios and reinsurance pool such that any potential change in shares can readily be examined. The SRA model can also be used to examine loss mitigation options such as limiting coverage. For instance, higher coverage levels could be excluded, premiums could be increased, or SRA parameters could be defined on a regional rather than national level. Clearly, there are modifications that could be made to increase the expected net gain and reduce the variability of gains for the FCIC, but what those actions would potentially be depends on the individual climate scenario and FCIC goals.

5.4 Need for Catastrophic Modeling

Based on the existing literature on potential climate change and GCM projections, catastrophic modeling is likely to become increasingly important over time as temperature thresholds for crop germination, growth, and winter chill are exceeded more frequently; water availability increasing becomes a constraint limiting yields for certain crop/region combinations; and catastrophic events may occur more frequently. Relying on historical data implicitly assumes low-frequency high-loss events are reflected in the data. However, data series for some crops/regions may not be long enough to capture these events and the probability of these extreme events may change in the future given projected changes in climate. EPIC simulates the effects of temperature thresholds and extreme events to the extent that they are present in the GCM outputs, but changes in extreme events are highly uncertain and are not necessarily well-captured in available GCMs. There is also little existing information in the literature quantifying potential changes in extreme events that could be utilized in our modeling system. Thus, as a simple sensitivity analysis we explored the effects on simulated net gains of making the probability of experiencing years like the two years in our dataset with the lowest simulated returns out of the 36 historical years included in the simulations (1988 and 1993) occur about twice as frequently. As expected, this decreases simulated average net gains for both AIPs and the FCIC, with a 1.5 percentage point reduction in average net gain to AIPs (6.5% reduction) and a 2.7 percentage point reduction in average net gain to the FCIC (21.3% reduction).

5.5 Loss Mitigation Options

Under any of the future climate scenarios modeled, the crop insurance program is expected to be impacted through changes in expected losses that may necessitate modifications to the program to maintain actuarial soundness. However, to the extent that these changes occur very gradually over time, they may largely be handled through the normal annual updating process for insurance programs. The larger issue is the extent to which conditions in the near future can no longer be predicted reasonably well based on historical experience because conditions are changing too rapidly, certain crop/region combinations begin hitting temperature or water availability thresholds that have large non-linear negative yield effects, or there are changes in the probability of other catastrophic events that would increase requirements for the disaster reserve factor to adequately account for such events. However, there is currently not enough consensus on these effects to accurately determine specific changes to the crop insurance program would sufficiently mitigate these impacts.

As mentioned above, the SRA model is well-suited to analysis of loss mitigation options, including changes to the shares of gains and losses distributed between FCIC and AIPs for the different reinsurance pools, which can be readily incorporated in the current model version. In addition, it is straightforward to limit coverage levels by excluding liabilities and premiums from high coverage levels from the SRA model or by redistributing them (following adjustments) to lower coverage levels. The model can also be used to examine the implications of limiting coverage for particular crops and/or regions. An important consideration for any of the loss mitigation options is the assumed rules that AIPs use to respond to changes in the SRA in their reinsurance decisions. Although high losses for particular crop/region/product/coverage levels may imply restrictions on those combinations to reduce losses, it is also important to consider potential changes in AIP behavior that could partially offset reductions in FCIC losses. Different assumptions regarding AIP behavior can be incorporated into the model to explore the impacts of varied AIP responses to implementation of loss mitigation options.

5.6 Stress Testing

The models being applied in this project are certainly well-suited to conducting a number of stress tests/sensitivity analyses to explore the implications of different assumptions. In a project and modeling structure as necessarily complex as this one, there are a large number of assumptions that are required to construct and run the models so it is important to consider the implications of varying some of those key assumptions. The changes in temperature and precipitation based on alternative GCMs provide insights into the importance of underlying weather assumptions and associated changes in potential crop yields. We have calibrated our models to generate baseline net returns by reinsurance fund that are close to the historical values, though with the assumption that the 2006 book of business is applied to all previous years will tend to lead to greater differences between the simulated and historical returns, especially as one moves farther away in time from 2006. We have conducted a number of sensitivity analyses, but one implication is that there is considerable uncertainty surrounding the simulation results, as noted elsewhere.

5.7 Implications for U.S. Crop Insurance

Given the large uncertainties regarding the direction and magnitude of effects for individual crops and regions, it remains premature to provide definitive answers regarding the projected impacts of future climate conditions on the U.S. crop insurance program. In general, the crop insurance program may be impacted by changes in the expected losses that necessitate modifications to the program to maintain actuarial soundness. However, to the extent that these changes occur very gradually over time, they may largely be handled through the normal annual updating process for insurance programs. The larger issue is the extent to which conditions in the near future can no longer be predicted reasonably well based on historical experience because conditions are changing too rapidly, certain crop/region combinations begin hitting temperature or water availability thresholds that have large non-linear negative yield effects, or there are changes in the probability of other catastrophic events that would increase requirements for the disaster reserve factor to adequately account for such events.

Between the scenarios included in this study, there are numerous cases where the mean and/or variance of the yield distribution for a given crop/region/irrigation status combination may be increasing in one scenario and decreasing in another, making it difficult to determine with confidence whether a given crop/region/practice is becoming more or less risky. One of the implications is that it is possible that expected losses could decline and returns could actually improve under some scenarios, especially at the national level when aggregating across all crops where there may be both positive and negative effects and the net effect will depend on the distribution of liabilities across crops, regions, and coverage levels. Therefore, one of the most important implications of this analysis is that there remains a need for additional data and research to improve our understanding of future climate and provide a more consistent picture of expected future impacts under a given GHG emissions scenario.

Regardless of future climate scenario, issues that would likely need to be considered in the future development of the crop insurance program include the need to develop rates, loss adjustment standards, underwriting standards, and other insurance program materials that are appropriate for new production regions or for changes in practices within existing regions. For instance, areas that have not relied heavily on water-saving practices or irrigation in the past may begin switching to those practices in the future if drying occurs in their regions. Other regions may move in the opposite direction. Either would tend to make historical yield data less useful for predicting future yields. Certain crop varieties may also offer considerably better yields than others under hot, wet, or dry conditions. Generally, it is likely that there will need to be greater resources devoted to modeling the effects of the more rapidly changing conditions and practices that are expected under climate change and appropriately include them within insurance policy specifications, loss adjustment standards, and underwriting standards. Agricultural production has been adapting to changing conditions and practices from the beginning of human cultivation, but the key difference typically attributed to production under climate change scenarios is the extremely rapid rate of change in typical regional weather conditions. Devoting additional resources to both understanding these more rapid changes in future conditions and adapting agricultural production and risk management programs is expected to be important for maintaining the actuarial soundness and risk management offered by the U.S. crop insurance program.

References

Adams, D., R. Alig, B.A. McCarl, and B.C. Murray. 2005. "FASOMGHG Conceptual Structure and Specification: Documentation." Available at http://agecon2.tamu.edu/people/faculty/mccarl-bruce/papers/1212FASOMGHG_doc.pdf.

Amthor, J.S. 2001. "Effects of Atmospheric CO_2 Concentration on Wheat Yield: Review of Results from Experiments Using Various Approaches to Control CO_2 Concentration." *Field Crops Research* 73: 1-34.

Baldocchi, D., and S. Wong. 2006. *An Assessment of the Impacts of Future CO_2 and Climate on Californian Agriculture*. CEC-500-2005-187-SF. Sacramento, CA: California Climate Change Center.

Boote, K.J., J.W. Jones, and N.B. Pickering. 1996. "Potential Uses and Limitations of Crop Models." *Agronomy Journal* 88:704–716.

Boote, K.J., N.B. Pickering, and L.H. Allen, Jr. 1997. "Plant Modeling: Advances and Gaps in Our Capability to Project Future Crop Growth and Yield in Response to Global Climate Change." In *Advances in Carbon Dioxide Effects Research.* [L.H.Allen, Jr., M.B. Kirkman, D.M. Olszyk, and C.E. Whitman (eds.)]. ASA Special Publication No. 61. ASA-CSSA-SSSA: Madison, WI.

Brown, R.A., and N.J. Rosenberg. 1999. "Climate Change Impacts on the Potential Productivity of Corn and Winter Wheat in Their Primary United States Growing Regions." *Climatic Change* 41:73-107.

Brown, R.A., N.J. Rosenberg, C.J. Hays, W.E. Easterling, and L.O. Mearns. 2000. "Potential Production and Environmental Effects of Switchgrass and Traditional Crops under Current and Greenhouse-Altered Climate in the Central United States: A Simulation Study." *Agriculture, Ecosystems, and the Environment* 78(1):31-47.

Carbone, G.J., W. Kiechle, C. Locke, L.O. Mearns, L. McDaniel, and M.W. Downton. 2003. "Responses of Soybean and Sorghum to Varying Spatial Scales of Climate Change Scenarios in the Southeastern United States." *Climatic Change* 60:73–98.

Cavero, J., R.E. Plant, C. Shennan, J.R. Williams, J.R. Kiniry, and V.W. Benson. 1998. "Application of EPIC Model to Nitrogen Cycling in Irrigated Processing Tomatoes under Different Management Systems." *Agricultural Systems* 56:391-414.

Chen, C.C. and B.A. McCarl. 2000. "The Value of ENSO Information to Agriculture: Consideration of Event Strength and Trade." *Journal of Agricultural and Resource Economics* 25(2):368-385.

Chen, C.C. and B.A. McCarl. 2009. "Hurricanes and Possible Intensity Increases: Effects on and Reactions from U.S. Agriculture." *Journal of Agricultural and Applied Economics* 41(1):125-144.

Chen, C.C., B.A. McCarl, and R.M. Adams. 2001. "Economic Implications of Potential Climate Change Induced ENSO Frequency and Strength Shifts." *Climatic Change* 49:147-159.

Chen, C.C., D. Gillig, and B.A. McCarl. 2001. "Effects of Climatic Change on a Water Dependent Regional Economy: A Study of the Texas Edwards Aquifer." *Climatic Change* 49:397-409.

Chung, S.W., P.W. Gassman, L.A. Kramer, J.R. Williams, and R. Gu. 1999. "Validation of EPIC for Two Watersheds in Southwest Iowa." *Journal of Environmental Quality* 28:971-979.

Easterling, W.E., C.J. Hays, M.M. Easterling, and J.R. Brandle. 1996. "Modeling the Effect of Shelterbelts on Maize Productivity Under Climate Change: An Application of the EPIC Model." *Agriculture, Ecosystems and Environment* 61:163-176.

Gassman, P.W., J.R. Williams, V.W. Benson, R.C. Izaurralde, L.M. Hauck, C.A. Jones, J.D. Atwood, J.R. Kiniry, and J.D. Flowers. 2005. "Historical Development and Applications of the EPIC and APEX Models." Working Paper 05-WP 397. Ames, IA: Center for Agricultural and Rural Development.

Glecker, P.J., K.E. Taylor, and C. Doutriaux. 2008. "Performance Metrics for Climate Models." *Journal of Geophysical Research* 113:D06104. doi:10.1029/2007JD008972

Goodwin, B.K. 2008. "Payment Limitations and Acreage Decisions under Risk Aversion: A Simulation Approach." *American Journal of Agricultural Economics* 91(1):19-41.

Goodwin, B.K. and A.P. Ker. 1998. "Nonparametric Estimation of Crop Yield Distributions: Implications for Rating Group-Risk Crop Insurance Contracts." *American Journal of Agricultural Economics* 80(1):139-153.

Goodwin, B.K. and A.P. Ker. 2002. "Modeling Price and Yield Risk." In R.E. Just and R.D. Pope, eds., *A Comprehensive Assessment of the Role of Risk in U.S. Agriculture*. Boston, MA: Kluwer Academic Press.

Government Accounting Office. 2007. *Climate Change; Financial Risks to Federal and Private Insurers in Coming Decades Are Potentially Significant*. Report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate. Washington, DC: GAO.

Greenstone, M. and O. Deschenes. 2007. "The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather." *American Economic Review* 97(1): 354-385.

Harri, A., C. Erdem, K.H. Coble, and T.O. Knight. 2009. "Crop Yield Distributions: A Reconciliation of Previous Research and Statistical Tests for Normality." *Review of Agricultural Economics* 31(1):163-182.

Intergovernmental Panel on Climate Change (IPCC). 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.). Cambridge, UK: Cambridge University Press.

Isik, M., and S. Devadoss. 2006. "An Analysis of the Impact of Climate Change on Crop Yields and Yield Variability." *Applied Economics* 38(7):835-844.

Izaurralde, R.C., K.H. Haugen-Kozyra, D.C. Jans, W.B. McGill, R.F. Grant, and J.C. Hiley. 2001. "Soil C Dynamics: Measurement, Simulation and Site-to-Region Scale-up." p.553-575. In R. Lal, J.M. Kimble, R.F. Follett and B.A. Stewart (eds.), *Assessment methods for soil carbon*. Boca Raton, FL: Lewis Publishers.

Izaurralde, R.C., N.J. Rosenberg, R.A. Brown, D.M. Legler, M. Tiscareño-López, and R. Srinivasan. 1999. "Modeled Effects of Moderate and Strong Los Niños on Crop Productivity in North America." *Agricultural and Forest Meteorology* 94:259-268.

Izaurralde, R.C., N.J. Rosenberg, R.A. Brown, and A.M. Thomson. 2003. "Integrated Assessment of Hadley Center (HadCM2 Climate-Change Impacts on Agricultural Productivity and Irrigation Water Supply in the Conterminous United States—Part II: Regional Agriculture Production in 2030 and 2095." *Agricultural and Forest Meteorology* 117:97-122.

Johnson, J.L., S. Kotz, and N. Balakrishnan. 1994. *Continuous Univariate Distributions*. New York: Wiley and Sons.

Ker, A.P. and B.K. Goodwin. 2000. "Nonparametric Estimation of Crop Insurance Rates Revisited." *American Journal of Agricultural Economics* 82(2):463-78.

Ker, A.P. and K. Coble. 2003. "Modeling Conditional Yield Densities." *American Journal of Agricultural Economics* 85(2):291-304.

Kimball, B.A. 1983. "Carbon Dioxide and Agricultural Yield: An Assemblage of Analysis of 430 Prior Observations." *Agronomy Journal* 75:779-788.

Kimball, B.A. and S.B. Idso. 1983 "Increasing Atmospheric CO2: Effects on Crop Yield, Water Use, and Climate." *Agricultural Water Management* 7:55-72.

Legler, D.M., K.J. Bryant, and J.J. O'Brien. 1999. "Impact of ENSO-related Climate Anomalies on Crop Yields in the US." *Climatic Change* 42:351-375.

Morgan, P.B., T.A. Mies, G.A. Bollero, R.L. Nelson, and S.P. Long. 2006. "Season-long Elevation of Ozone Concentration to Projected 2050 levels under Fully Open-air Conditions Substantially Decreases the Growth and Production of Soybean." *New Phytologist* 170:333-343.

Lu, Y., O.A. Ramirez, R.M. Rejesus, T.O. Knight, and B.J. Sherrick. 2008. "Empirically Evaluating the Flexibility of the Johnson Family of Distributions: A Crop Insurance Application." *Agricultural and Resource Economics Review* 37(1):79-91.

McCarl, B. and J. Reilly. 2006. "US Agriculture in the Climate Change Squeeze: Part 1: Sectoral Sensitivity and Vulnerability." Working paper. College Station, TX: Texas A&M University.

McCarl, B.A., X. Villavicencio, and X. Wu. 2008. "Climate Change and Future Analysis: Is Stationarity Dying?" *American Journal of Agricultural Economics* 90(5):1241-1247.

Meehl, G.A., T.F. Stocker, W.D. Collins, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007. "Global Climate Projections." In *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt,

M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Mendelsohn, R., W. Nordhaus, and D. Shaw. 1994. “The Impact of Global Warming on Agriculture: A Ricardian Analysis.” *American Economic Review* 84(4):753-771.

Mitchell, P.D. and T.O. Knight. 2008. “Economic Analysis of Supplemental Deductible Coverage as Recommended in the USDA’s 2007 Farm Bill Proposal.” *Agricultural and Resource Economics Review* 37(1):117-131.

Long, S.P., E.A. Ainsworth, A.D.B. Leakey, J. Nösberger, and D.R. Ort. 2006. “Food for Thought: Lower-Than-Expected Crop Yield Stimulation with Rising CO_2 Concentrations.” *Science* 312(5782):1918-1921.

Nakicenovic, N., J. Alcamo, G. Davis, et al. 2000. *Special Report on Emissions Scenarios: A Special Report of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press.

Post, W.M., R.C.C. Izaurralde, J.D. Jastrow, B.A. McCarl, J.E. Amonette, V.L. Bailey, P.M. Jardine, T.O. West, and J. Zhou. 2004. "Enhancement of Carbon Sequestration in US Soils." *BioScience* 54(10):895-908.

Potter, S.R., J.D. Atwood, R.L. Kellogg, and J.R. Williams. 2004. “An Approach for Estimating Soil Carbon Using the National Nutrient Loss Database.” *Environmental Management* 33:496-506.

Potter, K.N., J.R. Williams, F.J. Larney, and M.S. Bullock. 1998. “Evaluation of EPIC's Wind Erosion Submodel using Data from Southern Alberta.” *Canadian Journal of Soil Science* 78:485-492.

Puurveen, H.P., R.C. Izaurralde, D.S. Chanasyk, J.R. Williams, and R.F. Grant. 1997. “Evaluation of EPIC's Snowmelt and Water Erosion Submodels using Data from the Peace River Region of Alberta.” *Canadian Journal of Soil Science* 77:41-50.

Randall, D.A., R.A. Wood, S. Bony, R. Colman, T. Fichefet, J. Fyfe, V. Kattsov, A. Pitman, J. Shukla, J. Srinivasan, R.J. Stouffer, A. Sumi and K.E. Taylor, 2007. “Climate Models and Their Evaluation.” In *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Reilly, J., F. Tubiello, B. McCarl, D. Abler, R. Darwin, K. Fuglie, S. Hollinger, C. Izaurralde, S. Jagtap, J. Jones, L. Mearns, D. Ojima, E. Paul, K. Paustian, S. Riha, N. Rosenberg, and C. Rosenzweig. 2003. “U.S. Agriculture and Climate Change: New Results.” *Climatic Change* 57:43-69.

Roloff, G., R. de Jong, R.P. Zentner, C.A. Campbell, and V.W. Benson. 1998. “Estimating Spring Wheat Yield Variability with EPIC.” *Canadian Journal of Soil Science* 78:541-549.

Rosenzweig, C., A. Iglesias, X.B. Yang, P.R. Epstein, and E. Chivian. 2000. “Climate Change and U.S. Agriculture: The Impacts of Warming and Extreme Weather Events on Productivity, Plant Diseases, and Pests.” Center for Health and the Global Environment, Harvard Medical School.

Schlenker, W. and M. Roberts. 2006. “Estimating the Impact of Climate Change on Crop Yields: Non-linear Effects of Weather on Corn Yields." *Review of Agricultural Economics* 28(3):391-398.

Schlenker, W., M. Hanneman, and A.C. Fisher. 2005. “Will U.S. Agriculture Really Benefit From Global Warming? Accounting for Irrigation in the Hedonic Approach.” *American Economic Review* 95(1):395-406.

Schlenker, W., M. Hanneman, and A.C. Fisher. 2007. “Water Availability, Degree Days, and the Potential Impact of Climate Change on Irrigated Agriculture in California.” *Climatic Change* 81:19-38.

Sherrick, B.J., F.C. Zanini, G.D. Schnitkey and S.H. Irwin. 2004. “Crop Insurance Valuation under Alternative Yield Distributions.” *American Journal of Agricultural Economics* 86(2):406-419.

Southworth, J., J.C. Randolph, M. Habeck, O.C. Doering, R.A. Pfeifer, D.G. Rao, and J.J. Johnston. 2000. “Consequences of Future Climate Change and Changing Climate Variability on Maize Yields in the Midwestern United States.” *Agriculture, Ecosystems & Environment* 82(1-3):139-158.

Stockle, C.O., P.T. Dyke, J.R. Williams, C.A. Allen, and N.J. Rosenberg. 1992a. “A Method for Estimating Direct and Climatic Effects of Rising Atmospheric Carbon Dioxide on Growth and Yield of Crops: Part II -- Sensitivity Analysis at Three Sites in the Midwestern U.S.A.” *Agricultural Systems* 38: 239-256.

Stockle, C.O., J.R. Williams, N.J. Rosenberg, and C.A. Allen. 1992b. “A Method for Estimating Direct and Climatic Effects of Rising Atmospheric Carbon Dioxide on Growth and Yield of Crops: Part I -- Modification of the EPIC Model for Climate Change Analysis.” *Agricultural Systems* 38: 225-228.

Thomson, A.M., R.A. Brown, S.J. Ghan, R.C. Izaurralde, N.J. Rosenberg, and L.R. Leung. 2002. “Potential Impacts of Climate Change on Winter Wheat Production in Eastern Washington State: A Simulation Study Linking the PNNL Regional Climate Model with EPIC.” *Climatic Change* 54:141-164.

Thomson, A.M., N.J. Rosenberg, R.C. Izaurralde, and R.A. Brown. 2005a. “Climate Change Impacts for the Conterminous USA: An Integrated Assessment, Part 2, Models and Validation.” *Climatic Change* 69(1):27-42.

Thomson, A.M., R.A. Brown, N.J. Rosenberg, R.C. Izaurralde, and V. Benson. 2005b. “Climate Change Impacts for the Conterminous USA: An Integrated Assessment, Part 3, Dryland Production of Grain and Forage Crops.” *Climatic Change* 69(1):43-66.

U.S. Climate Change Science Program (CCSP). 2008. *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States.* A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. P. Backlund, A. Janetos, D. Schimel, J. Hatfield, K. Boote, P. Fay, L. Hahn, C. Izaurralde, B.A. Kimball, T. Mader, J. Morgan, D. Ort, W. Polley, A. Thomson, D. Wolfe, M. Ryan, S. Archer, R. Birdsey, C. Dahm, L. Heath, J. Hicke, D. Hollinger, T. Huxman, G. Okin, R. Oren, J. Randerson, W. Schlesinger, D. Lettenmaier, D. Major, L. Poff, S. Running, L. Hansen, D. Inouye, B.P. Kelly, L Meyerson, B. Peterson, R. Shaw. Washington, DC: U.S. Department of Agriculture.

Van Vuuren, D and K Riahi. 2008. “Do Recent Emissions Trends Imply Higher Emissions Forever?” *Climatic Change* 91:237-248. doi: 10.1007/s10584-008-9485-y

Vedenov, D.V., M.J. Miranda, R. Dismukes, and J.W. Glauber. 2004. “Economic Analysis of the Standard Reinsurance Agreement.” *Agricultural Finance Review* 64(2):119-134.

Vedenov, D.V., M.J. Miranda, R. Dismukes, and J.W. Glauber. 2006. “Portfolio Allocation and Alternative Structures of the Standard Reinsurance Agreement.” *Journal of Agricultural and Resource Economics* 31(1):57-73.

Williams, J.R. 1995. “The EPIC Model.” In *Computer Models in Watershed Hydrology*, V.P. Singh (ed.), pp. 909-1000. Highlands Ranch, CO: Water Resources Publication.

Appendix A: Results from Climate and Crop Yield Simulations for Additional GCMs

This appendix presents results from climate and crop yield simulations for two additional GCMs for the 2010-2040 time period relative to 1960-1990 baseline climate conditions. Thus, these climate scenario results are centered around 2025 rather than 2050 as for the four primary GCM scenarios. In addition, we present a summary of the yield effects implied by the CCSP SAP 4.3 report. The crop yield impacts from these GCMs were not included in the FASOM and actuarial analyses because the scope of this study called for analysis of three climate scenarios (although we did add a fourth to better capture variability across GCMs), although we did some exploratory analyses of the CCSP SAP 4.3 scenario. In addition, the archived GCM data available for these scenarios was at a monthly rather than daily timestep. Thus, unlike the primary GCM results used for analyses in the main body of the report, EPIC model simulations of these two GCMs cannot capture the effects of changes in climate variability within a given month, only the effects of changes in monthly average climate values for each month of the year.

In addition, the specific GCMs with available archived data for this earlier timeframe differ from those with available daily simulation data for 2045-2055. Therefore, results are not directly comparable in terms of showing the transition path for changes in climate over time using a given GCM. Nonetheless, the additional results provided in this appendix provide valuable information on potential climate change and crop yield effects in an earlier timeframe than the primary results presented in the report, as well as presenting results from additional GCMs. Because changes in climate are generally smaller for these nearer-term simulation results, yield effects also tend to be smaller. This is not necessarily the case for all crops and regions, though, due largely to substantial differences in simulated changes in precipitation patterns between GCMs. In addition, the fact that there is less warming in the nearer-term scenarios may result in higher simulated yields in more southern regions, but lower simulated yields in more northern regions of the U.S. relative to the longer-term climate scenarios for many crops.

The two GCMs used for the nearer-term simulations were the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) GCM and the NASA Goddard Institute for Space Studies (GISS) GCM (U.S.). Figures A-1 and A-2 display simulated changes in spring and summer climate conditions for the CSIRO and GISS models, respectively. As expected, these nearer-term simulations generally show less warming across the U.S. than the longer-term simulations presented in the report and there are even some areas of slight cooling in the Western and Northern Midwest U.S. in the summer in the GISS GCM. The CSIRO GCM predicts more warming in northern regions during the growing season while the GISS GCM results show more warming in southern regions. Changes in precipitation are also very different between these GCMs, with the CSIRO model tending to show the Southcentral and Southeast regions getting wetter with drying across the Midwest and the GISS model showing the opposite trends in those regions.

Figure A-1. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the CSIRO GCM, 2010-2040

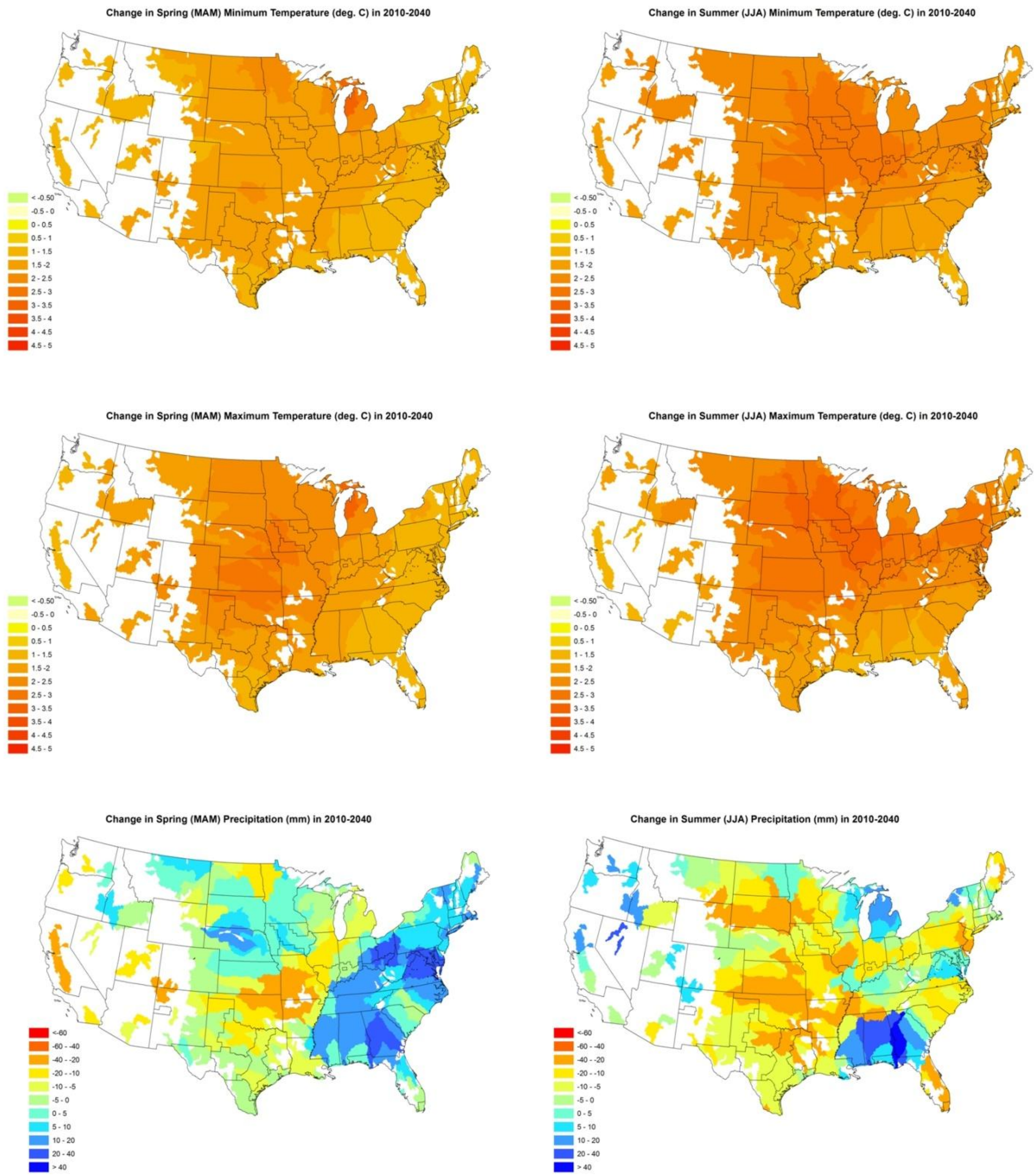
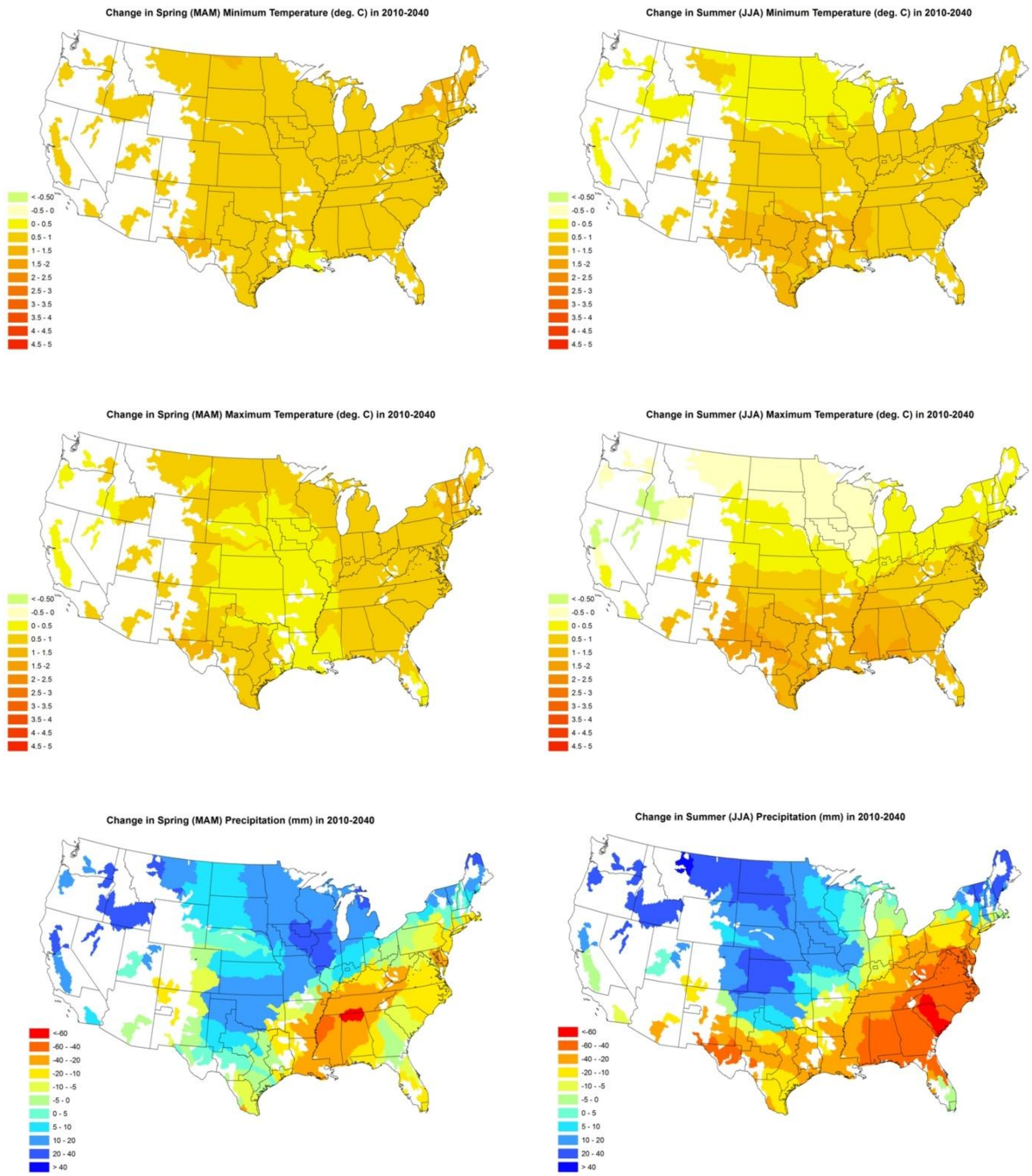
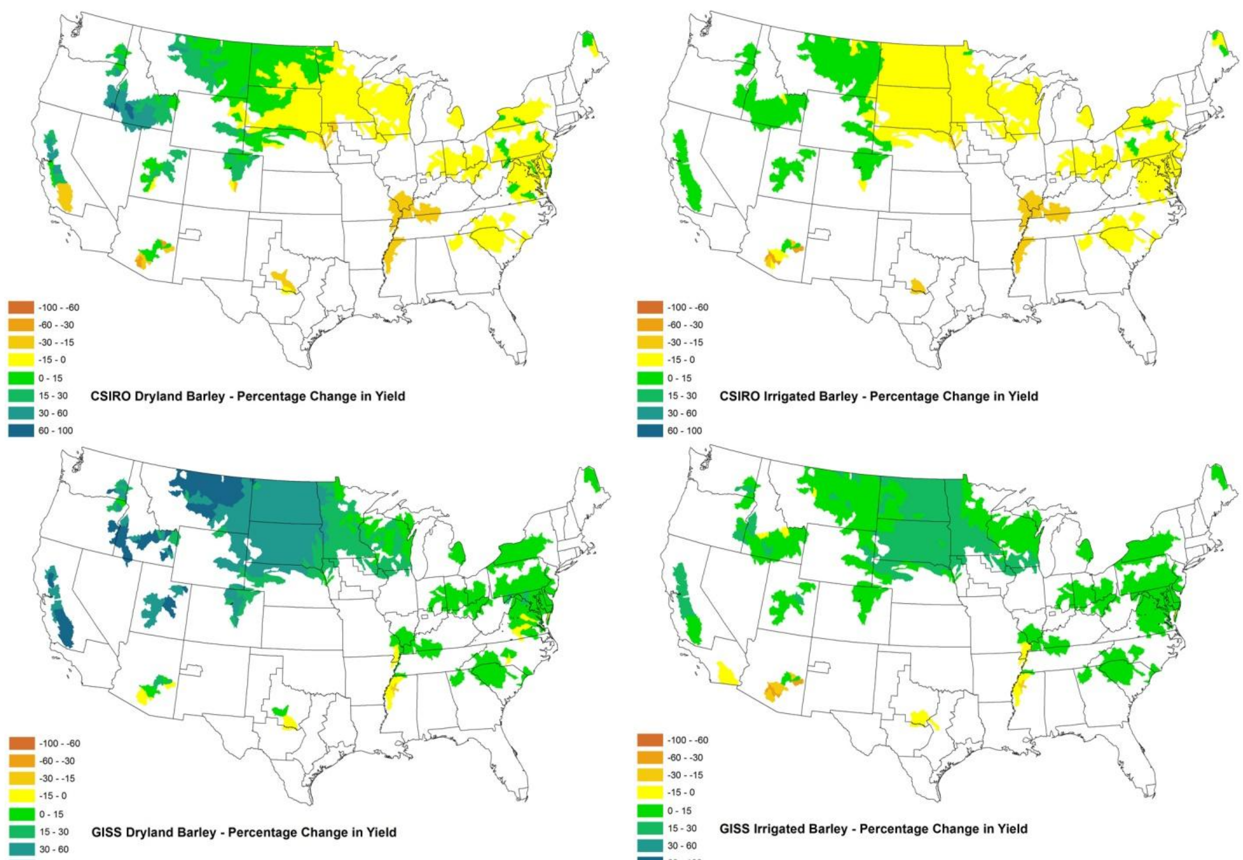


Figure A-2. Simulated Changes in Average Spring (MAM) and Summer (JJA) Temperature (Degrees C) and Precipitation (mm) Using the GISS GCM, 2010-2040



We applied EPIC to simulate the effects of these climate scenarios on crop yields and present the simulation results for major crops grown under both dryland and irrigated conditions below in Figures A-3 through A-11.[8] As expected given the greater warming and Midwestern drying in the CSIRO GCM, yields for major crops tend to be more negatively (or less positively) affected in the CSIRO scenario than the GISS scenario. As for our longer-term scenarios, for every crop and for both GCMs, there are regions that have increases in simulated yields under the projected future climate conditions. For the GISS GCM, there are larger areas with increasing yields than decreasing yields for every crop modeled with EPIC. In addition, crops produced under irrigated conditions are less negatively (more positively) impacted by the simulated changes in climate. Of course, changes in simulated mean yields do not translate directly into changes in expected net gains under the crop insurance program because changes in yield and price distributions as well as market effects play a key role as described in the main body of the report.

Figure A-3. Percentage Change in Dryland and Irrigated Barley Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040



[8] Similar to the simulations conducted for the longer-term climate scenarios, crop yields were simulated using EPIC for both dryland and irrigated conditions for all regions where a given crop was grown in the historical dataset as well as the expanded regions shown in Section 3 of this report regardless of whether both dryland and irrigated production was present in a region in the baseline. This was done to enable FASOM modeling of potential switching between dryland and irrigated production depending on relative yields available under climate scenarios.

Figure A-4. Percentage Change in Dryland and Irrigated Corn Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

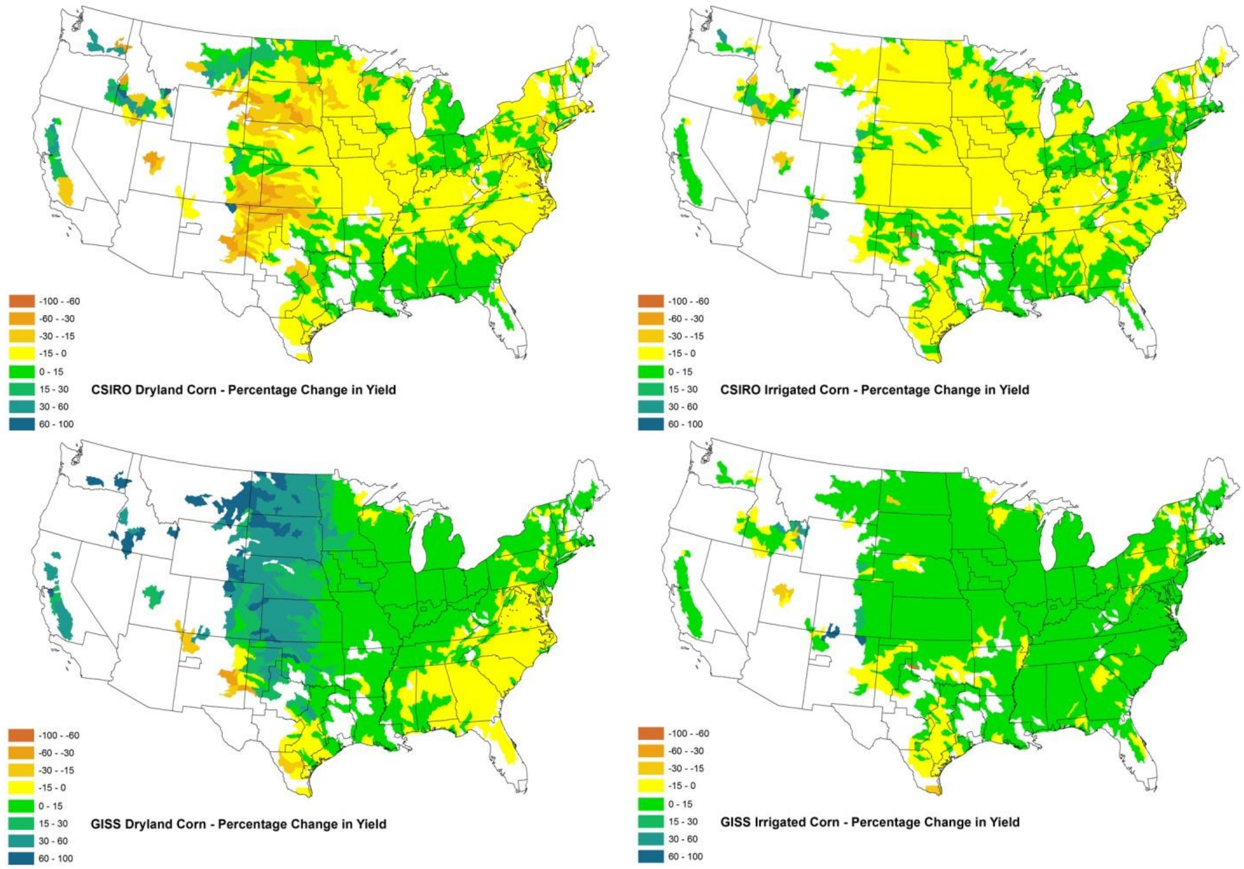


Figure A-5. Percentage Change in Dryland and Irrigated Cotton Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

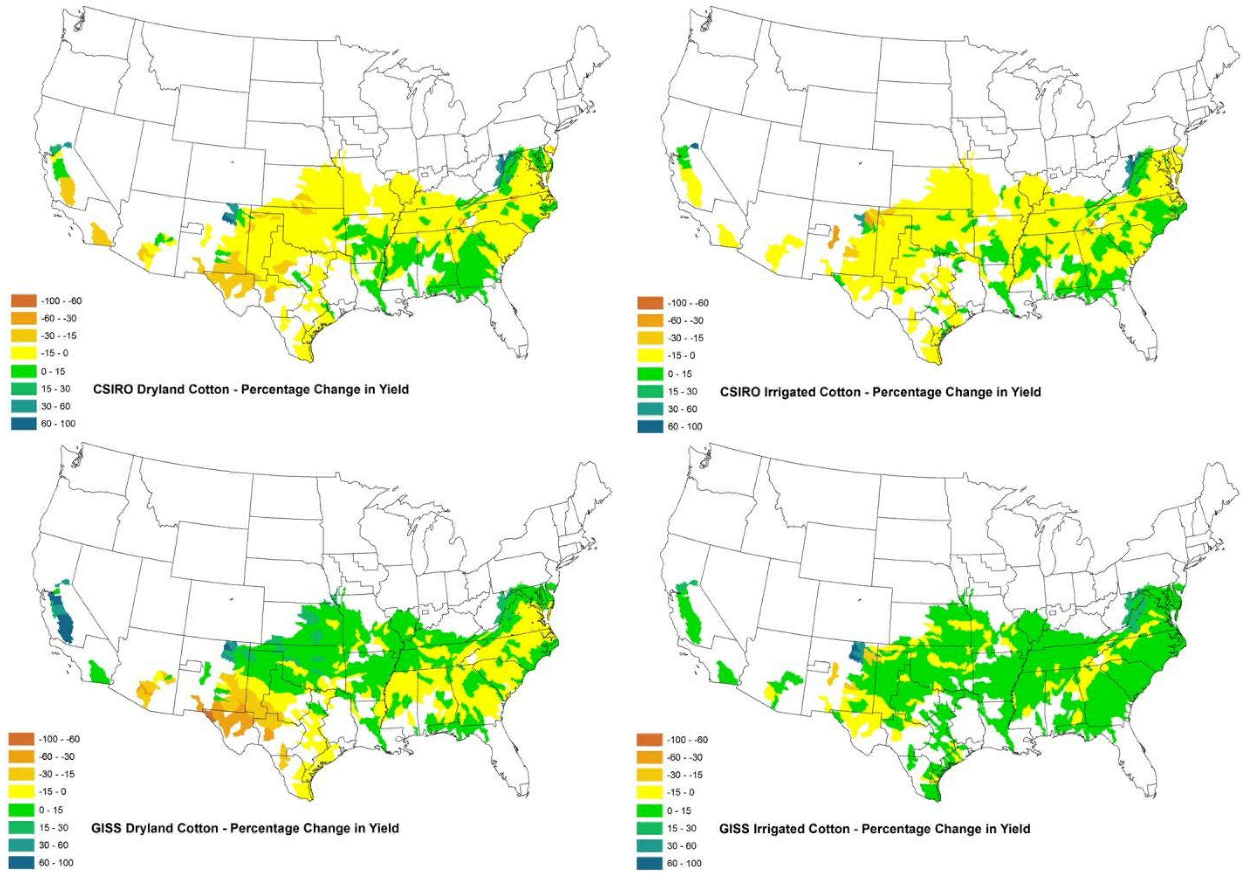


Figure A-6. Percentage Change in Dryland and Irrigated Hay Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

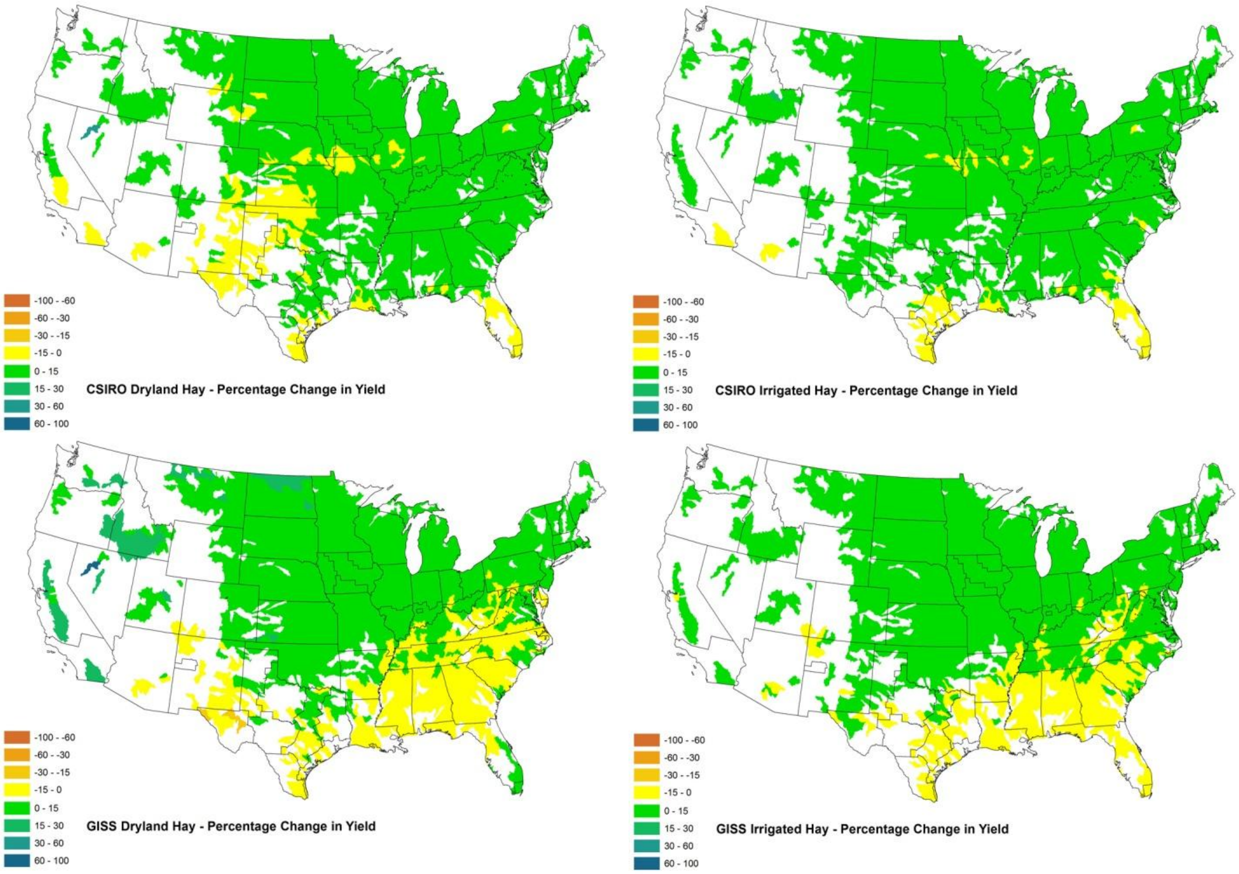


Figure A-7. Percentage Change in Irrigated Potato Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

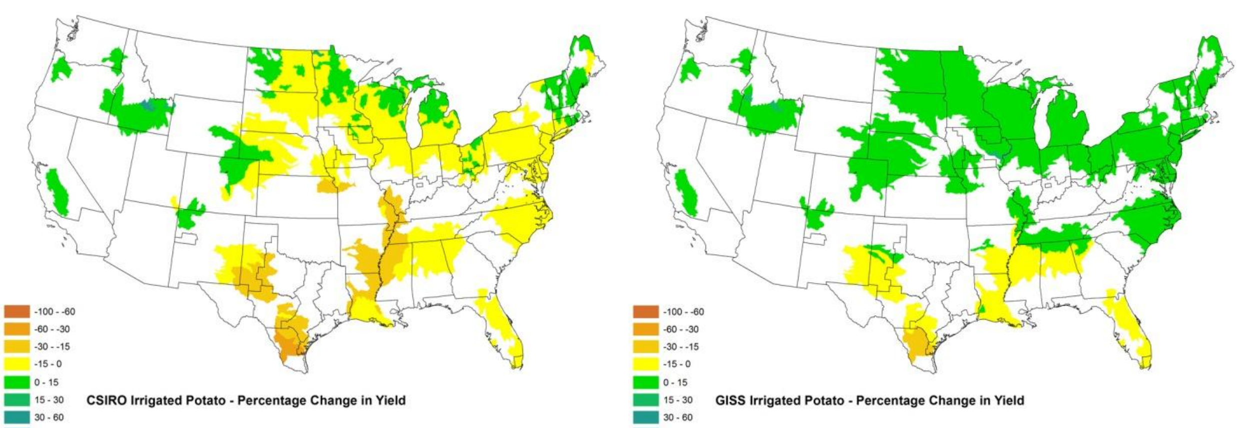


Figure A-8. Percentage Change in Irrigated Rice Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

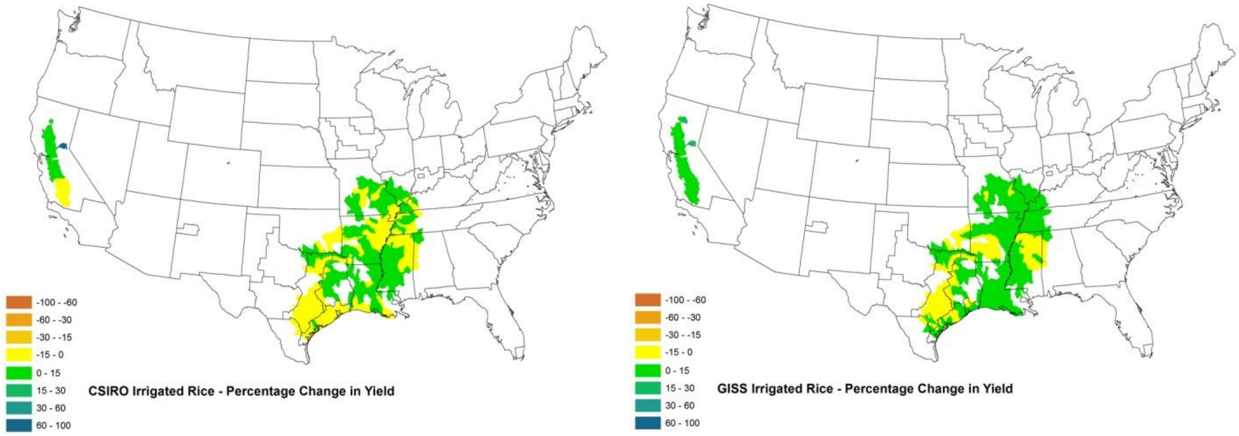


Figure A-9. Percentage Change in Dryland and Irrigated Sorghum Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

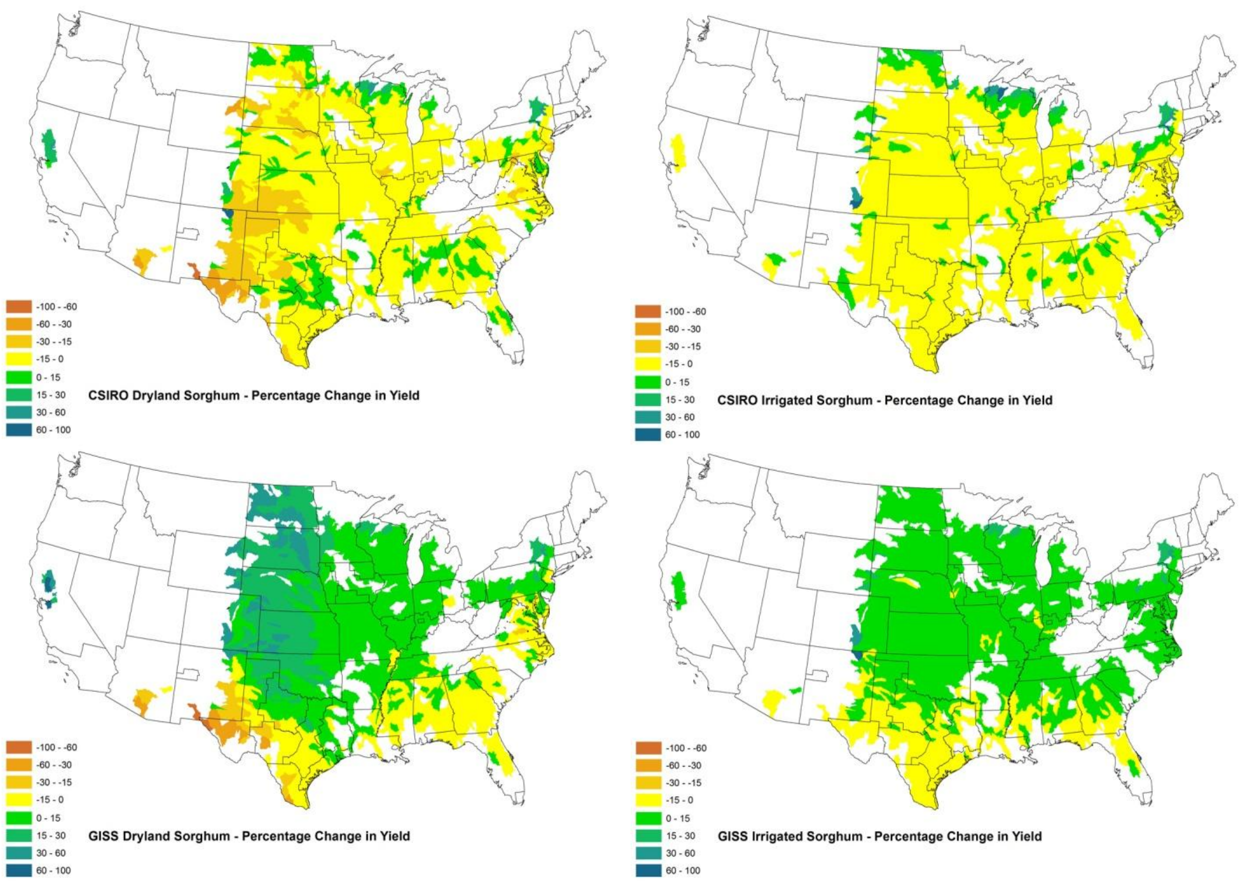


Figure A-10. Percentage Change in Dryland and Irrigated Soybean Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040

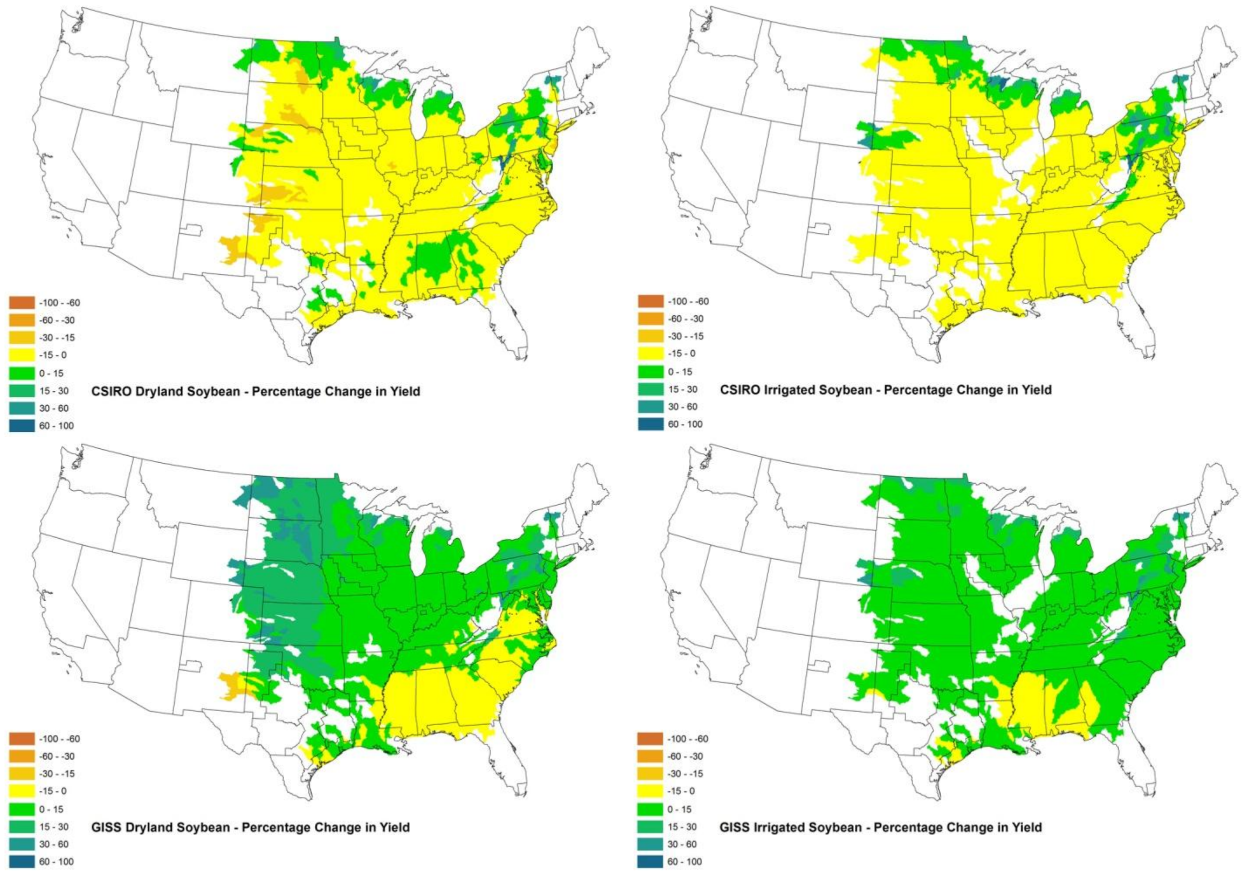
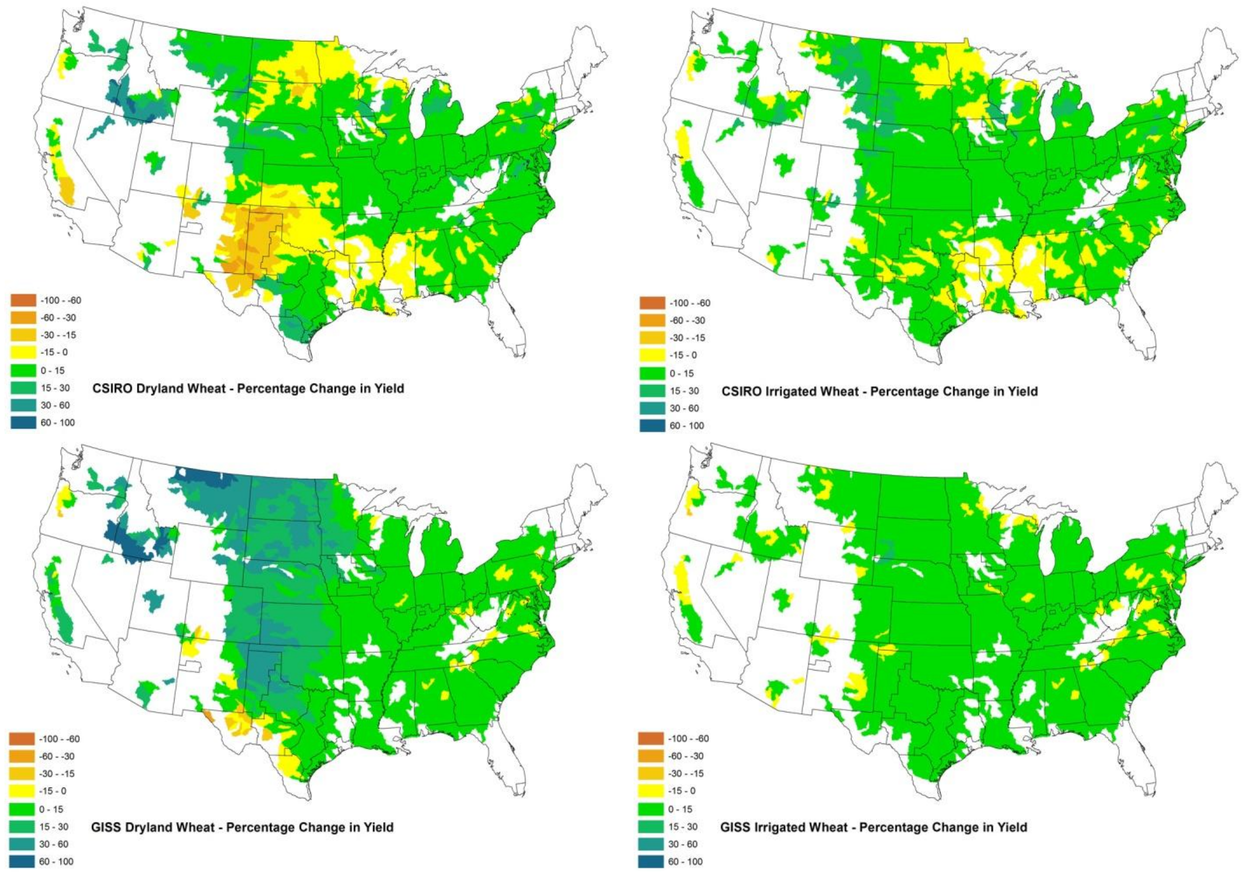


Figure A-11. Percentage Change in Dryland and Irrigated Wheat Yields under the CSIRO and GISS GCMs Simulated Using EPIC, 2010-2040



In addition to all of the EPIC simulation results, we also constructed a far simpler scenario consistent with the CCSP SAP 4.3 report. That report summarizes some of the existing literature on climate change impacts on agricultural production and discusses potential impacts, but differs from the other scenarios considered that are based on GCM outputs run through the EPIC model because it is based on the limited summary information contained in the report rather than detailed and disaggregated modeling results. CCSP SAP 4.3 provided percentage changes in mean yield for corn, wheat, sorghum, cotton, soybean, and rice. No changes in standard deviations of yields or changes in maximum achievable yields were reported in SAP 4.3. To get estimates of changes in standard deviation for corn, cotton, soybean, and wheat, we multiply the SAP 4.3 percent change in mean yield by crop-specific factor. The factor is the ratio of % change in mean yield to % change in standard deviation calculated based on estimates reported in McCarl, Villavicencio, and Wu (2008). However, we felt the ratio implied by the McCarl et al. study for sorghum is too large (576%) to be plausible. Therefore, we calculated this ratio for sorghum using % changes in mean and standard deviations estimated by EPIC for the GCMs available. Finally, SAP 4.3 did not report projected percentage changes in yields for barley, hay, and potato. For these latter crops, we used the average crop-specific percentage change in mean yields and standard deviations across regions estimated by EPIC for the GCMs available. The values used in the CCSP SAP 4.3 scenario for changes in mean yield and standard deviation are shown in Table A-1.

Table A-1. Percentage Shifts in Mean Yield and Standard Deviation under CCSP SAP 4.3 Scenarios

Crop	% Mean Shift	% Standard Deviation Shift
Barley	42.3	82.0
Corn	-3.0	12.9
Cotton	3.5	5.7
Hay	1.2	-0.3
Potato	-36.8	10.3
Rice	-5.6	-0.6
Sorghum	-8.4	-31.6
Soybean	9.9 (Midwest), 3.9 (South)	63.4 (Midwest), 24.9 (South)
Wheat	0.1	0.4

Note: CCSP SAP 4.3 provided percentage changes in mean yield for corn, wheat, sorghum, cotton, soybean, and rice. No changes in standard deviations of yields or changes in maximum achievable yields were reported in SAP 4.3. To get estimates of changes in standard deviation for corn, cotton, soybean, and wheat, we multiply the SAP 4.3 percent change in mean yield by crop-specific factor. The factor is the ratio of % change in mean yield to % change in standard deviation calculated based on estimates reported in McCarl, Villavicencio, and Wu (2008). This ratio implied by the McCarl et al. study for sorghum is too large (576%) to be plausible. Therefore, we calculated this ratio for sorghum using % changes in mean and standard deviations estimated by EPIC. Finally, SAP 4.3 did not report projected % changes in yields for barley, hay, and potato. For these latter crops, we used the average crop-specific % change in mean yields and standard deviations across regions estimated by EPIC.

We conducted several exploratory analyses using the values for this scenario, but did not include it among our primary scenarios because information was available at a far less disaggregated level and it required a number of assumptions from outside of the report itself to generate even a very simple potential scenario. Thus, we felt that the full scenarios with detailed information from the GCMs and full EPIC simulations provided a better picture of potential climate impacts.

Appendix B: Percentage Changes in Crop Yields Incorporated into FASOM

This appendix presents tables of percentage changes in mean crop yields and standard deviations relative to baseline values that were incorporated into the FASOM model. The values in Tables B-1 through B-32 are based on EPIC model results where available and assumed to be equal to proxy crops in each region where EPIC model results are not available. Values were calculated for both dryland and irrigated conditions for major crops in FASOM regions where a crop could potentially be grown even if a region has not historically used both irrigation practices. This was done to provide data for analysis of potential switching of irrigation practices or regional shifts in growing regions in response to changing climate conditions. This results in large changes in simulated yields under our climate scenarios in some regions, particularly regions where dryland yields would be very low in the baseline and almost all acreage is irrigated. In regions where a scenario results in a large increase in growing season precipitation, it is possible that potential dryland yields will experience large percentage increases, although from low starting points. The presence of values for changes in potential yield does not necessarily mean that a crop/region/irrigation status combination is grown in the model equilibrium.

Table B-1. Percent Changes in Mean Yield Incorporated into FASOM, Barley

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	22.0	13.7	17.8	17.8	21.8	13.7	17.8	17.1
Arizona	-48.6	-40.3	-32.2	5.7	24.8	47.9	64.4	109.4
Arkansas	42.0	32.9	28.9	29.1	42.0	32.9	28.9	29.1
CaliforniaN	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
CaliforniaS	40.9	24.4	46.3	134.2	52.0	78.1	72.4	186.3
Colorado	-15.0	-21.7	-15.7	-22.6	24.9	17.8	27.6	5.9
Connecticut	5.2	2.1	-1.5	2.5	4.4	0.1	-1.5	2.4
Delaware	18.6	13.6	51.7	25.0	28.6	23.1	64.6	35.6
Florida	9.7	5.1	14.7	13.4	9.7	5.1	14.7	13.5
Georgia	53.9	44.9	57.4	28.9	54.3	45.3	57.8	29.3
Idaho	0.6	-7.0	-6.7	3.2	29.3	27.9	20.4	18.5
IllinoisN	23.2	42.5	40.9	9.6	23.9	43.3	41.8	10.2
IllinoisS	46.3	37.4	57.3	32.3	48.1	39.1	59.3	33.9
IndianaN	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IndianaS	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IowaW	51.2	58.0	59.3	10.6	53.2	60.1	61.4	12.1
IowaCent	45.2	46.0	46.9	7.1	51.3	52.1	52.8	11.5
IowaNE	49.0	49.0	49.1	15.5	49.1	49.1	49.1	15.5
IowaS	7.1	2.0	-0.5	-2.3	6.2	1.8	-0.5	-2.3
Kansas	9.8	6.2	6.8	4.8	7.9	5.6	5.9	3.7
Kentucky	49.9	42.6	60.7	30.3	50.1	42.8	60.9	30.4

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Louisiana	14.9	20.5	25.1	22.9	14.2	20.5	26.0	22.7
Maine	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Maryland	22.1	16.6	44.7	17.1	29.1	23.2	53.1	23.8
Massachusetts	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
Michigan	18.9	43.2	44.0	23.0	21.5	46.0	46.3	25.7
Minnesota	38.3	38.0	35.2	12.1	53.3	52.6	49.4	24.2
Mississippi	46.6	35.3	42.1	24.3	46.9	35.5	42.3	24.5
Missouri	46.7	40.9	55.6	29.6	46.8	40.9	55.6	29.6
Montana	-18.8	-7.4	-14.5	-17.8	21.9	44.6	32.7	20.8
Nebraska	13.3	24.1	18.5	-6.5	46.6	61.4	53.9	21.1
Nevada	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
NewJersey	11.0	18.5	56.5	16.0	15.2	23.0	62.4	20.3
NewMexico	71.7	63.5	69.3	122.7	6.1	-4.0	8.7	6.8
NewYork	46.5	44.3	52.3	30.4	50.3	47.9	56.0	33.6
NorthCarolina	42.8	36.8	53.0	32.6	45.1	39.0	55.6	34.8
NorthDakota	16.3	17.0	10.4	-10.2	56.4	57.4	48.1	20.9
OhioNW	66.1	64.6	90.9	53.2	67.5	66.0	92.6	54.5
OhioS	48.6	44.6	65.8	39.0	49.0	45.0	66.2	39.4
OhioNE	50.2	45.9	59.8	36.9	51.8	47.4	61.5	38.4
Oklahoma	13.3	8.3	12.7	8.8	12.1	7.8	11.9	9.7
Oregon	9.3	18.1	2.5	12.7	40.0	54.6	28.9	36.7
Pennsylvania	31.4	31.8	53.1	23.2	34.9	35.3	57.2	26.5
RhodeIsland	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
SouthCarolina	45.2	40.9	63.3	38.3	45.5	41.2	63.6	38.6
SouthDakota	14.3	25.5	13.8	-2.3	49.3	65.2	49.4	28.3
Tennessee	42.2	34.6	55.5	29.1	42.8	35.1	56.1	29.6
TxHiPlains	45.1	18.3	20.1	16.0	7.7	1.7	4.8	3.8
TxRolingPl	40.6	33.0	33.4	33.9	68.1	59.0	57.9	60.1
TxCntBlack	67.4	53.0	67.0	38.2	67.9	53.4	67.5	38.6
TxEast	24.0	15.3	22.1	26.3	22.9	16.4	22.3	26.3
TxEdplat	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
TxCoastBe	12.4	0.0	20.6	20.9	12.4	-1.7	22.8	23.2
TxSouth	8.2	10.5	23.1	21.6	7.9	-2.9	19.1	17.1
TxTranspec	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
Utah	-31.8	-50.6	-41.2	-23.3	48.0	14.3	30.2	61.0
Vermont	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Virginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Washington	-26.6	-24.2	-25.9	-14.4	35.8	103.7	15.2	73.2
WestVirginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Wisconsin	19.4	35.5	33.8	11.3	22.8	38.9	37.1	14.8
Wyoming	-11.9	-12.0	-10.5	-13.1	41.2	49.5	49.9	30.3

Table B-2. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Barley

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	17.3	-11.2	-20.7	8.6	17.4	-11.3	-20.7	11.6
Arizona	-45.0	-39.6	-38.8	-9.3	5.2	10.1	-11.5	-10.2
Arkansas	51.9	80.5	54.5	39.9	51.9	80.5	54.5	39.9
CaliforniaN	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
CaliforniaS	133.6	73.4	45.4	113.7	70.3	93.5	44.8	66.2
Colorado	45.2	77.4	69.6	6.3	51.7	69.1	47.6	9.3
Connecticut	74.3	106.4	19.7	-20.5	85.0	127.7	19.7	-20.2
Delaware	205.4	199.4	164.1	240.3	99.0	96.2	72.1	121.8
Florida	14.9	-2.2	0.7	-5.0	14.9	-2.1	0.6	-5.0
Georgia	78.3	46.4	94.8	53.3	77.9	46.1	94.4	52.9
Idaho	92.6	64.4	50.7	23.0	95.1	16.1	53.0	23.6
IllinoisN	47.9	115.8	63.6	69.8	44.4	110.8	59.8	65.8
IllinoisS	73.2	147.0	133.2	64.2	70.3	143.1	130.0	62.5
IndianaN	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IndianaS	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IowaW	81.7	179.4	48.3	72.5	67.9	158.1	37.0	59.4
IowaCent	104.7	180.4	84.9	128.6	69.7	132.4	52.3	91.0
IowaNE	26.9	85.7	43.8	49.4	26.6	85.2	43.5	49.0
IowaS	25.1	29.7	11.7	3.8	32.0	29.5	11.6	5.7
Kansas	-6.4	3.5	13.0	17.1	16.3	7.1	14.8	29.4
Kentucky	69.7	106.7	150.4	81.4	68.6	105.3	148.7	80.2
Louisiana	15.6	42.1	3.1	-13.6	18.1	42.3	8.1	-13.1
Maine	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Maryland	191.0	177.8	102.9	81.2	121.6	113.6	54.4	38.2
Massachusetts	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
Michigan	-3.8	102.3	82.2	21.5	-22.3	62.9	48.7	-1.8
Minnesota	153.6	142.8	85.0	91.1	97.4	100.6	45.8	48.2
Mississippi	63.6	70.1	25.2	38.3	64.2	70.8	25.7	38.8
Missouri	55.7	161.3	105.2	74.4	55.5	161.0	105.0	74.2
Montana	112.2	114.9	113.3	54.1	110.1	77.8	60.8	45.6
Nebraska	122.6	242.1	110.0	53.5	59.6	148.8	53.0	13.1
Nevada	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
NewJersey	128.4	107.1	50.7	89.8	82.9	65.9	20.7	52.0
NewMexico	-26.9	-70.0	-40.2	46.8	-8.3	27.9	-37.3	18.6
NewYork	190.2	138.7	160.5	111.7	140.0	97.7	116.2	73.8
NorthCarolina	123.7	96.7	118.5	70.7	117.3	93.1	112.5	66.0
NorthDakota	208.2	205.4	127.8	174.8	82.0	88.8	30.8	59.4
OhioNW	152.7	192.9	158.4	241.6	139.7	177.9	145.1	224.1
OhioS	139.3	164.4	111.7	192.4	137.8	162.8	110.3	190.6
OhioNE	136.3	149.0	102.9	170.0	119.5	131.3	88.5	150.8
Oklahoma	2.0	10.4	3.8	14.3	11.9	15.7	7.2	12.5
Oregon	279.0	157.3	107.4	98.4	210.3	62.8	83.6	107.2
Pennsylvania	172.6	106.9	68.1	95.2	134.8	78.3	44.8	68.1
RhodeIsland	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
SouthCarolina	106.7	58.3	240.0	74.8	107.1	58.6	240.6	75.2
SouthDakota	180.9	236.8	101.1	69.2	100.4	132.1	38.3	17.1

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Tennessee	75.2	108.7	220.3	90.5	76.5	110.2	222.6	91.9
TxHiPlains	-39.9	-49.4	-22.0	-3.1	30.9	5.5	17.5	16.9
TxRolingPl	104.8	37.2	9.6	75.1	73.0	15.9	-3.3	47.9
TxCntBlack	83.1	13.3	9.4	81.4	83.5	13.6	9.7	81.8
TxEast	11.6	-24.7	1.3	17.7	11.8	-18.6	2.0	17.7
TxEdplat	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
TxCoastBe	-3.0	-1.2	-4.5	6.3	-3.0	2.0	2.1	6.1
TxSouth	10.9	58.3	-36.8	-22.0	9.8	95.5	52.4	11.2
TxTranspec	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
Utah	62.9	75.6	23.4	14.9	58.3	69.4	60.4	21.2
Vermont	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Virginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Washington	-65.3	13.9	-67.4	-54.3	61.7	37.4	-4.3	46.1
WestVirginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Wisconsin	75.5	147.6	178.3	105.6	32.0	88.8	120.9	52.7
Wyoming	65.1	149.0	134.5	20.4	118.1	102.7	117.5	26.8

Table B-3. Percent Changes in Mean Yield Incorporated into FASOM, Corn

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-0.9	-4.4	-2.9	3.1	2.6	-0.7	-0.4	3.5
Arizona	8.3	-0.8	-6.8	41.0	3.6	-2.7	-7.2	-3.1
Arkansas	-2.4	-10.2	-8.2	4.3	-1.9	-8.0	-8.1	4.7
CaliforniaN	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
CaliforniaS	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
Colorado	25.7	12.9	8.8	39.0	2.9	0.5	-6.8	5.0
Connecticut	-2.9	-4.1	-1.8	0.6	-1.2	-2.4	-1.6	1.0
Delaware	0.8	-2.1	-4.3	0.2	0.9	-2.3	-4.7	0.7
Florida	-10.4	-4.1	-7.0	1.6	-1.7	0.2	4.3	2.6
Georgia	-4.0	0.5	-3.1	2.3	-1.6	0.2	-1.5	2.4
Idaho	82.3	65.0	94.3	86.4	17.2	-1.0	-7.8	-2.0
IllinoisN	-1.5	-11.1	-10.4	5.0	-1.5	-10.3	-10.5	5.9
IllinoisS	-4.0	-13.9	-12.4	3.7	-4.0	-13.4	-12.7	3.9
IndianaN	-0.9	-7.6	-5.7	6.3	-0.7	-6.6	-6.4	6.7
IndianaS	-0.4	-7.8	-7.0	4.3	-0.4	-6.8	-7.5	4.5
IowaCent	0.9	-7.8	-9.2	7.3	0.7	-7.5	-8.9	7.9
IowaNE	-0.1	-8.0	-8.8	6.8	-0.2	-7.5	-8.3	7.2
IowaS	0.6	-11.1	-13.9	7.2	0.5	-10.8	-14.6	7.3
IowaW	0.6	-7.1	-10.7	6.5	0.4	-7.0	-10.7	6.6
Kansas	-2.4	-9.5	-15.4	7.0	-4.1	-9.9	-16.5	5.1
Kentucky	1.2	-5.7	-7.2	2.7	1.5	-5.1	-7.2	2.9
Louisiana	-0.5	-8.6	-11.5	6.8	0.5	-2.3	-3.1	7.1
Maine	2.6	-0.8	-0.1	8.4	2.6	-0.2	0.0	8.4
Maryland	1.7	-0.8	-3.0	4.4	1.7	-0.5	-4.2	4.7

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Massachusetts	0.0	-0.2	-3.4	1.8	0.0	0.3	-3.6	1.8
Michigan	-1.7	-6.7	-4.0	3.1	-1.4	-6.5	-5.2	3.5
Minnesota	1.5	-4.3	-4.6	6.3	1.2	-3.1	-5.7	6.8
Mississippi	1.3	-4.3	-1.5	5.8	2.9	-1.2	-1.0	6.3
Missouri	-2.5	-14.9	-14.5	5.1	-2.6	-14.4	-14.8	5.3
Montana	31.5	1.1	15.5	30.8	5.5	-7.7	-7.1	-1.9
Nebraska	6.4	-0.9	-5.5	7.2	2.4	-2.6	-9.3	3.5
Nevada	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
NewHampshire	-7.6	-15.1	-11.1	1.3	-7.5	-12.0	-10.7	1.9
NewJersey	0.8	-4.4	-3.2	-0.9	2.6	-4.2	-3.5	-0.1
NewMexico	-20.4	51.9	5.5	60.3	3.2	-1.0	-0.8	10.2
NewYork	0.0	1.9	-3.0	4.4	0.1	1.9	-3.2	4.4
NorthCarolina	0.3	-1.6	-4.3	-0.4	0.3	-1.7	-4.4	-0.2
NorthDakota	8.6	3.4	13.8	10.8	3.9	2.3	-1.4	6.3
OhioNE	-0.2	-3.5	-7.3	3.5	-0.1	-3.4	-7.6	3.6
OhioNW	-0.2	-5.4	-6.1	4.3	-0.1	-5.3	-6.5	4.5
OhioS	-0.9	-4.1	-6.6	3.0	-0.9	-3.9	-6.8	3.0
Oklahoma	-2.6	-4.8	-12.3	5.1	-2.8	-5.7	-11.1	6.1
Oregon	143.5	152.3	289.9	228.9	19.7	-10.7	-20.3	-5.9
Pennsylvania	2.0	-2.8	-5.7	1.3	2.3	-2.8	-6.1	1.4
RhodeIsland	0.0	-0.2	-3.4	1.8	0.0	0.3	-3.6	1.8
SouthCarolina	-1.4	-0.6	-3.8	0.6	-1.1	-0.6	-3.5	0.7
SouthDakota	6.7	-2.2	1.9	7.2	2.4	-3.4	-6.0	4.3
Tennessee	1.3	-5.9	-5.2	2.6	1.4	-5.5	-5.3	2.7
TxCntBlack	-6.2	-10.0	-30.8	-10.1	-5.7	-7.0	-10.7	-0.2
TxCoastBe	-6.7	-7.9	-34.6	-9.8	-6.9	-2.1	-10.5	-0.1
TxEast	-2.0	2.5	-8.2	6.5	-2.0	9.4	-0.3	6.5
TxEdplat	-7.8	3.6	-5.6	-0.5	-7.9	-7.7	-4.8	-0.4
TxHiPlains	19.5	22.4	-7.4	15.3	-2.3	-6.0	-11.0	1.6
TxRolingPl	-0.5	4.8	-19.6	-4.7	-6.0	-7.9	-14.4	0.7
TxSouth	-6.1	-6.0	-34.4	-0.2	-8.6	-3.9	-18.3	-2.8
TxTranspec	-7.8	3.6	-5.6	-0.5	-7.9	-7.7	-4.8	-0.4
Utah	-75.8	1.6	-5.9	-66.3	36.2	26.3	7.6	4.0
Vermont	14.3	18.3	16.3	36.0	14.3	18.3	16.3	36.0
Virginia	-0.4	-3.1	-3.8	-1.1	-0.5	-3.0	-5.1	0.3
Washington	-19.1	-26.9	-55.4	582.0	-3.8	-11.5	-9.9	-3.0
WestVirginia	-0.9	-3.3	-5.3	2.9	-0.9	-2.9	-6.1	3.2
Wisconsin	-3.3	-7.0	-8.4	2.9	-3.3	-6.0	-6.9	3.1
Wyoming	92.3	42.7	50.6	153.3	18.3	10.7	7.1	17.7

Table B-4. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Corn

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-2.0	2.4	11.7	0.0	-10.1	-11.7	-1.0	0.2
Arizona	38.2	73.9	48.0	85.1	-14.9	-13.5	-3.2	-9.3
Arkansas	-15.8	-5.0	-13.9	7.2	-17.3	-18.0	-14.1	6.8
CaliforniaN	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
CaliforniaS	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
Colorado	-34.9	-32.3	-37.5	-4.2	-13.6	-16.5	-16.8	0.2
Connecticut	-0.5	-1.4	-0.9	4.3	0.0	-4.4	-1.9	3.9
Delaware	-2.5	-14.5	-4.6	-0.8	-2.2	-14.8	-4.4	0.6
Florida	9.8	-0.6	28.1	-0.2	-10.1	-13.2	-13.9	-0.9
Georgia	-6.0	-8.4	6.1	0.2	-12.7	-7.2	-3.5	0.3
Idaho	15.8	-3.9	30.5	14.5	-11.3	-25.8	-15.5	-6.4
IllinoisN	-9.1	-10.9	-16.6	6.8	-8.6	-15.0	-15.7	6.0
IllinoisS	-5.9	-12.4	-12.9	3.0	-5.8	-15.2	-10.5	2.7
IndianaN	-10.1	-14.2	-11.8	2.5	-10.1	-16.6	-10.0	3.2
IndianaS	-9.7	-22.8	-13.5	2.5	-9.6	-23.5	-12.7	3.0
IowaCent	-10.2	8.0	-6.2	11.3	-8.4	4.0	-8.8	8.8
IowaNE	-1.3	1.7	0.5	12.1	-0.3	-0.6	-3.0	11.6
IowaS	-30.3	87.8	-33.8	11.4	-29.6	82.7	-23.9	11.5
IowaW	-15.2	-4.3	-30.9	3.7	-13.2	-4.8	-30.6	2.9
Kansas	-18.4	-14.7	-19.3	3.0	-9.0	-10.6	-10.2	9.8
Kentucky	-11.1	-9.8	2.6	7.2	-13.0	-16.8	2.6	6.4
Louisiana	-8.8	7.6	34.2	-5.4	-9.2	-25.5	1.3	-5.7
Maine	-10.7	-11.5	-7.4	-26.2	-10.7	-11.2	-7.7	-26.2
Maryland	-10.4	-4.0	-6.2	-2.8	-10.2	-6.1	-2.0	-2.5
Massachusetts	1.5	19.2	16.6	2.3	1.7	17.5	17.2	2.5
Michigan	-16.3	-0.4	-7.1	18.2	-16.3	-3.3	-1.4	19.3
Minnesota	1.9	1.0	-0.3	9.7	3.1	-9.2	-1.3	8.8
Mississippi	-6.1	2.0	1.6	2.6	-9.5	-15.6	-0.7	2.6
Missouri	-8.8	39.5	-20.2	16.6	-7.5	31.6	-12.7	15.9
Montana	-61.8	-59.1	-65.9	-54.8	-26.5	-10.9	-11.9	33.4
Nebraska	-16.8	-10.2	-39.2	-1.9	-10.8	-3.7	-22.8	11.8
Nevada	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
NewHampshire	-19.0	15.4	10.3	-3.6	-19.0	-15.2	7.3	-5.9
NewJersey	-8.6	-1.4	-5.0	3.8	-6.9	-1.4	-4.2	3.8
NewMexico	0.8	-7.6	-21.1	-2.9	-15.6	-26.0	-23.6	-18.2
NewYork	5.9	5.8	10.4	16.6	5.7	6.0	11.6	16.8
NorthCarolina	-5.1	-6.0	-6.4	-0.1	-4.9	-6.0	-6.0	0.1
NorthDakota	-15.9	-5.1	-39.9	-5.4	14.0	-6.9	9.8	25.0
OhioNE	-4.9	-8.6	-0.8	6.5	-5.0	-9.0	0.0	6.5
OhioNW	-8.9	-10.4	-4.3	6.3	-8.8	-10.2	-4.0	6.8
OhioS	-5.0	-15.3	-2.8	3.3	-5.0	-15.7	-2.5	3.3
Oregon	26.2	28.4	169.1	68.2	-16.1	-22.8	-6.9	-1.2
Pennsylvania	-9.2	-0.9	2.2	-3.0	-8.7	-1.0	4.1	-3.3
RhodeIsland	1.5	19.2	16.6	2.3	1.7	17.5	17.2	2.5
SouthCarolina	-11.2	-4.3	-4.2	2.3	-11.3	-4.4	-6.0	2.3
SouthDakota	-31.2	-14.1	-52.2	-7.4	-0.7	6.1	-17.4	14.5

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Tennessee	-16.6	-11.0	0.6	6.3	-16.5	-13.4	1.6	6.4
TxCntBlack	-5.3	-10.7	5.2	13.8	-3.6	-16.3	-3.5	0.1
TxCoastBe	-14.8	-19.9	-4.5	8.0	-14.5	-24.5	-15.1	2.0
TxEast	-5.8	-33.1	-17.1	5.6	-5.8	-46.3	-32.6	5.7
TxEdplat	-8.4	-54.4	-22.9	-20.4	-7.3	-17.3	46.6	0.5
TxHiPlains	-30.3	-32.7	-24.3	10.4	-15.3	-9.3	-21.0	4.7
TxRolingPl	-35.1	-34.5	-21.6	9.8	-16.4	-24.3	-16.1	0.9
TxSouth	-37.9	3.7	-17.9	-6.4	-15.1	-18.8	-18.3	-1.7
TxTranspec	-8.4	-54.4	-22.9	-20.4	-7.3	-17.3	46.6	0.5
Utah	-20.3	115.4	-5.8	-13.6	14.7	-9.8	-16.0	-12.7
Vermont	-51.7	-27.0	-43.6	-33.7	-51.7	-27.0	-43.6	-33.7
Virginia	-1.4	-8.0	-12.3	2.4	-0.8	-9.8	1.5	1.7
Washington	-20.0	-12.6	-21.3	767.5	7.5	-18.8	-1.5	-33.0
WestVirginia	9.2	-12.6	2.1	-2.5	9.4	-15.6	19.6	-2.5
Wisconsin	-10.3	-1.4	7.7	12.4	-10.3	-5.7	-1.3	12.4
Wyoming	-45.4	-19.0	-33.5	-34.1	-28.7	29.0	27.3	-3.8

Table B-5. Percent Changes in Mean Yield Incorporated into FASOM, Cotton

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-11.3	-4.8	-4.6	3.6	0.7	-1.4	-2.3	5.1
Arizona	-53.4	-46.7	-34.5	-58.9	-4.7	-23.7	-22.9	-11.7
Arkansas	-14.1	-19.8	-22.1	5.2	-1.7	-12.1	-14.3	8.3
CaliforniaN	95.4	96.4	75.7	77.0	11.2	-8.5	-2.2	2.8
CaliforniaS	-21.8	-12.8	30.3	-12.0	-1.6	-28.3	-24.8	-0.4
Colorado	17.0	137.2	111.6	126.3	66.6	100.7	111.5	101.1
Delaware	1.1	12.7	7.7	3.3	4.1	11.6	3.6	7.8
Florida	-9.0	1.3	1.2	4.5	-0.2	4.5	3.1	4.4
Georgia	-9.5	5.6	1.3	3.5	0.2	3.1	2.3	3.5
IllinoisN	-1.5	-10.5	-9.2	15.5	0.6	-6.2	-10.9	16.0
IllinoisS	-5.0	-13.6	-14.3	6.9	-2.2	-11.3	-14.3	8.6
IowaS	6.6	5.6	-7.3	21.8	6.2	5.8	-7.8	21.8
IowaW	7.0	2.9	-8.7	19.3	5.9	3.0	-9.2	19.3
Kansas	-5.4	-8.9	-15.5	8.8	1.7	-6.0	-11.7	10.5
Kentucky	-3.1	-11.3	-11.0	8.1	-0.3	-9.5	-10.2	9.1
Louisiana	-22.2	-29.5	-34.7	3.8	-0.3	-9.9	-13.5	7.2
Maryland	15.0	45.3	25.9	17.3	14.6	45.7	20.9	19.5
Mississippi	-12.3	-14.6	-16.0	6.5	0.8	-5.6	-8.8	9.4
Missouri	-1.6	-17.6	-13.2	20.3	1.1	-10.6	-11.2	21.5
Nevada	95.4	96.4	75.7	77.0	11.2	-8.5	-2.2	2.8
NewJersey	-18.9	22.3	18.8	0.3	6.7	25.8	9.6	12.2
NewMexico	-19.1	39.7	20.5	32.4	2.8	6.5	6.5	9.5
NorthCarolina	3.0	6.5	3.9	4.6	3.4	5.6	2.8	5.7
Oklahoma	-9.6	-9.2	-30.7	-6.9	-1.4	-4.8	-11.6	7.9

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
SouthCarolina	-0.8	7.1	4.7	4.0	1.0	5.7	4.8	4.2
Tennessee	-1.7	-10.0	-6.7	7.3	0.0	-8.5	-7.1	8.2
TxCntBlack	-15.2	-36.5	-52.4	-31.5	0.9	-3.1	-6.0	-0.2
TxCoastBe	-7.0	-50.9	-67.4	-42.1	-0.8	-6.8	-10.2	-3.6
TxEast	-22.9	-22.3	-33.9	2.0	0.3	-9.3	-12.1	8.9
TxEdplat	11.9	-10.8	-34.4	-17.9	-0.7	-2.6	-8.2	-0.5
TxHiPlains	-1.1	11.1	-18.8	7.6	-1.2	-0.9	-9.7	7.3
TxRolingPl	1.6	-9.4	-34.3	-9.0	-3.1	-8.1	-13.9	3.7
TxSouth	12.6	-42.3	-61.9	-29.6	-0.4	-7.4	-9.5	-3.3
TxTranspec	-4.8	10.2	11.6	49.8	6.8	2.3	-4.2	9.5
Utah	17.0	137.2	111.6	126.3	66.6	100.7	111.5	101.1
Virginia	7.5	15.6	10.8	8.4	6.2	14.9	7.0	12.5
WestVirginia	36.5	86.1	68.9	54.3	43.3	99.8	62.1	61.4

Table B-6. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Cotton

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	12.3	29.0	29.5	6.1	-4.2	11.1	14.3	12.2
Arizona	-28.3	-58.1	-26.2	-45.8	-23.2	3.9	-2.9	-22.0
Arkansas	21.3	17.7	-0.7	16.1	0.2	13.2	-1.5	15.0
CaliforniaN	96.2	120.0	66.9	39.1	-39.2	-25.0	-11.0	38.6
CaliforniaS	-14.8	-44.4	17.3	4.5	30.5	-19.4	63.2	35.1
Colorado	19.7	25.3	107.9	-3.2	-5.5	-33.2	-40.5	-2.0
Delaware	55.7	-3.6	-55.2	213.2	2.3	-40.0	67.5	49.7
Florida	21.6	8.2	6.5	8.3	14.8	-3.3	-5.3	8.5
Georgia	24.9	14.8	15.3	13.7	7.6	10.2	4.1	13.8
IllinoisN	85.9	115.5	14.4	22.6	37.4	113.3	59.5	14.2
IllinoisS	83.9	52.4	11.7	32.9	43.0	70.2	37.6	14.8
IowaS	-21.1	48.3	-18.5	-43.4	-17.3	47.0	-12.0	-43.4
IowaW	-25.6	78.6	-20.9	-33.5	-17.0	78.2	-13.0	-33.5
Kansas	5.7	10.3	-13.3	11.6	17.7	11.9	-14.8	16.6
Kentucky	36.9	50.1	24.4	23.8	1.6	63.1	39.8	16.3
Louisiana	32.3	4.9	-4.3	14.2	4.0	-1.4	9.5	8.4
Maryland	-17.9	-7.2	-28.0	-41.0	-21.3	-31.8	-24.5	-40.9
Mississippi	23.6	27.7	18.7	-0.1	-3.6	8.7	15.6	3.0
Missouri	32.8	68.0	17.4	45.6	20.6	68.1	34.9	45.3
Nevada	96.2	120.0	66.9	39.1	-39.2	-25.0	-11.0	38.6
NewJersey	60.9	-5.1	-71.6	108.8	-22.0	-67.2	-30.8	-17.8
NewMexico	20.3	0.8	9.8	21.8	11.0	13.9	-5.0	-7.0
NorthCarolina	21.1	19.0	18.7	22.0	20.6	18.7	22.9	24.4
Oklahoma	-3.5	-26.9	-25.5	8.7	1.1	1.9	-11.0	7.4
SouthCarolina	16.1	39.3	26.9	21.6	15.4	30.0	25.9	22.6
Tennessee	1.1	26.5	8.1	13.6	-3.9	18.3	15.5	14.9

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
TxCntBlack	-9.3	-46.3	-47.3	-22.1	-9.5	-21.8	-23.5	-2.2
TxCoastBe	-1.0	-64.4	-63.6	-44.0	0.6	-11.9	-12.7	-2.3
TxEast	17.0	-4.3	-15.8	12.0	-4.2	-21.2	-8.7	10.7
TxEdplat	29.8	-52.2	-30.5	-34.7	-4.8	-7.9	-4.8	-8.7
TxHiPlains	2.1	-46.2	-19.0	12.7	-5.5	6.8	-9.1	9.4
TxRolingPl	3.5	-42.0	-35.4	-2.9	-1.0	-7.5	-10.9	6.5
TxSouth	5.8	-61.7	-54.5	-40.6	2.0	-19.5	-19.7	2.8
TxTranspec	50.2	-15.2	25.5	39.4	-16.9	1.2	-8.4	-4.8
Utah	19.7	25.3	107.9	-3.2	-5.5	-33.2	-40.5	-2.0
Virginia	27.5	5.4	-7.9	2.9	25.5	-6.0	21.4	-0.6
WestVirginia	-4.9	30.0	3.8	-20.3	-55.1	-26.4	-38.9	-25.9

Table B-7. Percent Changes in Mean Yield Incorporated into FASOM, Grapefruit

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	NA	NA	NA	NA	-3.9	-6.5	-13.5	0.7
CaliforniaN	NA	NA	NA	NA	-6.1	-16.7	-17.0	-21.6
CaliforniaS	NA	NA	NA	NA	-6.1	-16.7	-17.0	-21.6
Florida	NA	NA	NA	NA	-16.9	-15.5	-22.7	-7.4
TxSouth	NA	NA	NA	NA	-33.3	-23.6	-59.8	-2.5

Table B-8. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Grapefruit

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	NA	NA	NA	NA	-14.0	-28.5	51.9	13.4
CaliforniaN	NA	NA	NA	NA	-3.3	-13.0	-8.6	10.6
CaliforniaS	NA	NA	NA	NA	-3.3	-13.0	-8.6	10.6
Florida	NA	NA	NA	NA	13.8	-15.3	-2.5	2.3
TxSouth	NA	NA	NA	NA	0.7	-25.7	-12.3	13.1

Table B-9. Percent Changes in Mean Yield Incorporated into FASOM, Hay

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-4.2	-0.7	-7.0	-0.7	-3.7	-0.8	-7.0	0.0
Arizona	2.0	6.5	14.0	1.6	-1.5	1.1	5.8	-1.4
Arkansas	-4.7	-2.9	-6.4	-4.9	-4.3	-2.6	-6.1	-3.7
CaliforniaN	19.2	16.0	8.5	15.0	8.5	4.0	2.4	0.8
CaliforniaS	16.0	26.9	49.4	34.1	2.9	3.5	9.4	1.1
Colorado	17.5	29.7	16.2	23.2	11.6	20.3	7.2	12.0
Connecticut	0.3	2.9	6.1	1.3	3.3	4.5	5.9	2.3
Delaware	2.4	5.4	6.6	0.8	3.5	5.3	6.3	1.4
Florida	-4.9	-7.8	-13.4	-5.8	-4.3	-7.1	-12.7	-5.7
Georgia	-1.8	3.4	-4.0	2.3	-1.6	3.1	-4.0	2.3
Idaho	26.0	25.0	10.0	9.9	17.4	18.2	8.9	9.0
IllinoisN	3.4	-2.0	-4.8	0.2	3.7	-1.1	-4.7	0.9
IllinoisS	3.9	0.1	-2.0	-0.1	3.8	0.3	-2.2	0.8
IndianaN	5.5	-0.1	0.8	1.3	5.8	0.6	0.5	2.0
IndianaS	6.6	-1.9	0.9	-0.9	6.7	-0.9	0.5	0.0
IowaCent	2.8	-3.8	-9.6	5.3	2.9	-3.3	-9.5	5.7
IowaNE	3.1	-1.1	-6.6	3.0	3.2	-0.2	-6.0	3.7
IowaS	-1.8	-5.4	-8.8	0.4	-1.8	-5.0	-8.8	0.9
IowaW	0.9	-1.5	-6.5	3.5	0.8	-1.5	-6.6	3.6
Kansas	-0.9	-0.2	-6.7	-0.3	-0.8	-0.2	-6.8	0.7
Kentucky	2.8	2.4	0.3	2.0	2.9	2.5	0.1	3.1
Louisiana	-9.0	-14.2	-15.0	-6.6	-7.0	-12.7	-12.6	-6.1
Maine	9.1	8.6	8.2	5.9	9.7	9.0	8.1	6.0
Maryland	5.6	7.7	6.8	3.3	5.9	7.8	6.4	3.5
Massachusetts	6.8	6.7	6.5	4.1	7.3	7.2	6.4	4.5
Michigan	7.0	4.5	1.9	2.9	7.9	5.1	2.0	3.7
Minnesota	5.6	-1.2	-3.1	4.2	5.5	-0.2	-2.3	4.5
Mississippi	-5.0	-2.9	-6.8	-1.9	-4.7	-2.9	-6.7	-1.0
Missouri	0.5	-2.4	-5.0	-2.9	0.6	-1.9	-5.1	-1.5
Montana	17.8	25.9	14.0	20.6	11.4	17.0	7.0	11.1
Nebraska	6.4	8.7	-0.3	7.1	4.7	7.4	-2.6	5.7
Nevada	56.1	42.0	27.5	26.4	15.2	6.1	3.3	2.0
NewHampshire	9.7	8.5	7.5	4.7	9.9	9.0	7.4	5.0
NewJersey	-2.2	3.8	5.8	-0.6	0.4	4.2	5.6	0.3
NewMexico	-5.6	9.0	6.8	2.4	0.3	5.8	2.7	1.2
NewYork	8.8	8.7	7.4	5.5	9.2	8.8	7.3	5.5
NorthCarolina	3.5	9.1	2.6	3.4	3.6	9.1	2.5	3.8
NorthDakota	12.5	8.5	7.2	7.8	7.5	6.2	2.9	5.3
OhioNE	5.4	4.6	4.1	2.0	5.8	5.0	3.9	2.7
OhioNW	8.1	2.7	3.2	3.0	8.4	3.4	2.7	3.8
OhioS	6.7	4.9	5.6	3.2	6.9	5.5	5.3	4.3
Oklahoma	-3.6	-1.8	-4.9	-5.7	-2.2	-2.6	-5.2	-3.0
Oregon	10.9	2.4	-9.6	-0.1	9.3	5.2	4.0	2.9
Pennsylvania	2.9	5.2	5.3	2.1	3.8	5.5	5.1	2.5
RhodeIsland	6.8	6.7	6.5	4.1	7.3	7.2	6.4	4.5
SouthCarolina	0.5	9.8	-0.7	0.3	0.5	9.7	-0.7	0.4
SouthDakota	9.4	7.7	2.9	8.2	5.5	5.1	-1.1	5.6

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Tennessee	1.2	2.7	-0.9	3.4	1.3	2.5	-1.0	4.0
TxCntBlack	-7.1	-10.9	-10.0	-10.8	-6.3	-10.9	-9.4	-7.5
TxCoastBe	-8.2	-10.4	-13.7	-12.6	-7.2	-8.6	-10.1	-10.4
TxEast	-8.3	-5.2	-7.4	-5.3	-6.8	-4.4	-6.1	-4.5
TxEdplat	9.5	1.9	3.1	-1.8	2.4	-5.8	-3.8	-0.8
TxHiPlains	10.9	16.1	7.6	3.4	4.1	7.3	0.6	1.9
TxRolingPl	5.2	7.3	3.5	-3.1	2.3	2.3	-0.8	-2.5
TxSouth	-2.7	-4.1	-8.4	-14.0	-3.9	-8.1	-10.7	-13.4
TxTranspec	20.4	29.9	31.6	28.0	6.5	8.2	7.7	7.1
Utah	-18.1	-10.4	-12.0	-19.4	-2.5	-1.6	-3.5	-4.6
Vermont	12.3	11.2	7.9	5.8	12.4	11.5	7.9	6.0
Virginia	8.1	11.0	7.5	4.7	8.1	11.2	7.1	5.2
Washington	-5.7	-8.4	-21.8	25.6	-2.6	-0.9	-3.8	12.4
WestVirginia	5.0	8.6	7.3	3.0	5.4	8.9	7.1	3.8
Wisconsin	5.8	1.5	-2.3	2.7	6.4	2.3	-1.1	3.2
Wyoming	22.6	40.0	26.7	29.6	13.5	27.9	15.0	16.2

Table B-10. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Hay

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	2.0	-0.8	-5.2	0.7	1.9	-1.1	-5.1	1.2
Arizona	7.8	-8.0	5.1	4.1	0.4	-6.6	1.2	0.6
Arkansas	0.1	-1.8	-2.9	3.3	0.1	-1.7	-2.7	4.1
CaliforniaN	21.5	14.6	6.9	16.6	6.1	-3.2	-5.3	0.4
CaliforniaS	3.6	-10.9	13.6	68.3	-0.5	-3.5	1.7	0.9
Colorado	20.7	26.8	8.7	25.6	13.2	17.1	2.5	11.6
Connecticut	2.6	6.4	8.2	5.2	5.1	7.2	8.4	5.4
Delaware	1.7	1.9	3.2	0.7	2.6	2.3	3.8	0.2
Florida	0.3	-10.8	-17.2	-4.0	0.4	-10.4	-16.9	-4.5
Georgia	1.1	1.5	-6.6	0.3	1.0	1.2	-6.7	0.3
Idaho	20.0	20.3	6.2	5.8	12.2	12.0	7.4	7.7
IllinoisN	1.5	-4.8	-7.2	9.3	1.7	-4.5	-7.3	9.6
IllinoisS	2.1	-2.6	-1.7	3.3	2.1	-2.7	-1.7	4.4
IndianaN	1.2	-6.4	-4.8	12.3	1.4	-6.6	-4.8	12.3
IndianaS	4.3	-4.2	-1.9	1.6	4.3	-3.7	-2.0	3.1
IowaCent	4.7	-5.5	-10.6	16.9	4.6	-5.7	-10.9	16.7
IowaNE	4.6	-1.9	-5.9	13.7	4.5	-2.1	-6.2	13.6
IowaS	-2.5	-7.8	-11.9	10.4	-2.5	-8.3	-11.8	10.2
IowaW	1.6	-5.7	-9.0	11.0	1.6	-5.8	-9.5	10.9
Kansas	2.5	0.1	-8.4	5.4	3.2	-0.6	-8.1	5.3
Kentucky	3.2	2.9	4.0	4.7	3.2	2.6	4.2	5.2
Louisiana	-1.8	-14.5	-13.8	-2.3	-0.5	-13.0	-11.0	-2.5
Maine	10.1	15.3	10.9	13.6	10.8	13.9	11.1	12.9

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Maryland	7.2	4.8	6.9	6.9	7.3	4.8	7.2	6.7
Massachusetts	10.6	12.0	8.2	11.1	10.5	11.9	8.4	11.0
Michigan	6.9	2.4	-4.0	13.0	7.4	2.4	-4.1	13.3
Minnesota	7.5	-3.3	-1.9	14.2	6.9	-3.7	-3.7	14.0
Mississippi	0.2	-1.1	-1.2	2.1	0.5	-0.9	-0.9	3.0
Missouri	0.1	-2.4	-4.3	4.3	0.1	-2.9	-3.9	4.7
Montana	13.3	13.9	7.9	8.4	8.0	10.1	4.7	4.2
Nebraska	1.0	1.6	-8.3	6.1	0.6	1.6	-8.6	6.3
Nevada	112.9	88.8	59.5	60.4	23.7	5.3	5.4	4.3
NewHampshire	18.7	17.1	11.8	11.8	18.1	15.6	12.0	11.0
NewJersey	8.6	9.2	8.6	4.1	8.7	8.6	8.9	3.6
NewMexico	-13.3	-1.9	0.5	-9.7	4.6	7.1	3.7	1.0
NewYork	14.1	15.0	10.0	14.1	13.9	14.7	10.2	14.0
NorthCarolina	4.4	0.6	-6.1	4.2	4.4	0.5	-6.1	4.5
NorthDakota	12.8	-0.6	3.9	9.2	8.1	0.2	0.3	7.8
OhioNE	6.9	3.9	4.5	8.5	7.0	3.7	4.5	8.5
OhioNW	4.0	-2.7	-4.2	14.6	4.0	-2.9	-4.2	14.7
OhioS	5.7	0.2	3.7	6.7	5.7	1.1	3.6	8.9
Oklahoma	-0.8	-11.2	-8.5	-6.3	0.8	-11.7	-8.8	-3.5
Oregon	-3.9	-7.7	-17.7	-4.5	-1.2	1.4	3.1	0.7
Pennsylvania	7.0	10.7	12.1	6.0	7.4	10.4	12.4	5.8
RhodeIsland	10.6	12.0	8.2	11.1	10.5	11.9	8.4	11.0
SouthCarolina	2.5	7.2	-4.9	-1.5	2.4	7.2	-4.9	-1.5
SouthDakota	5.0	-3.0	-4.4	6.8	3.1	-2.8	-5.4	6.7
Tennessee	5.3	0.0	-3.7	6.5	5.3	-0.3	-3.8	6.9
TxCntBlack	-5.7	-16.9	-8.1	-12.3	-5.7	-16.8	-10.6	-8.9
TxCoastBe	5.0	-18.4	-14.7	-6.0	-0.2	-4.1	-12.2	-8.6
TxEast	-7.9	-0.3	5.7	-2.0	-7.5	-3.1	2.5	-1.6
TxEdplat	4.0	-5.5	-6.7	-5.6	-0.7	-9.9	-7.3	-1.9
TxHiPlains	10.7	8.6	5.5	4.8	3.0	1.4	0.3	2.6
TxRolingPl	8.9	-0.5	0.5	-0.5	5.4	-3.6	-4.2	-0.9
TxSouth	-13.9	-7.1	-22.3	-19.1	-13.2	0.1	-15.3	-17.7
TxTranspec	19.4	16.1	20.0	17.7	5.4	6.1	3.8	4.2
Utah	-19.9	-13.3	-11.7	-21.0	4.2	0.7	-0.2	-0.8
Vermont	25.7	18.4	11.4	14.8	25.6	18.0	11.4	14.7
Virginia	9.1	4.9	-0.4	13.6	9.0	4.9	-0.4	13.8
Washington	-12.3	-15.5	-26.8	-2.3	-10.1	-7.4	-4.5	0.6
WestVirginia	5.3	6.8	10.0	3.9	5.5	6.4	10.0	4.0
Wisconsin	7.0	0.5	-0.9	13.3	7.3	0.1	-1.4	13.3
Wyoming	20.9	32.4	21.1	19.2	11.6	22.3	10.8	10.5

Table B-11. Percent Changes in Mean Yield Incorporated into FASOM, Oats

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	22.0	13.7	17.8	17.8	21.8	13.7	17.8	17.1
Arizona	-48.6	-40.3	-32.2	5.7	24.8	47.9	64.4	109.4
Arkansas	42.0	32.9	28.9	29.1	42.0	32.9	28.9	29.1
CaliforniaN	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
CaliforniaS	40.9	24.4	46.3	134.2	52.0	78.1	72.4	186.3
Colorado	-15.0	-21.7	-15.7	-22.6	24.9	17.8	27.6	5.9
Connecticut	5.2	2.1	-1.5	2.5	4.4	0.1	-1.5	2.4
Delaware	18.6	13.6	51.7	25.0	28.6	23.1	64.6	35.6
Florida	9.7	5.1	14.7	13.4	9.7	5.1	14.7	13.5
Georgia	53.9	44.9	57.4	28.9	54.3	45.3	57.8	29.3
Idaho	0.6	-7.0	-6.7	3.2	29.3	27.9	20.4	18.5
IllinoisN	23.2	42.5	40.9	9.6	23.9	43.3	41.8	10.2
IllinoisS	46.3	37.4	57.3	32.3	48.1	39.1	59.3	33.9
IndianaN	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IndianaS	52.5	52.3	66.4	35.8	53.1	53.0	67.2	36.3
IowaCent	45.2	46.0	46.9	7.1	51.3	52.1	52.8	11.5
IowaNE	49.0	49.0	49.1	15.5	49.1	49.1	49.1	15.5
IowaS	7.1	2.0	-0.5	-2.3	6.2	1.8	-0.5	-2.3
IowaW	51.2	58.0	59.3	10.6	53.2	60.1	61.4	12.1
Kansas	9.8	6.2	6.8	4.8	7.9	5.6	5.9	3.7
Kentucky	49.9	42.6	60.7	30.3	50.1	42.8	60.9	30.4
Louisiana	14.9	20.5	25.1	22.9	14.2	20.5	26.0	22.7
Maine	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Maryland	22.1	16.6	44.7	17.1	29.1	23.2	53.1	23.8
Massachusetts	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
Michigan	18.9	43.2	44.0	23.0	21.5	46.0	46.3	25.7
Minnesota	38.3	38.0	35.2	12.1	53.3	52.6	49.4	24.2
Mississippi	46.6	35.3	42.1	24.3	46.9	35.5	42.3	24.5
Missouri	46.7	40.9	55.6	29.6	46.8	40.9	55.6	29.6
Montana	-18.8	-7.4	-14.5	-17.8	21.9	44.6	32.7	20.8
Nebraska	13.3	24.1	18.5	-6.5	46.6	61.4	53.9	21.1
Nevada	21.1	-2.2	3.0	134.2	34.6	51.8	44.8	186.3
NewJersey	11.0	18.5	56.5	16.0	15.2	23.0	62.4	20.3
NewMexico	71.7	63.5	69.3	122.7	6.1	-4.0	8.7	6.8
NewYork	46.5	44.3	52.3	30.4	50.3	47.9	56.0	33.6
NorthCarolina	42.8	36.8	53.0	32.6	45.1	39.0	55.6	34.8
NorthDakota	16.3	17.0	10.4	-10.2	56.4	57.4	48.1	20.9
OhioNE	50.2	45.9	59.8	36.9	51.8	47.4	61.5	38.4
OhioNW	66.1	64.6	90.9	53.2	67.5	66.0	92.6	54.5
OhioS	48.6	44.6	65.8	39.0	49.0	45.0	66.2	39.4
Oklahoma	13.3	8.3	12.7	8.8	12.1	7.8	11.9	9.7
Oregon	9.3	18.1	2.5	12.7	40.0	54.6	28.9	36.7
Pennsylvania	31.4	31.8	53.1	23.2	34.9	35.3	57.2	26.5
RhodeIsland	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
SouthCarolina	45.2	40.9	63.3	38.3	45.5	41.2	63.6	38.6
SouthDakota	14.3	25.5	13.8	-2.3	49.3	65.2	49.4	28.3
Tennessee	42.2	34.6	55.5	29.1	42.8	35.1	56.1	29.6

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
TxCntBlack	67.4	53.0	67.0	38.2	67.9	53.4	67.5	38.6
TxCoastBe	12.4	0.0	20.6	20.9	12.4	-1.7	22.8	23.2
TxEast	24.0	15.3	22.1	26.3	22.9	16.4	22.3	26.3
TxEdplat	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
TxHiPlains	45.1	18.3	20.1	16.0	7.7	1.7	4.8	3.8
TxRolingPl	40.6	33.0	33.4	33.9	68.1	59.0	57.9	60.1
TxSouth	8.2	10.5	23.1	21.6	7.9	-2.9	19.1	17.1
TxTranspec	3.3	-3.0	10.2	14.4	55.9	43.4	48.7	49.2
Utah	-31.8	-50.6	-41.2	-23.3	48.0	14.3	30.2	61.0
Vermont	27.4	47.7	34.6	25.9	28.9	49.4	35.9	27.1
Virginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Washington	-26.6	-24.2	-25.9	-14.4	35.8	103.7	15.2	73.2
WestVirginia	20.3	13.6	35.3	15.2	26.2	19.2	42.0	20.9
Wisconsin	19.4	35.5	33.8	11.3	22.8	38.9	37.1	14.8
Wyoming	-11.9	-12.0	-10.5	-13.1	41.2	49.5	49.9	30.3

Table B-12. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Oats

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	17.3	-11.2	-20.7	8.6	17.4	-11.3	-20.7	11.6
Arizona	-45.0	-39.6	-38.8	-9.3	5.2	10.1	-11.5	-10.2
Arkansas	51.9	80.5	54.5	39.9	51.9	80.5	54.5	39.9
CaliforniaN	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
CaliforniaS	133.6	73.4	45.4	113.7	70.3	93.5	44.8	66.2
Colorado	45.2	77.4	69.6	6.3	51.7	69.1	47.6	9.3
Connecticut	74.3	106.4	19.7	-20.5	85.0	127.7	19.7	-20.2
Delaware	205.4	199.4	164.1	240.3	99.0	96.2	72.1	121.8
Florida	14.9	-2.2	0.7	-5.0	14.9	-2.1	0.6	-5.0
Georgia	78.3	46.4	94.8	53.3	77.9	46.1	94.4	52.9
Idaho	92.6	64.4	50.7	23.0	95.1	16.1	53.0	23.6
IllinoisN	47.9	115.8	63.6	69.8	44.4	110.8	59.8	65.8
IllinoisS	73.2	147.0	133.2	64.2	70.3	143.1	130.0	62.5
IndianaN	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IndianaS	93.5	149.2	78.8	51.4	90.4	145.2	76.0	49.0
IowaCent	104.7	180.4	84.9	128.6	69.7	132.4	52.3	91.0
IowaNE	26.9	85.7	43.8	49.4	26.6	85.2	43.5	49.0
IowaS	25.1	29.7	11.7	3.8	32.0	29.5	11.6	5.7
IowaW	81.7	179.4	48.3	72.5	67.9	158.1	37.0	59.4
Kansas	-6.4	3.5	13.0	17.1	16.3	7.1	14.8	29.4
Kentucky	69.7	106.7	150.4	81.4	68.6	105.3	148.7	80.2
Louisiana	15.6	42.1	3.1	-13.6	18.1	42.3	8.1	-13.1
Maine	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Maryland	191.0	177.8	102.9	81.2	121.6	113.6	54.4	38.2

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Massachusetts	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
Michigan	-3.8	102.3	82.2	21.5	-22.3	62.9	48.7	-1.8
Minnesota	153.6	142.8	85.0	91.1	97.4	100.6	45.8	48.2
Mississippi	63.6	70.1	25.2	38.3	64.2	70.8	25.7	38.8
Missouri	55.7	161.3	105.2	74.4	55.5	161.0	105.0	74.2
Montana	112.2	114.9	113.3	54.1	110.1	77.8	60.8	45.6
Nebraska	122.6	242.1	110.0	53.5	59.6	148.8	53.0	13.1
Nevada	0.8	10.8	-1.4	113.7	22.0	24.0	19.3	66.2
NewJersey	128.4	107.1	50.7	89.8	82.9	65.9	20.7	52.0
NewMexico	-26.9	-70.0	-40.2	46.8	-8.3	27.9	-37.3	18.6
NewYork	190.2	138.7	160.5	111.7	140.0	97.7	116.2	73.8
NorthCarolina	123.7	96.7	118.5	70.7	117.3	93.1	112.5	66.0
NorthDakota	208.2	205.4	127.8	174.8	82.0	88.8	30.8	59.4
OhioNE	136.3	149.0	102.9	170.0	119.5	131.3	88.5	150.8
OhioNW	152.7	192.9	158.4	241.6	139.7	177.9	145.1	224.1
OhioS	139.3	164.4	111.7	192.4	137.8	162.8	110.3	190.6
Oklahoma	2.0	10.4	3.8	14.3	11.9	15.7	7.2	12.5
Oregon	279.0	157.3	107.4	98.4	210.3	62.8	83.6	107.2
Pennsylvania	172.6	106.9	68.1	95.2	134.8	78.3	44.8	68.1
RhodeIsland	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
SouthCarolina	106.7	58.3	240.0	74.8	107.1	58.6	240.6	75.2
SouthDakota	180.9	236.8	101.1	69.2	100.4	132.1	38.3	17.1
Tennessee	75.2	108.7	220.3	90.5	76.5	110.2	222.6	91.9
TxCntBlack	83.1	13.3	9.4	81.4	83.5	13.6	9.7	81.8
TxCoastBe	-3.0	-1.2	-4.5	6.3	-3.0	2.0	2.1	6.1
TxEast	11.6	-24.7	1.3	17.7	11.8	-18.6	2.0	17.7
TxEdplat	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
TxHiPlains	-39.9	-49.4	-22.0	-3.1	30.9	5.5	17.5	16.9
TxRollingPl	104.8	37.2	9.6	75.1	73.0	15.9	-3.3	47.9
TxSouth	10.9	58.3	-36.8	-22.0	9.8	95.5	52.4	11.2
TxTranspec	91.1	16.2	-22.0	53.1	55.3	1.5	-19.8	36.5
Utah	62.9	75.6	23.4	14.9	58.3	69.4	60.4	21.2
Vermont	228.1	208.5	250.3	212.2	211.2	195.7	240.7	205.5
Virginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Washington	-65.3	13.9	-67.4	-54.3	61.7	37.4	-4.3	46.1
WestVirginia	125.9	157.1	118.5	45.8	102.8	130.9	96.2	30.8
Wisconsin	75.5	147.6	178.3	105.6	32.0	88.8	120.9	52.7
Wyoming	65.1	149.0	134.5	20.4	118.1	102.7	117.5	26.8

Table B-13. Percent Changes in Mean Yield Incorporated into FASOM, Oranges

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	NA	NA	NA	NA	-3.9	-6.5	-13.5	0.7
CaliforniaN	NA	NA	NA	NA	-6.1	-16.7	-17.0	-21.6
CaliforniaS	NA	NA	NA	NA	-6.1	-16.7	-17.0	-21.6
Florida	NA	NA	NA	NA	-16.9	-15.5	-22.7	-7.4
TxSouth	NA	NA	NA	NA	-33.3	-23.6	-59.8	-2.5

Table B-14. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Oranges

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	NA	NA	NA	NA	-14.0	-28.5	51.9	13.4
CaliforniaN	NA	NA	NA	NA	-3.3	-13.0	-8.6	10.6
CaliforniaS	NA	NA	NA	NA	-3.3	-13.0	-8.6	10.6
Florida	NA	NA	NA	NA	13.8	-15.3	-2.5	2.3
TxSouth	NA	NA	NA	NA	0.7	-25.7	-12.3	13.1

Table B-15. Percent Changes in Mean Yield Incorporated into FASOM, Potatoes

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-21.7	-30.0	-22.5	1.2	-21.7	-30.0	-22.5	1.2
Arizona	-3.9	-6.5	-13.5	0.7	-3.9	-6.5	-13.5	0.7
Arkansas	-25.1	-39.7	-30.1	-2.2	-25.1	-39.7	-30.1	-2.2
CaliforniaN	-6.1	-16.7	-17.0	-21.6	-6.1	-16.7	-17.0	-21.6
CaliforniaS	-6.1	-16.7	-17.0	-21.6	-6.1	-16.7	-17.0	-21.6
Colorado	-4.0	-11.1	-22.3	6.8	-4.0	-11.1	-22.3	6.8
Connecticut	2.6	-13.3	-7.8	4.6	2.6	-13.3	-7.8	4.6
Delaware	-8.1	-16.3	-19.6	-0.5	-8.1	-16.3	-19.6	-0.5
Florida	-16.9	-15.5	-22.7	-7.4	-16.9	-15.5	-22.7	-7.4
Georgia	-15.1	-20.5	-18.0	3.4	-15.1	-20.5	-18.0	3.4
Idaho	15.1	-12.6	-16.5	5.6	15.1	-12.6	-16.5	5.6
IllinoisN	-10.7	-20.4	-18.7	9.0	-10.7	-20.4	-18.7	9.0
IllinoisS	-21.2	-24.6	-22.8	3.1	-21.2	-24.6	-22.8	3.1
IndianaN	-11.5	-17.3	-19.3	9.0	-11.5	-17.3	-19.3	9.0
IndianaS	-11.5	-17.3	-19.3	9.0	-11.5	-17.3	-19.3	9.0
IowaCent	-6.1	-19.8	-19.4	8.4	-6.1	-19.8	-19.4	8.4
IowaNE	-3.2	-20.1	-15.8	11.7	-3.2	-20.1	-15.8	11.7
IowaS	-7.4	-16.0	-26.8	5.4	-7.4	-16.0	-26.8	5.4

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
IowaW	-8.5	-15.9	-27.4	5.7	-8.5	-15.9	-27.4	5.7
Kansas	-11.2	-15.9	-30.6	5.2	-11.2	-15.9	-30.6	5.2
Kentucky	-24.6	-35.0	-25.2	1.9	-24.6	-35.0	-25.2	1.9
Louisiana	-16.5	-41.4	-32.6	-3.7	-16.5	-41.4	-32.6	-3.7
Maine	3.1	-8.2	0.7	6.1	3.1	-8.2	0.7	6.1
Maryland	-8.5	-14.8	-18.3	0.9	-8.5	-14.8	-18.3	0.9
Massachusetts	1.9	-15.8	-7.6	5.4	1.9	-15.8	-7.6	5.4
Michigan	-4.1	-18.5	-8.5	12.9	-4.1	-18.5	-8.5	12.9
Minnesota	-0.9	-13.6	-10.8	9.2	-0.9	-13.6	-10.8	9.2
Mississippi	-25.3	-39.2	-29.4	1.6	-25.3	-39.2	-29.4	1.6
Missouri	-19.7	-25.2	-24.1	6.5	-19.7	-25.2	-24.1	6.5
Montana	15.1	-12.6	-16.5	5.6	15.1	-12.6	-16.5	5.6
Nebraska	-5.0	-13.6	-20.1	7.2	-5.0	-13.6	-20.1	7.2
Nevada	-6.1	-16.7	-17.0	-21.6	-6.1	-16.7	-17.0	-21.6
NewHampshire	3.5	-11.1	-3.3	8.3	3.5	-11.1	-3.3	8.3
NewJersey	-4.1	-16.2	-16.5	2.2	-4.1	-16.2	-16.5	2.2
NewMexico	-26.2	-8.0	-28.9	-1.5	-26.2	-8.0	-28.9	-1.5
NewYork	-0.7	-11.6	-9.4	7.6	-0.7	-11.6	-9.4	7.6
NorthCarolina	-12.0	-9.2	-11.7	-0.5	-12.0	-9.2	-11.7	-0.5
NorthDakota	-0.5	-10.4	-8.2	6.8	-0.5	-10.4	-8.2	6.8
OhioNE	-6.7	-12.6	-15.1	7.4	-6.7	-12.6	-15.1	7.4
OhioNW	-10.2	-17.9	-20.7	8.6	-10.2	-17.9	-20.7	8.6
OhioS	-7.2	-11.6	-15.6	4.9	-7.2	-11.6	-15.6	4.9
Oregon	4.0	-14.3	-12.1	-7.8	4.0	-14.3	-12.1	-7.8
Pennsylvania	-3.1	-11.8	-13.0	6.3	-3.1	-11.8	-13.0	6.3
RhodeIsland	1.9	-15.8	-7.6	5.4	1.9	-15.8	-7.6	5.4
SouthDakota	-4.0	-12.6	-11.5	7.3	-4.0	-12.6	-11.5	7.3
Tennessee	-17.7	-23.5	-16.4	2.0	-17.7	-23.5	-16.4	2.0
TxCntBlack	-28.1	-23.5	-40.6	-5.8	-28.1	-23.5	-40.6	-5.8
TxCoastBe	-37.1	5.1	-20.6	-2.0	-37.1	5.1	-20.6	-2.0
TxEast	-29.2	-41.3	-37.5	-6.9	-29.2	-41.3	-37.5	-6.9
TxEdplat	-29.2	-33.5	-39.8	-5.4	-29.2	-33.5	-39.8	-5.4
TxHiPlains	-31.5	-28.7	-32.2	-3.5	-31.5	-28.7	-32.2	-3.5
TxRolingPl	-28.1	-23.5	-40.6	-5.8	-28.1	-23.5	-40.6	-5.8
TxSouth	-33.3	-23.6	-59.8	-2.5	-33.3	-23.6	-59.8	-2.5
TxTranspec	-29.0	-12.1	-29.7	-5.5	-29.0	-12.1	-29.7	-5.5
Utah	-4.0	-11.1	-22.3	6.8	-4.0	-11.1	-22.3	6.8
Vermont	4.6	-8.7	0.3	10.2	4.6	-8.7	0.3	10.2
Virginia	-10.4	-12.2	-14.9	0.6	-10.4	-12.2	-14.9	0.6
Washington	1.0	-15.1	-21.2	-9.0	1.0	-15.1	-21.2	-9.0
WestVirginia	-10.4	-12.2	-14.9	0.6	-10.4	-12.2	-14.9	0.6
Wisconsin	-4.3	-20.7	-12.1	12.4	-4.3	-20.7	-12.1	12.4
Wyoming	2.0	-16.2	-17.2	8.0	2.0	-16.2	-17.2	8.0

Table B-16. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Potatoes

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	40.8	75.5	49.9	-12.1	40.8	75.5	49.9	-12.1
Arizona	-14.0	-28.5	51.9	13.4	-14.0	-28.5	51.9	13.4
Arkansas	8.2	66.1	48.6	-10.9	8.2	66.1	48.6	-10.9
CaliforniaN	-3.3	-13.0	-8.6	10.6	-3.3	-13.0	-8.6	10.6
CaliforniaS	-3.3	-13.0	-8.6	10.6	-3.3	-13.0	-8.6	10.6
Colorado	17.9	7.8	48.9	11.1	17.9	7.8	48.9	11.1
Connecticut	-9.8	-0.5	24.6	-10.0	-9.8	-0.5	24.6	-10.0
Delaware	35.9	56.5	30.6	26.4	35.9	56.5	30.6	26.4
Florida	13.8	-15.3	-2.5	2.3	13.8	-15.3	-2.5	2.3
Georgia	64.2	71.7	71.0	2.1	64.2	71.7	71.0	2.1
Idaho	-31.7	-13.6	6.3	13.0	-31.7	-13.6	6.3	13.0
IllinoisN	17.2	25.6	40.3	16.2	17.2	25.6	40.3	16.2
IllinoisS	49.5	85.3	44.4	-10.8	49.5	85.3	44.4	-10.8
IndianaN	20.5	28.1	73.4	6.7	20.5	28.1	73.4	6.7
IndianaS	20.5	28.1	73.4	6.7	20.5	28.1	73.4	6.7
IowaCent	29.3	2.8	41.9	2.9	29.3	2.8	41.9	2.9
IowaNE	13.2	-14.9	100.2	-7.4	13.2	-14.9	100.2	-7.4
IowaS	18.3	47.0	22.3	-6.7	18.3	47.0	22.3	-6.7
IowaW	15.0	34.6	10.8	-5.5	15.0	34.6	10.8	-5.5
Kansas	10.8	19.6	15.0	-6.1	10.8	19.6	15.0	-6.1
Kentucky	34.4	135.6	30.2	-43.0	34.4	135.6	30.2	-43.0
Louisiana	7.2	27.6	65.5	-3.4	7.2	27.6	65.5	-3.4
Maine	19.4	26.0	24.5	31.7	19.4	26.0	24.5	31.7
Maryland	42.8	53.0	37.7	23.9	42.8	53.0	37.7	23.9
Massachusetts	33.5	50.5	62.0	26.7	33.5	50.5	62.0	26.7
Michigan	3.2	14.3	100.3	13.2	3.2	14.3	100.3	13.2
Minnesota	20.2	-5.5	23.6	15.2	20.2	-5.5	23.6	15.2
Mississippi	30.3	99.7	46.8	-20.7	30.3	99.7	46.8	-20.7
Missouri	46.0	110.0	45.7	1.8	46.0	110.0	45.7	1.8
Montana	-31.7	-13.6	6.3	13.0	-31.7	-13.6	6.3	13.0
Nebraska	40.1	4.4	14.9	20.9	40.1	4.4	14.9	20.9
Nevada	-3.3	-13.0	-8.6	10.6	-3.3	-13.0	-8.6	10.6
NewHampshire	5.8	84.1	70.0	17.4	5.8	84.1	70.0	17.4
NewJersey	26.1	32.6	20.2	15.7	26.1	32.6	20.2	15.7
NewMexico	-11.9	9.2	44.2	11.6	-11.9	9.2	44.2	11.6
NewYork	3.7	17.7	71.8	11.9	3.7	17.7	71.8	11.9
NorthCarolina	19.3	9.5	24.6	10.6	19.3	9.5	24.6	10.6
NorthDakota	50.5	-5.8	-4.5	29.9	50.5	-5.8	-4.5	29.9
OhioNE	10.5	48.9	73.2	12.9	10.5	48.9	73.2	12.9
OhioNW	13.8	22.8	64.1	8.6	13.8	22.8	64.1	8.6
OhioS	26.3	77.1	67.8	35.6	26.3	77.1	67.8	35.6
Oregon	0.0	-1.2	52.3	19.7	0.0	-1.2	52.3	19.7
Pennsylvania	16.5	11.8	59.9	14.0	16.5	11.8	59.9	14.0
RhodeIsland	33.5	50.5	62.0	26.7	33.5	50.5	62.0	26.7
SouthDakota	65.0	-1.0	-8.4	14.5	65.0	-1.0	-8.4	14.5
Tennessee	46.9	70.5	36.2	-2.2	46.9	70.5	36.2	-2.2

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
TxCntBlack	6.0	-14.1	11.8	9.2	6.0	-14.1	11.8	9.2
TxCoastBe	1.1	32.3	74.2	-6.1	1.1	32.3	74.2	-6.1
TxEast	-1.7	28.8	46.1	-9.0	-1.7	28.8	46.1	-9.0
TxEdplat	8.9	6.2	4.0	3.6	8.9	6.2	4.0	3.6
TxHiPlains	-1.3	5.6	10.7	2.7	-1.3	5.6	10.7	2.7
TxRolingPl	6.0	-14.1	11.8	9.2	6.0	-14.1	11.8	9.2
TxSouth	0.7	-25.7	-12.3	13.1	0.7	-25.7	-12.3	13.1
TxTranspec	-9.3	0.5	44.5	22.7	-9.3	0.5	44.5	22.7
Utah	17.9	7.8	48.9	11.1	17.9	7.8	48.9	11.1
Vermont	13.9	37.9	14.9	42.0	13.9	37.9	14.9	42.0
Virginia	24.1	46.9	24.5	15.0	24.1	46.9	24.5	15.0
Washington	0.0	-13.4	57.3	146.5	0.0	-13.4	57.3	146.5
WestVirginia	24.1	46.9	24.5	15.0	24.1	46.9	24.5	15.0
Wisconsin	-3.9	6.3	122.9	14.8	-3.9	6.3	122.9	14.8
Wyoming	30.9	14.4	-16.3	19.3	30.9	14.4	-16.3	19.3

Table B-17. Percent Changes in Mean Yield Incorporated into FASOM, Rice

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	NA	NA	NA	NA	-5.0	-5.3	-14.0	4.5
Arkansas	NA	NA	NA	NA	-5.6	-19.4	-24.5	5.5
CaliforniaN	NA	NA	NA	NA	25.6	0.4	2.3	7.5
CaliforniaS	NA	NA	NA	NA	25.6	0.4	2.3	7.5
Florida	NA	NA	NA	NA	-5.0	-5.3	-14.0	4.5
IllinoisS	NA	NA	NA	NA	0.4	-20.0	-17.2	6.8
Kentucky	NA	NA	NA	NA	-4.8	-20.0	-20.4	6.2
Louisiana	NA	NA	NA	NA	0.8	-9.7	-12.5	3.3
Mississippi	NA	NA	NA	NA	-3.2	-4.8	-12.9	5.7
Missouri	NA	NA	NA	NA	0.4	-21.4	-22.2	14.7
Nevada	NA	NA	NA	NA	25.6	0.4	2.3	7.5
Oklahoma	NA	NA	NA	NA	-6.8	-7.1	-21.8	3.2
Tennessee	NA	NA	NA	NA	-4.4	-18.2	-13.0	6.6
TxCntBlack	NA	NA	NA	NA	-1.4	-7.6	-12.3	-6.6
TxCoastBe	NA	NA	NA	NA	-1.9	-5.3	-9.0	-7.0
TxEast	NA	NA	NA	NA	-4.1	-20.2	-27.2	5.1
TxEdplat	NA	NA	NA	NA	-1.4	-7.6	-12.3	-6.6
TxRolingPl	NA	NA	NA	NA	-1.4	-7.6	-12.3	-6.6
TxSouth	NA	NA	NA	NA	-1.9	-5.3	-9.0	-7.0

Table B-18. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Rice

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	NA	NA	NA	NA	-13.2	21.9	18.3	3.9
Arkansas	NA	NA	NA	NA	-5.4	0.8	-7.8	7.7
CaliforniaN	NA	NA	NA	NA	12.3	-10.6	-9.6	15.4
CaliforniaS	NA	NA	NA	NA	12.3	-10.6	-9.6	15.4
Florida	NA	NA	NA	NA	-13.2	21.9	18.3	3.9
IllinoisS	NA	NA	NA	NA	-16.7	34.0	1.9	1.6
Kentucky	NA	NA	NA	NA	-7.8	36.3	20.4	1.4
Louisiana	NA	NA	NA	NA	13.0	-23.5	-8.6	-7.1
Mississippi	NA	NA	NA	NA	-9.5	4.7	5.3	9.1
Missouri	NA	NA	NA	NA	-6.2	13.9	-9.2	25.8
Nevada	NA	NA	NA	NA	12.3	-10.6	-9.6	15.4
Oklahoma	NA	NA	NA	NA	9.5	-7.2	17.1	-0.4
Tennessee	NA	NA	NA	NA	-20.8	-2.9	13.9	3.6
TxCntBlack	NA	NA	NA	NA	-9.7	-21.2	-25.8	-13.3
TxCoastBe	NA	NA	NA	NA	-4.0	-14.1	-14.9	-18.8
TxEast	NA	NA	NA	NA	-5.7	-20.0	-22.5	3.8
TxEdplat	NA	NA	NA	NA	-9.7	-21.2	-25.8	-13.3
TxRolingPl	NA	NA	NA	NA	-9.7	-21.2	-25.8	-13.3
TxSouth	NA	NA	NA	NA	-4.0	-14.1	-14.9	-18.8

Table B-19. Percent Changes in Mean Yield Incorporated into FASOM, Silage

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-0.9	-4.4	-2.9	3.1	2.6	-0.7	-0.4	3.5
Arizona	8.3	-0.8	-6.8	41.0	3.6	-2.7	-7.2	-3.1
Arkansas	-2.4	-10.2	-8.2	4.3	-1.9	-8.0	-8.1	4.7
CaliforniaN	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
CaliforniaS	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
Colorado	25.7	12.9	8.8	39.0	2.9	0.5	-6.8	5.0
Connecticut	-2.9	-4.1	-1.8	0.6	-1.2	-2.4	-1.6	1.0
Delaware	0.8	-2.1	-4.3	0.2	0.9	-2.3	-4.7	0.7
Florida	-10.4	-4.1	-7.0	1.6	-1.7	0.2	4.3	2.6
Georgia	-4.0	0.5	-3.1	2.3	-1.6	0.2	-1.5	2.4
Idaho	82.3	65.0	94.3	86.4	17.2	-1.0	-7.8	-2.0
IllinoisN	-1.5	-11.1	-10.4	5.0	-1.5	-10.3	-10.5	5.9
IllinoisS	-4.0	-13.9	-12.4	3.7	-4.0	-13.4	-12.7	3.9
IndianaN	-0.9	-7.6	-5.7	6.3	-0.7	-6.6	-6.4	6.7
IndianaS	-0.4	-7.8	-7.0	4.3	-0.4	-6.8	-7.5	4.5
IowaCent	0.9	-7.8	-9.2	7.3	0.7	-7.5	-8.9	7.9
IowaNE	-0.1	-8.0	-8.8	6.8	-0.2	-7.5	-8.3	7.2
IowaS	0.6	-11.1	-13.9	7.2	0.5	-10.8	-14.6	7.3

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
IowaW	0.6	-7.1	-10.7	6.5	0.4	-7.0	-10.7	6.6
Kansas	-2.4	-9.5	-15.4	7.0	-4.1	-9.9	-16.5	5.1
Kentucky	1.2	-5.7	-7.2	2.7	1.5	-5.1	-7.2	2.9
Louisiana	-0.5	-8.6	-11.5	6.8	0.5	-2.3	-3.1	7.1
Maine	2.6	-0.8	-0.1	8.4	2.6	-0.2	0.0	8.4
Maryland	1.7	-0.8	-3.0	4.4	1.7	-0.5	-4.2	4.7
Massachusetts	0.0	-0.2	-3.4	1.8	0.0	0.3	-3.6	1.8
Michigan	-1.7	-6.7	-4.0	3.1	-1.4	-6.5	-5.2	3.5
Minnesota	1.5	-4.3	-4.6	6.3	1.2	-3.1	-5.7	6.8
Mississippi	1.3	-4.3	-1.5	5.8	2.9	-1.2	-1.0	6.3
Missouri	-2.5	-14.9	-14.5	5.1	-2.6	-14.4	-14.8	5.3
Montana	31.5	1.1	15.5	30.8	5.5	-7.7	-7.1	-1.9
Nebraska	6.4	-0.9	-5.5	7.2	2.4	-2.6	-9.3	3.5
Nevada	316.7	154.5	91.1	31.0	3.2	-9.4	-10.4	-9.3
NewHampshire	-7.6	-15.1	-11.1	1.3	-7.5	-12.0	-10.7	1.9
NewJersey	0.8	-4.4	-3.2	-0.9	2.6	-4.2	-3.5	-0.1
NewMexico	-20.4	51.9	5.5	60.3	3.2	-1.0	-0.8	10.2
NewYork	0.0	1.9	-3.0	4.4	0.1	1.9	-3.2	4.4
NorthCarolina	0.3	-1.6	-4.3	-0.4	0.3	-1.7	-4.4	-0.2
NorthDakota	8.6	3.4	13.8	10.8	3.9	2.3	-1.4	6.3
OhioNE	-0.2	-3.5	-7.3	3.5	-0.1	-3.4	-7.6	3.6
OhioNW	-0.2	-5.4	-6.1	4.3	-0.1	-5.3	-6.5	4.5
OhioS	-0.9	-4.1	-6.6	3.0	-0.9	-3.9	-6.8	3.0
Oklahoma	-2.6	-4.8	-12.3	5.1	-2.8	-5.7	-11.1	6.1
Oregon	143.5	152.3	289.9	228.9	19.7	-10.7	-20.3	-5.9
Pennsylvania	2.0	-2.8	-5.7	1.3	2.3	-2.8	-6.1	1.4
RhodeIsland	0.0	-0.2	-3.4	1.8	0.0	0.3	-3.6	1.8
SouthCarolina	-1.4	-0.6	-3.8	0.6	-1.1	-0.6	-3.5	0.7
SouthDakota	6.7	-2.2	1.9	7.2	2.4	-3.4	-6.0	4.3
Tennessee	1.3	-5.9	-5.2	2.6	1.4	-5.5	-5.3	2.7
TxCntBlack	-6.2	-10.0	-30.8	-10.1	-5.7	-7.0	-10.7	-0.2
TxCoastBe	-6.7	-7.9	-34.6	-9.8	-6.9	-2.1	-10.5	-0.1
TxEast	-2.0	2.5	-8.2	6.5	-2.0	9.4	-0.3	6.5
TxEdplat	-7.8	3.6	-5.6	-0.5	-7.9	-7.7	-4.8	-0.4
TxHiPlains	19.5	22.4	-7.4	15.3	-2.3	-6.0	-11.0	1.6
TxRolingPl	-0.5	4.8	-19.6	-4.7	-6.0	-7.9	-14.4	0.7
TxSouth	-6.1	-6.0	-34.4	-0.2	-8.6	-3.9	-18.3	-2.8
TxTranspec	-7.8	3.6	-5.6	-0.5	-7.9	-7.7	-4.8	-0.4
Utah	-75.8	1.6	-5.9	-66.3	36.2	26.3	7.6	4.0
Vermont	14.3	18.3	16.3	36.0	14.3	18.3	16.3	36.0
Virginia	-0.4	-3.1	-3.8	-1.1	-0.5	-3.0	-5.1	0.3
Washington	-19.1	-26.9	-55.4	582.0	-3.8	-11.5	-9.9	-3.0
WestVirginia	-0.9	-3.3	-5.3	2.9	-0.9	-2.9	-6.1	3.2
Wisconsin	-3.3	-7.0	-8.4	2.9	-3.3	-6.0	-6.9	3.1
Wyoming	92.3	42.7	50.6	153.3	18.3	10.7	7.1	17.7

Table B-20. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Silage

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-2.0	2.4	11.7	0.0	-10.1	-11.7	-1.0	0.2
Arizona	38.2	73.9	48.0	85.1	-14.9	-13.5	-3.2	-9.3
Arkansas	-15.8	-5.0	-13.9	7.2	-17.3	-18.0	-14.1	6.8
CaliforniaN	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
CaliforniaS	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
Colorado	-34.9	-32.3	-37.5	-4.2	-13.6	-16.5	-16.8	0.2
Connecticut	-0.5	-1.4	-0.9	4.3	0.0	-4.4	-1.9	3.9
Delaware	-2.5	-14.5	-4.6	-0.8	-2.2	-14.8	-4.4	0.6
Florida	9.8	-0.6	28.1	-0.2	-10.1	-13.2	-13.9	-0.9
Georgia	-6.0	-8.4	6.1	0.2	-12.7	-7.2	-3.5	0.3
Idaho	15.8	-3.9	30.5	14.5	-11.3	-25.8	-15.5	-6.4
IllinoisN	-9.1	-10.9	-16.6	6.8	-8.6	-15.0	-15.7	6.0
IllinoisS	-5.9	-12.4	-12.9	3.0	-5.8	-15.2	-10.5	2.7
IndianaN	-10.1	-14.2	-11.8	2.5	-10.1	-16.6	-10.0	3.2
IndianaS	-9.7	-22.8	-13.5	2.5	-9.6	-23.5	-12.7	3.0
IowaCent	-10.2	8.0	-6.2	11.3	-8.4	4.0	-8.8	8.8
IowaNE	-1.3	1.7	0.5	12.1	-0.3	-0.6	-3.0	11.6
IowaS	-30.3	87.8	-33.8	11.4	-29.6	82.7	-23.9	11.5
IowaW	-15.2	-4.3	-30.9	3.7	-13.2	-4.8	-30.6	2.9
Kansas	-18.4	-14.7	-19.3	3.0	-9.0	-10.6	-10.2	9.8
Kentucky	-11.1	-9.8	2.6	7.2	-13.0	-16.8	2.6	6.4
Louisiana	-8.8	7.6	34.2	-5.4	-9.2	-25.5	1.3	-5.7
Maine	-10.7	-11.5	-7.4	-26.2	-10.7	-11.2	-7.7	-26.2
Maryland	-10.4	-4.0	-6.2	-2.8	-10.2	-6.1	-2.0	-2.5
Massachusetts	1.5	19.2	16.6	2.3	1.7	17.5	17.2	2.5
Michigan	-16.3	-0.4	-7.1	18.2	-16.3	-3.3	-1.4	19.3
Minnesota	1.9	1.0	-0.3	9.7	3.1	-9.2	-1.3	8.8
Mississippi	-6.1	2.0	1.6	2.6	-9.5	-15.6	-0.7	2.6
Missouri	-8.8	39.5	-20.2	16.6	-7.5	31.6	-12.7	15.9
Montana	-61.8	-59.1	-65.9	-54.8	-26.5	-10.9	-11.9	33.4
Nebraska	-16.8	-10.2	-39.2	-1.9	-10.8	-3.7	-22.8	11.8
Nevada	181.0	75.6	68.6	2.9	3.5	-15.5	-15.5	-12.3
NewHampshire	-19.0	15.4	10.3	-3.6	-19.0	-15.2	7.3	-5.9
NewJersey	-8.6	-1.4	-5.0	3.8	-6.9	-1.4	-4.2	3.8
NewMexico	0.8	-7.6	-21.1	-2.9	-15.6	-26.0	-23.6	-18.2
NewYork	5.9	5.8	10.4	16.6	5.7	6.0	11.6	16.8
NorthCarolina	-5.1	-6.0	-6.4	-0.1	-4.9	-6.0	-6.0	0.1
NorthDakota	-15.9	-5.1	-39.9	-5.4	14.0	-6.9	9.8	25.0
OhioNE	-4.9	-8.6	-0.8	6.5	-5.0	-9.0	0.0	6.5
OhioNW	-8.9	-10.4	-4.3	6.3	-8.8	-10.2	-4.0	6.8
OhioS	-5.0	-15.3	-2.8	3.3	-5.0	-15.7	-2.5	3.3
Oregon	26.2	28.4	169.1	68.2	-16.1	-22.8	-6.9	-1.2
Pennsylvania	-9.2	-0.9	2.2	-3.0	-8.7	-1.0	4.1	-3.3
RhodeIsland	1.5	19.2	16.6	2.3	1.7	17.5	17.2	2.5
SouthCarolina	-11.2	-4.3	-4.2	2.3	-11.3	-4.4	-6.0	2.3
SouthDakota	-31.2	-14.1	-52.2	-7.4	-0.7	6.1	-17.4	14.5

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Tennessee	-16.6	-11.0	0.6	6.3	-16.5	-13.4	1.6	6.4
TxCntBlack	-5.3	-10.7	5.2	13.8	-3.6	-16.3	-3.5	0.1
TxCoastBe	-14.8	-19.9	-4.5	8.0	-14.5	-24.5	-15.1	2.0
TxEast	-5.8	-33.1	-17.1	5.6	-5.8	-46.3	-32.6	5.7
TxEdplat	-8.4	-54.4	-22.9	-20.4	-7.3	-17.3	46.6	0.5
TxHiPlains	-30.3	-32.7	-24.3	10.4	-15.3	-9.3	-21.0	4.7
TxRolingPl	-35.1	-34.5	-21.6	9.8	-16.4	-24.3	-16.1	0.9
TxSouth	-37.9	3.7	-17.9	-6.4	-15.1	-18.8	-18.3	-1.7
TxTranspec	-8.4	-54.4	-22.9	-20.4	-7.3	-17.3	46.6	0.5
Utah	-20.3	115.4	-5.8	-13.6	14.7	-9.8	-16.0	-12.7
Vermont	-51.7	-27.0	-43.6	-33.7	-51.7	-27.0	-43.6	-33.7
Virginia	-1.4	-8.0	-12.3	2.4	-0.8	-9.8	1.5	1.7
Washington	-20.0	-12.6	-21.3	767.5	7.5	-18.8	-1.5	-33.0
WestVirginia	9.2	-12.6	2.1	-2.5	9.4	-15.6	19.6	-2.5
Wisconsin	-10.3	-1.4	7.7	12.4	-10.3	-5.7	-1.3	12.4
Wyoming	-45.4	-19.0	-33.5	-34.1	-28.7	29.0	27.3	-3.8

Table B-21. Percent Changes in Mean Yield Incorporated into FASOM, Sorghum

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-9.0	-7.7	-8.3	2.7	-1.6	-5.4	-5.8	4.3
Arizona	-12.8	-2.8	-8.6	-16.6	-1.1	-18.7	-25.9	-15.2
Arkansas	-2.7	-9.2	-9.5	3.7	-1.8	-7.3	-9.2	4.5
CaliforniaN	122.8	87.7	48.1	17.6	6.2	-10.5	-9.7	-10.2
CaliforniaS	122.8	87.7	48.1	17.6	6.2	-10.5	-9.7	-10.2
Colorado	27.3	28.7	17.5	42.0	5.7	12.0	2.1	8.1
Delaware	1.4	-0.7	-2.5	-0.6	1.5	-1.1	-4.1	1.6
Florida	-23.2	-23.9	-24.9	-3.0	-2.1	-3.3	-5.3	2.2
Georgia	-6.8	0.0	-5.9	3.1	-2.0	-0.4	-3.7	3.2
IllinoisN	0.5	-7.8	-7.5	5.6	0.4	-6.1	-8.0	7.2
IllinoisS	-1.4	-9.5	-9.0	5.0	-1.3	-9.3	-9.1	5.1
IndianaN	-0.3	-4.5	-3.5	9.2	0.0	-3.0	-4.9	10.6
IndianaS	-0.8	-7.0	-6.6	5.0	-0.4	-5.4	-7.2	6.1
IowaCent	3.8	-0.3	-5.3	12.5	3.4	1.2	-4.4	14.2
IowaNE	5.6	6.6	-2.2	17.6	5.6	6.6	-2.2	17.6
IowaS	2.0	-5.0	-8.7	10.4	2.0	-4.7	-9.3	10.4
IowaW	2.4	-2.3	-7.6	8.5	2.3	-2.2	-7.8	8.5
Kansas	0.1	-5.2	-12.9	7.1	-1.5	-5.6	-13.5	6.4
Kentucky	-5.3	-11.2	-9.0	3.7	-1.2	-8.6	-8.8	5.6
Louisiana	-8.0	-17.2	-18.5	1.7	-1.4	-7.5	-9.8	4.4
Maine	11.9	43.3	15.6	9.9	13.2	46.8	13.5	12.0
Maryland	1.8	9.2	1.7	7.1	2.1	9.1	-0.4	7.8
Massachusetts	11.9	43.3	15.6	9.9	13.2	46.8	13.5	12.0
Michigan	7.7	9.1	4.1	19.3	10.2	12.0	5.4	22.2

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Minnesota	9.0	15.5	5.7	16.7	8.6	17.5	4.7	17.6
Mississippi	-5.7	-9.1	-8.8	5.3	-1.2	-5.6	-7.7	7.1
Missouri	0.0	-10.5	-10.1	7.1	0.2	-9.9	-10.3	7.4
Montana	49.3	19.7	33.1	42.5	14.1	8.8	4.4	5.6
Nebraska	9.0	5.0	-1.2	11.7	5.0	3.7	-4.5	8.8
Nevada	122.8	87.7	48.1	17.6	6.2	-10.5	-9.7	-10.2
NewJersey	-1.2	5.7	1.4	3.5	6.0	8.2	0.0	8.2
NewMexico	-23.7	66.4	10.0	38.1	2.9	6.9	-0.8	6.1
NewYork	40.0	60.3	34.2	64.0	40.5	60.3	33.6	64.0
NorthCarolina	1.3	-1.8	-3.2	1.5	1.3	-2.0	-3.9	1.9
NorthDakota	21.0	24.9	32.4	31.5	12.8	20.7	12.9	24.2
OhioNE	2.4	9.0	-0.8	7.6	2.4	9.0	-1.3	7.7
OhioNW	0.9	-1.3	0.5	7.5	1.4	-0.9	-2.0	10.2
OhioS	0.9	-1.3	0.5	7.5	1.4	-0.9	-2.0	10.2
Oklahoma	-6.2	-1.6	-16.9	5.0	-6.2	-4.9	-14.9	6.1
Pennsylvania	5.4	38.2	10.9	8.3	6.1	38.3	7.9	8.9
RhodeIsland	11.9	43.3	15.6	9.9	13.2	46.8	13.5	12.0
SouthCarolina	0.5	0.6	-3.2	2.6	1.1	0.5	-2.7	2.8
SouthDakota	18.4	10.2	11.4	16.1	7.8	8.8	1.6	8.8
Tennessee	0.1	-7.7	-6.6	3.6	0.2	-7.4	-6.7	3.7
TxCntBlack	-4.0	-12.7	-31.8	-9.4	-2.6	-5.3	-8.2	1.3
TxCoastBe	-5.3	-13.7	-39.8	-7.6	-5.3	-5.0	-11.4	3.8
TxEast	-5.9	-7.8	-14.6	3.1	-4.5	-5.3	-10.8	4.0
TxEdplat	2.3	16.5	-15.4	-6.9	-6.4	-3.9	-12.3	0.9
TxHiPlains	17.2	41.5	-1.9	21.7	-3.8	0.4	-12.6	5.8
TxRolingPl	-0.9	12.5	-19.0	-5.9	-7.3	-5.5	-16.6	2.0
TxSouth	-1.6	-11.2	-38.9	-9.6	-5.3	-7.2	-14.7	-1.9
TxTranspec	57.8	78.6	52.8	95.6	3.0	5.3	-4.9	6.2
Utah	27.3	28.7	17.5	42.0	5.7	12.0	2.1	8.1
Virginia	0.9	-2.9	-1.7	-1.4	0.6	-2.8	-3.3	1.7
WestVirginia	0.9	-2.9	-1.7	-1.4	0.6	-2.8	-3.3	1.7
Wisconsin	4.6	14.3	0.2	16.4	6.4	20.9	6.6	18.4
Wyoming	109.9	51.9	50.4	168.3	26.7	9.9	6.2	18.5

Table B-22. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Sorghum

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	108.8	35.9	25.1	3.1	13.7	35.4	17.9	-10.0
Arizona	-31.8	-55.6	-48.6	-47.3	-1.1	-17.6	-5.6	-12.7
Arkansas	-6.3	17.5	-16.4	56.4	-13.9	-4.9	-17.3	54.9
CaliforniaN	98.3	74.2	45.3	-8.0	13.6	32.9	37.2	26.6
CaliforniaS	98.3	74.2	45.3	-8.0	13.6	32.9	37.2	26.6
Colorado	-41.6	-54.2	-44.0	12.7	-41.0	-58.4	-45.1	0.6
Delaware	7.3	-28.5	-41.2	124.3	2.4	-35.9	38.0	56.4
Florida	135.1	41.4	76.0	37.2	9.3	8.3	23.6	-5.2
Georgia	109.6	-11.4	89.6	-6.9	23.1	-7.5	32.8	-7.2
IllinoisN	-18.6	16.3	-19.9	20.3	-12.5	-5.9	-10.8	10.3
IllinoisS	4.0	12.1	-5.7	6.6	2.4	7.4	-0.6	5.3
IndianaN	-0.1	9.3	-16.6	-12.7	-2.1	-4.7	-8.2	-10.9
IndianaS	-13.1	69.0	-15.0	21.9	-17.6	33.2	3.2	9.0
IowaCent	-26.9	14.1	-1.0	-5.7	-18.1	-11.6	-14.3	-29.7
IowaNE	-53.3	-49.4	-12.2	-56.4	-53.3	-49.4	-12.2	-56.4
IowaS	-28.3	56.3	-30.3	2.0	-27.9	50.9	-21.0	2.1
IowaW	-17.0	-8.5	-30.6	-8.9	-15.3	-9.4	-27.9	-9.0
Kansas	-20.8	-15.2	-15.9	5.0	-7.8	-16.3	-9.9	8.9
Kentucky	50.1	43.1	-2.8	21.5	-9.5	15.6	11.3	-0.5
Louisiana	58.0	124.3	23.4	39.1	-3.1	39.7	25.3	-15.1
Maine	-40.8	-77.9	-58.7	25.5	-33.7	-71.9	-76.7	5.1
Maryland	2.5	-31.0	-10.3	-21.2	0.1	-35.6	3.2	-23.6
Massachusetts	-40.8	-77.9	-58.7	25.5	-33.7	-71.9	-76.7	5.1
Michigan	-33.6	-42.6	-21.4	-40.2	-42.5	-62.2	-51.8	-42.1
Minnesota	-39.2	-43.4	-11.4	-31.2	-40.0	-61.5	-26.8	-37.5
Mississippi	60.9	68.0	1.8	1.9	8.0	32.9	5.8	-5.3
Missouri	-3.9	37.1	-18.9	20.6	-6.9	32.5	-13.8	21.2
Montana	-47.6	-51.4	-65.1	-76.6	-61.1	-36.7	-43.4	37.3
Nebraska	-39.1	-34.3	-46.5	-24.8	-38.1	-31.7	-34.0	-6.9
Nevada	98.3	74.2	45.3	-8.0	13.6	32.9	37.2	26.6
NewJersey	-6.9	-44.7	-28.7	-5.1	-27.5	-47.5	-27.0	-33.4
NewMexico	0.7	6.5	-10.5	-1.6	-54.9	-49.9	-26.7	-34.4
NewYork	-72.1	-76.8	-69.2	-41.8	-69.8	-76.8	-69.7	-41.6
NorthCarolina	8.6	13.7	9.9	16.1	10.4	17.0	33.6	13.6
NorthDakota	-43.3	-50.8	-41.1	-18.8	-48.4	-61.2	-34.9	-26.3
OhioNE	-0.2	-14.7	-3.0	-9.3	-0.2	-14.7	4.4	-10.1
OhioNW	4.9	7.5	-34.3	30.9	-33.1	-5.7	20.4	-32.8
OhioS	4.9	7.5	-34.3	30.9	-33.1	-5.7	20.4	-32.8
Oklahoma	-0.3	-18.0	-6.6	1.2	22.8	-8.7	-4.9	-2.8
Pennsylvania	14.0	-29.2	-12.8	12.3	10.7	-31.5	-8.3	7.8
RhodeIsland	-40.8	-77.9	-58.7	25.5	-33.7	-71.9	-76.7	5.1
SouthCarolina	13.0	-3.7	32.8	3.4	-4.3	-3.3	18.1	2.3
SouthDakota	-39.9	-21.4	-51.6	-38.2	-27.8	-21.4	-29.0	-19.4
Tennessee	-17.8	20.9	8.8	7.6	-18.2	17.4	11.6	8.0
TxCntBlack	-19.3	-8.9	-5.6	3.4	-19.7	-17.1	-12.8	-5.9
TxCoastBe	-12.4	-21.1	-16.3	-9.0	-9.7	-24.4	-15.7	-16.2

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
TxEast	-7.1	-16.6	-15.8	3.5	-6.6	-24.0	-20.0	3.5
TxEdplat	-31.9	-29.3	-13.8	-18.1	-4.5	-25.6	13.5	-20.2
TxHiPlains	-35.3	-39.5	-15.3	1.9	-12.2	5.3	0.8	-10.3
TxRolingPl	-37.9	-40.8	-19.5	15.5	22.3	-9.6	13.2	8.7
TxSouth	-52.4	-3.7	-6.9	-9.4	-16.1	-11.2	61.2	3.6
TxTranspec	36.8	7.1	20.9	28.5	-48.4	-14.7	3.2	-22.4
Utah	-41.6	-54.2	-44.0	12.7	-41.0	-58.4	-45.1	0.6
Virginia	27.9	-8.8	-31.5	69.4	37.7	-19.6	29.6	31.3
WestVirginia	27.9	-8.8	-31.5	69.4	37.7	-19.6	29.6	31.3
Wisconsin	-39.4	-27.0	14.6	-23.8	-51.6	-59.1	-38.5	-32.4
Wyoming	-84.7	-75.0	-72.5	-76.8	-88.4	-49.0	-34.3	-65.0

Table B-23. Percent Changes in Mean Yield Incorporated into FASOM, Soybeans

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-10.5	-11.3	-13.9	1.9	-4.9	-11.0	-13.0	3.5
Arkansas	-9.0	-19.6	-20.3	5.5	-7.7	-19.0	-20.4	6.4
Colorado	45.5	25.7	11.4	55.0	10.6	5.7	-8.2	9.4
Connecticut	-15.0	-0.8	3.1	6.7	3.9	4.8	0.8	11.4
Delaware	1.6	-0.8	-3.3	3.2	2.4	-1.0	-4.8	5.7
Florida	-17.6	-12.3	-13.3	-0.9	-2.4	-5.1	-7.1	-0.1
Georgia	-6.2	-1.4	-8.8	3.8	-2.9	-2.8	-8.1	4.0
IllinoisN	1.5	-9.2	-9.8	12.0	1.6	-8.6	-10.1	13.3
IllinoisS	-3.5	-16.2	-14.9	7.5	-3.4	-15.8	-15.5	8.0
IndianaN	1.2	-3.8	-4.6	14.3	1.4	-3.2	-5.8	15.1
IndianaS	-1.4	-8.3	-11.4	9.8	-1.3	-7.3	-12.2	10.7
IowaCent	5.9	-3.7	-7.2	19.8	5.8	-3.4	-7.1	20.6
IowaNE	8.2	1.3	-5.2	23.3	8.2	2.0	-4.7	24.5
IowaS	4.6	-7.6	-16.0	17.9	4.4	-7.2	-16.6	18.2
IowaW	5.7	-2.6	-11.3	15.9	5.6	-2.6	-11.3	16.1
Kansas	-0.7	-14.5	-20.2	10.2	-1.3	-14.3	-20.8	11.0
Kentucky	-4.2	-14.6	-12.8	5.8	-3.6	-14.3	-13.1	6.7
Louisiana	-14.7	-25.8	-26.9	-0.8	-3.5	-16.2	-16.5	1.5
Maine	15.7	41.5	19.1	18.9	15.7	41.5	19.1	18.9
Maryland	6.2	32.6	9.6	9.2	6.2	32.2	6.8	10.8
Massachusetts	15.7	41.5	19.1	18.9	15.7	41.5	19.1	18.9
Michigan	4.6	1.7	3.2	16.2	5.3	1.6	1.4	17.7
Minnesota	11.7	10.1	6.0	22.5	11.0	11.6	3.9	23.6
Mississippi	-9.2	-18.7	-18.2	3.5	-6.8	-17.8	-18.2	4.9
Missouri	0.1	-15.7	-16.4	11.6	0.1	-15.3	-17.0	11.9
Montana	58.9	19.0	34.9	55.2	16.3	2.0	0.3	8.8
Nebraska	10.4	6.3	-4.3	19.4	7.0	4.6	-6.7	17.8
NewJersey	2.5	12.2	5.9	13.2	13.0	14.6	4.4	18.3
NewMexico	-15.8	73.6	23.0	57.2	-9.0	2.8	-13.7	1.8

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
NewYork	12.3	32.3	15.0	21.1	13.4	32.8	14.2	21.1
NorthCarolina	3.2	-0.9	-5.1	2.8	3.5	-1.1	-5.5	3.7
NorthDakota	19.1	19.5	29.7	29.6	14.0	19.0	14.5	28.1
OhioNE	4.3	4.3	0.1	12.9	4.5	4.5	-0.6	13.5
OhioNW	3.0	-0.2	-1.2	12.5	3.1	0.1	-2.3	13.1
OhioS	3.5	2.7	-0.8	9.8	3.5	2.7	-1.3	9.8
Oklahoma	-8.9	-12.8	-22.3	8.7	-8.8	-13.6	-21.9	9.7
Pennsylvania	14.4	55.5	25.7	23.1	18.0	56.3	23.2	25.5
RhodeIsland	15.7	41.5	19.1	18.9	15.7	41.5	19.1	18.9
SouthCarolina	1.4	0.6	-6.1	3.4	2.1	0.5	-6.0	3.8
SouthDakota	10.9	4.7	5.2	18.9	7.3	3.7	-0.7	17.1
Tennessee	-5.4	-14.6	-13.2	5.7	-5.1	-14.7	-13.5	6.2
TxCntBlack	-8.9	-13.6	-26.5	-1.8	-5.5	-8.9	-14.5	4.0
TxCoastBe	-6.2	-4.8	-27.5	12.8	-1.4	5.7	-4.3	22.1
TxEast	-9.7	-13.3	-21.8	3.0	-8.5	-12.9	-19.3	3.6
TxEdplat	-8.9	-13.6	-26.5	-1.8	-5.5	-8.9	-14.5	4.0
TxHiPlains	9.5	32.9	-9.0	24.7	-10.8	-0.7	-20.0	7.9
TxRolingPl	-8.9	-13.6	-26.5	-1.8	-5.5	-8.9	-14.5	4.0
TxSouth	-6.2	-4.8	-27.5	12.8	-1.4	5.7	-4.3	22.1
TxTranspec	-15.8	73.6	23.0	57.2	-9.0	2.8	-13.7	1.8
Utah	45.5	25.7	11.4	55.0	10.6	5.7	-8.2	9.4
Vermont	-15.0	-0.8	3.1	6.7	3.9	4.8	0.8	11.4
Virginia	2.7	-1.6	-1.1	2.6	2.2	-1.7	-3.2	6.5
WestVirginia	3.6	12.6	3.4	1.2	5.2	14.9	1.7	9.4
Wisconsin	4.3	7.0	0.6	18.2	5.3	9.4	2.5	19.4
Wyoming	105.5	45.5	40.7	163.7	24.1	6.7	1.0	18.2

Table B-24. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Soybeans

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	127.0	31.1	6.9	44.9	88.8	56.2	4.9	25.0
Arkansas	52.6	46.6	-7.8	59.7	44.9	56.8	-1.8	52.8
Colorado	-13.3	-38.9	-31.0	-33.2	-8.3	-10.1	11.7	-5.5
Connecticut	188.8	-21.6	-17.2	114.4	3.5	-79.4	19.0	35.7
Delaware	9.6	-11.2	-11.8	96.4	-1.8	-23.8	69.6	35.5
Florida	150.5	40.9	111.1	33.5	42.8	26.6	52.4	19.2
Georgia	104.6	-3.6	39.8	28.4	76.5	18.2	31.7	28.2
IllinoisN	-13.1	32.0	-17.8	24.9	-12.1	27.2	-14.9	14.4
IllinoisS	12.9	86.8	-5.2	16.8	12.7	95.4	3.7	2.6
IndianaN	-1.1	24.4	-6.8	16.8	-1.7	21.1	-2.3	15.7
IndianaS	-11.8	147.0	3.5	44.0	-13.9	140.8	23.5	3.3
IowaCent	-15.8	9.5	-10.0	-9.4	-14.5	7.5	-10.4	-14.1
IowaNE	-33.9	-12.9	2.8	-41.1	-33.9	-18.9	-2.2	-56.8

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
IowaS	-29.1	83.0	-26.9	-20.4	-28.4	80.5	-19.4	-24.6
IowaW	-13.2	13.6	-29.4	-3.5	-12.6	14.2	-28.5	-4.1
Kansas	-5.6	36.8	-14.8	13.1	2.4	52.9	-7.0	15.3
Kentucky	70.3	74.5	17.7	24.4	59.7	92.7	25.7	2.5
Louisiana	33.4	45.9	14.5	16.7	13.1	19.0	11.2	-13.1
Maine	-44.3	-69.4	-72.6	1.5	-44.3	-69.4	-72.6	1.5
Maryland	-27.5	-44.5	-51.7	-10.5	-32.9	-53.9	-45.2	-28.9
Massachusetts	-44.3	-69.4	-72.6	1.5	-44.3	-69.4	-72.6	1.5
Michigan	-14.2	-20.4	-26.5	-4.1	-24.0	-23.5	-13.0	-23.5
Minnesota	-17.0	-33.2	-1.7	-22.9	-15.6	-44.7	-0.8	-25.6
Mississippi	116.2	52.5	-6.2	42.7	105.9	71.7	-0.6	10.9
Missouri	-10.8	84.1	-19.1	29.0	-9.9	86.6	-12.5	24.8
Montana	-66.1	-69.4	-62.1	-75.4	-53.5	-18.8	2.6	20.9
Nebraska	-13.5	-13.9	-33.6	-27.4	-8.7	-10.0	-24.7	-27.2
NewJersey	16.8	-38.4	-16.3	10.0	-36.0	-54.2	-13.1	-19.8
NewMexico	1.1	5.2	20.2	20.9	43.3	21.2	54.3	-9.8
NewYork	-34.9	-46.1	-41.3	-31.5	-25.6	-46.1	-42.3	-30.3
NorthCarolina	26.2	-10.5	44.6	44.7	18.3	-6.6	66.9	27.8
NorthDakota	-15.8	-26.8	-18.7	-14.0	-8.9	-41.1	-0.6	-19.1
OhioNE	5.5	27.6	18.7	11.0	5.0	26.3	22.0	10.6
OhioNW	2.9	30.7	11.9	7.3	2.5	29.5	15.4	7.6
OhioS	-37.6	35.7	155.3	14.9	-37.6	34.5	219.9	14.9
Oklahoma	21.8	4.3	-6.2	5.5	37.7	14.7	-1.0	4.5
Pennsylvania	12.2	-5.6	-5.3	13.7	7.6	-7.7	-7.4	9.7
RhodeIsland	-44.3	-69.4	-72.6	1.5	-44.3	-69.4	-72.6	1.5
SouthCarolina	162.2	-26.0	58.3	14.4	133.1	-23.8	54.1	6.6
SouthDakota	-7.6	-15.0	-33.7	-23.5	12.9	-10.5	-6.5	-23.6
Tennessee	84.6	76.9	9.7	16.1	81.8	90.5	14.5	7.7
TxCntBlack	-2.8	-14.0	-10.1	7.8	-2.8	-5.9	-6.3	-0.9
TxCoastBe	-16.0	-28.5	-30.5	-2.5	-9.6	-18.2	-14.3	-1.7
TxEast	0.7	-12.3	-7.2	5.8	-0.4	-15.1	-11.4	5.3
TxEdplat	-2.8	-14.0	-10.1	7.8	-2.8	-5.9	-6.3	-0.9
TxHiPlains	-12.4	-30.5	-11.1	5.1	29.5	-5.2	7.1	-8.1
TxRolingPl	-2.8	-14.0	-10.1	7.8	-2.8	-5.9	-6.3	-0.9
TxSouth	-16.0	-28.5	-30.5	-2.5	-9.6	-18.2	-14.3	-1.7
TxTranspec	1.1	5.2	20.2	20.9	43.3	21.2	54.3	-9.8
Utah	-13.3	-38.9	-31.0	-33.2	-8.3	-10.1	11.7	-5.5
Vermont	188.8	-21.6	-17.2	114.4	3.5	-79.4	19.0	35.7
Virginia	-19.5	-3.1	-32.8	39.1	-13.4	-21.0	35.2	-10.7
WestVirginia	43.6	-15.7	-9.7	201.3	-24.9	-45.9	77.2	3.3
Wisconsin	-31.1	-34.2	14.7	-11.4	-35.8	-43.3	-7.4	-19.1
Wyoming	-65.7	-65.4	-67.4	-69.8	-71.7	-15.9	-12.6	-33.6

Table B-25. Percent Changes in Mean Yield Incorporated into FASOM, Sugarbeets

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	27.0	31.7	31.2	26.1	-1.6	-3.6	-4.6	3.3
CaliforniaN	NA	NA	NA	NA	-0.4	9.5	19.5	9.8
CaliforniaS	NA	NA	NA	NA	-0.4	9.5	19.5	9.8
Colorado	NA	NA	NA	NA	8.8	-1.5	-0.8	2.9
Idaho	NA	NA	NA	NA	-4.1	-2.9	-8.1	-1.4
Kansas	9.8	6.2	6.8	4.8	7.9	5.6	5.9	3.7
Michigan	NA	NA	NA	NA	-2.8	-4.0	-5.3	3.8
Minnesota	-1.7	-12.0	-12.5	1.1	NA	NA	NA	NA
Montana	NA	NA	NA	NA	-2.4	-5.0	-3.8	-3.2
Nebraska	NA	NA	NA	NA	2.6	-0.7	-2.0	-2.5
NewMexico	NA	NA	NA	NA	6.1	-4.0	8.7	6.8
NorthDakota	NA	NA	NA	NA	0.6	-11.6	-8.9	-1.0
OhioNW	0.1	-0.1	-2.9	2.3	0.0	-0.3	-2.9	2.3
OhioS	2.3	1.9	-1.5	7.4	NA	NA	NA	NA
OhioNE	-1.9	2.5	-1.7	4.0	NA	NA	NA	NA
Oregon	NA	NA	NA	NA	-5.6	1.9	3.6	-2.9
TxHiPlains	NA	NA	NA	NA	7.7	1.7	4.8	3.8
Utah	NA	NA	NA	NA	12.8	10.2	32.0	8.1
Washington	-10.7	-5.2	-7.2	-2.1	-10.9	-5.8	-6.7	-2.6
Wyoming	NA	NA	NA	NA	7.6	-4.7	-1.2	0.8

Table B-26. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Sugarbeets

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Arizona	-9.1	-28.3	-8.7	6.0	8.4	3.3	14.1	12.7
CaliforniaN	NA	NA	NA	NA	8.6	26.2	48.7	17.2
CaliforniaS	NA	NA	NA	NA	8.6	26.2	48.7	17.2
Colorado	NA	NA	NA	NA	-4.8	-3.6	-2.6	2.1
Idaho	NA	NA	NA	NA	4.0	4.1	14.3	-0.7
Kansas	-6.4	3.5	13.0	17.1	16.3	7.1	14.8	29.4
Michigan	NA	NA	NA	NA	2.4	-17.5	3.4	8.8
Minnesota	33.1	3.6	-16.0	11.7	NA	NA	NA	NA
Montana	NA	NA	NA	NA	13.8	-0.4	-16.4	-2.8
Nebraska	NA	NA	NA	NA	5.6	0.1	1.5	1.6
NewMexico	NA	NA	NA	NA	-8.3	27.9	-37.3	18.6
NorthDakota	NA	NA	NA	NA	14.7	15.9	-24.7	14.0
OhioNW	19.9	-7.1	9.6	7.5	20.3	-6.2	9.6	7.5
OhioS	13.5	15.2	16.2	8.9	NA	NA	NA	NA
OhioNE	23.6	4.9	13.2	12.4	NA	NA	NA	NA
Oregon	NA	NA	NA	NA	-4.4	6.0	-1.2	-8.1
TxHiPlains	NA	NA	NA	NA	30.9	5.5	17.5	16.9

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Utah	NA	NA	NA	NA	21.1	69.6	22.4	0.2
Washington	11.3	12.8	0.3	18.0	15.9	13.9	2.7	-2.0
Wyoming	NA	NA	NA	NA	10.0	-4.2	-22.3	-5.4

Table B-27. Percent Changes in Mean Yield Incorporated into FASOM, Sugarcane

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Florida	NA	NA	NA	NA	-5.0	-5.3	-14.0	4.5
Louisiana	NA	NA	NA	NA	0.8	-9.7	-12.5	3.3
TxSouth	NA	NA	NA	NA	-1.9	-5.3	-9.0	-7.0

Table B-28. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Sugarcane

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Florida	NA	NA	NA	NA	-13.2	21.9	18.3	3.9
Louisiana	NA	NA	NA	NA	13.0	-23.5	-8.6	-7.1
TxSouth	NA	NA	NA	NA	-4.0	-14.1	-14.9	-18.8

Table B-29. Percent Changes in Mean Yield Incorporated into FASOM, Tomatoes

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	-10.5	-11.3	-13.9	1.9	-4.9	-11.0	-13.0	3.5
Arkansas	-9.0	-19.6	-20.3	5.5	-7.7	-19.0	-20.4	6.4
CaliforniaN	NA	NA	NA	NA	3.2	-9.4	-10.4	-9.3
CaliforniaS	NA	NA	NA	NA	3.2	-9.4	-10.4	-9.3
Florida	-17.6	-12.3	-13.3	-0.9	-2.4	-5.1	-7.1	-0.1
Georgia	-6.2	-1.4	-8.8	3.8	-2.9	-2.8	-8.1	4.0
IndianaN	1.2	-3.8	-4.6	14.3	1.4	-3.2	-5.8	15.1
IndianaS	-1.4	-8.3	-11.4	9.8	-1.3	-7.3	-12.2	10.7
Louisiana	-14.7	-25.8	-26.9	-0.8	-3.5	-16.2	-16.5	1.5
Maryland	6.2	32.6	9.6	9.2	6.2	32.2	6.8	10.8
Massachusetts	15.7	41.5	19.1	18.9	15.7	41.5	19.1	18.9
Michigan	4.6	1.7	3.2	16.2	5.3	1.6	1.4	17.7
NewJersey	2.5	12.2	5.9	13.2	13.0	14.6	4.4	18.3

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
NewYork	12.3	32.3	15.0	21.1	13.4	32.8	14.2	21.1
NorthCarolina	3.2	-0.9	-5.1	2.8	3.5	-1.1	-5.5	3.7
OhioNW	3.0	-0.2	-1.2	12.5	3.1	0.1	-2.3	13.1
OhioS	3.5	2.7	-0.8	9.8	3.5	2.7	-1.3	9.8
OhioNE	4.3	4.3	0.1	12.9	4.5	4.5	-0.6	13.5
Pennsylvania	14.4	55.5	25.7	23.1	18.0	56.3	23.2	25.5
SouthCarolina	1.4	0.6	-6.1	3.4	2.1	0.5	-6.0	3.8
Tennessee	-5.4	-14.6	-13.2	5.7	-5.1	-14.7	-13.5	6.2
TxHiPlains	NA	NA	NA	NA	-10.8	-0.7	-20.0	7.9
TxRolingPl	-0.5	4.8	-19.6	-4.7	-6.0	-7.9	-14.4	0.7
TxCntBlack	-8.9	-13.6	-26.5	-1.8	-5.5	-8.9	-14.5	4.0
TxEast	-9.7	-13.3	-21.8	3.0	-8.5	-12.9	-19.3	3.6
TxCoastBe	-6.2	-4.8	-27.5	12.8	-1.4	5.7	-4.3	22.1
TxSouth	-6.1	-6.0	-34.4	-0.2	-8.6	-3.9	-18.3	-2.8
Virginia	2.7	-1.6	-1.1	2.6	2.2	-1.7	-3.2	6.5

Table B-30. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Tomatoes

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	127.0	31.1	6.9	44.9	88.8	56.2	4.9	25.0
Arkansas	52.6	46.6	-7.8	59.7	44.9	56.8	-1.8	52.8
CaliforniaN	NA	NA	NA	NA	3.5	-15.5	-15.5	-12.3
CaliforniaS	NA	NA	NA	NA	3.5	-15.5	-15.5	-12.3
Florida	150.5	40.9	111.1	33.5	42.8	26.6	52.4	19.2
Georgia	104.6	-3.6	39.8	28.4	76.5	18.2	31.7	28.2
IndianaN	-1.1	24.4	-6.8	16.8	-1.7	21.1	-2.3	15.7
IndianaS	-11.8	147.0	3.5	44.0	-13.9	140.8	23.5	3.3
Louisiana	33.4	45.9	14.5	16.7	13.1	19.0	11.2	-13.1
Maryland	-27.5	-44.5	-51.7	-10.5	-32.9	-53.9	-45.2	-28.9
Massachusetts	-44.3	-69.4	-72.6	1.5	-44.3	-69.4	-72.6	1.5
Michigan	-14.2	-20.4	-26.5	-4.1	-24.0	-23.5	-13.0	-23.5
NewJersey	16.8	-38.4	-16.3	10.0	-36.0	-54.2	-13.1	-19.8
NewYork	-34.9	-46.1	-41.3	-31.5	-25.6	-46.1	-42.3	-30.3
NorthCarolina	26.2	-10.5	44.6	44.7	18.3	-6.6	66.9	27.8
OhioNW	2.9	30.7	11.9	7.3	2.5	29.5	15.4	7.6
OhioS	-37.6	35.7	155.3	14.9	-37.6	34.5	219.9	14.9
OhioNE	5.5	27.6	18.7	11.0	5.0	26.3	22.0	10.6
Pennsylvania	12.2	-5.6	-5.3	13.7	7.6	-7.7	-7.4	9.7
SouthCarolina	162.2	-26.0	58.3	14.4	133.1	-23.8	54.1	6.6
Tennessee	84.6	76.9	9.7	16.1	81.8	90.5	14.5	7.7
TxHiPlains	NA	NA	NA	NA	29.5	-5.2	7.1	-8.1

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
TxRolingPl	-35.1	-34.5	-21.6	9.8	-16.4	-24.3	-16.1	0.9
TxCntBlack	-2.8	-14.0	-10.1	7.8	-2.8	-5.9	-6.3	-0.9
TxEast	0.7	-12.3	-7.2	5.8	-0.4	-15.1	-11.4	5.3
TxCoastBe	-16.0	-28.5	-30.5	-2.5	-9.6	-18.2	-14.3	-1.7
TxSouth	-37.9	3.7	-17.9	-6.4	-15.1	-18.8	-18.3	-1.7
Virginia	-19.5	-3.1	-32.8	39.1	-13.4	-21.0	35.2	-10.7

Table B-31. Percent Changes in Mean Yield Incorporated into FASOM, Wheat

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	22.0	13.7	17.8	17.8	21.8	13.7	17.8	17.1
Arizona	27.0	31.7	31.2	26.1	-1.6	-3.6	-4.6	3.3
Arkansas	16.4	12.4	10.6	11.4	15.6	12.5	10.6	10.2
CaliforniaN	1.2	9.9	18.3	14.1	-0.4	9.5	19.5	9.8
CaliforniaS	1.2	9.9	18.3	14.1	-0.4	9.5	19.5	9.8
Colorado	21.3	9.3	9.8	16.3	8.8	-1.5	-0.8	2.9
Connecticut	5.2	2.1	-1.5	2.5	4.4	0.1	-1.5	2.4
Delaware	10.3	4.5	-0.1	6.3	10.0	3.0	-0.1	6.3
Florida	9.7	5.1	14.7	13.4	9.7	5.1	14.7	13.5
Georgia	25.8	7.0	21.8	20.7	25.9	7.1	21.9	20.7
Idaho	-1.7	0.3	-2.2	10.9	-4.1	-2.9	-8.1	-1.4
IllinoisN	2.1	0.7	-1.8	3.6	1.7	0.2	-1.7	3.6
IllinoisS	8.0	5.8	6.1	8.1	7.8	5.7	6.4	7.2
IndianaN	0.7	-0.3	-1.8	3.2	0.7	-0.9	-1.8	3.2
IndianaS	3.8	2.3	4.1	6.7	3.8	1.8	4.1	6.7
IowaCent	2.6	-4.7	-12.6	0.4	2.5	-4.7	-12.6	0.3
IowaNE	1.8	-7.0	-12.5	1.8	1.8	-7.0	-12.5	1.8
IowaS	7.1	2.0	-0.5	-2.3	6.2	1.8	-0.5	-2.3
IowaW	3.9	0.5	-5.2	0.0	3.8	0.5	-5.2	0.0
Kansas	9.8	6.2	6.8	4.8	7.9	5.6	5.9	3.7
Kentucky	12.7	8.0	3.7	10.1	12.6	8.2	3.8	8.8
Louisiana	14.9	20.5	25.1	22.9	14.2	20.5	26.0	22.7
Maine	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
Maryland	4.0	2.0	-3.2	5.2	3.9	0.3	-3.2	5.3
Massachusetts	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
Michigan	-2.5	-3.8	-5.1	3.8	-2.8	-4.0	-5.3	3.8
Minnesota	-1.7	-12.0	-12.5	1.1	-1.8	-12.2	-12.8	1.1
Mississippi	22.5	18.4	18.9	19.3	22.5	18.4	19.0	17.9
Missouri	7.1	5.7	5.3	2.2	5.7	5.4	5.1	1.6
Montana	6.9	3.1	4.8	8.4	-2.4	-5.0	-3.8	-3.2
Nebraska	7.3	1.6	-0.2	2.8	2.6	-0.7	-2.0	-2.5
Nevada	35.1	28.5	19.5	14.0	4.1	8.6	-7.4	2.0
NewJersey	4.7	1.1	-0.9	6.2	2.6	-0.3	-1.0	6.3
NewMexico	71.7	63.5	69.3	122.7	6.1	-4.0	8.7	6.8

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
NewYork	3.2	-4.2	-5.7	-0.3	3.1	-4.4	-5.7	-0.3
NorthCarolina	22.6	10.5	11.9	18.0	22.7	10.5	11.8	17.9
NorthDakota	4.1	-9.5	-3.3	1.9	0.6	-11.6	-8.9	-1.0
OhioNE	-1.9	2.5	-1.7	4.0	-1.9	1.5	-1.7	4.0
OhioNW	0.1	-0.1	-2.9	2.3	0.0	-0.3	-2.9	2.3
OhioS	2.3	1.9	-1.5	7.4	2.4	1.2	-1.5	7.4
Oklahoma	13.3	8.3	12.7	8.8	12.1	7.8	11.9	9.7
Oregon	-5.9	2.9	4.8	-2.2	-5.6	1.9	3.6	-2.9
Pennsylvania	-0.7	-1.0	-1.9	3.0	-1.6	-2.2	-1.9	3.0
RhodeIsland	4.8	-1.9	5.0	5.2	4.8	-1.9	4.9	5.4
SouthCarolina	22.9	1.9	8.4	21.3	22.9	1.9	8.4	21.3
SouthDakota	5.3	-6.4	-5.7	3.8	-0.3	-7.1	-8.3	-0.6
Tennessee	18.3	10.2	6.6	13.1	18.6	10.2	6.6	10.3
TxCntBlack	14.7	8.5	13.6	18.3	14.1	7.9	15.4	21.3
TxCoastBe	12.4	0.0	20.6	20.9	12.4	-1.7	22.8	23.2
TxEast	24.0	15.3	22.1	26.3	22.9	16.4	22.3	26.3
TxEdplat	18.4	16.0	22.7	16.6	10.8	8.6	18.9	21.4
TxHiPlains	45.1	18.3	20.1	16.0	7.7	1.7	4.8	3.8
TxRolingPl	17.0	10.4	19.1	15.6	11.1	7.4	16.0	16.3
TxSouth	8.2	10.5	23.1	21.6	7.9	-2.9	19.1	17.1
TxTranspec	175.1	144.4	169.9	194.1	13.4	9.2	13.6	15.2
Utah	10.2	4.2	30.7	-40.6	12.8	10.2	32.0	8.1
Vermont	5.2	2.1	-1.5	2.5	4.4	0.1	-1.5	2.4
Virginia	17.7	12.5	9.3	13.5	17.0	12.2	9.2	13.5
Washington	-10.7	-5.2	-7.2	-2.1	-10.9	-5.8	-6.7	-2.6
WestVirginia	1.3	2.3	-6.0	12.2	1.3	0.8	-5.8	10.7
Wisconsin	-4.9	-7.1	-7.9	4.4	-5.2	-7.3	-8.1	4.4
Wyoming	9.7	-2.0	-1.0	0.2	7.6	-4.7	-1.2	0.8

Table B-32. Percent Changes in Standard Deviation of Yield Incorporated into FASOM, Wheat

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Alabama	17.3	-11.2	-20.7	8.6	17.4	-11.3	-20.7	11.6
Arizona	-9.1	-28.3	-8.7	6.0	8.4	3.3	14.1	12.7
Arkansas	13.9	5.1	3.5	15.9	15.7	4.5	1.9	22.7
CaliforniaN	8.6	10.3	20.3	16.7	8.6	26.2	48.7	17.2
CaliforniaS	8.6	10.3	20.3	16.7	8.6	26.2	48.7	17.2
Colorado	-5.4	-19.3	-5.0	1.7	-4.8	-3.6	-2.6	2.1
Connecticut	74.3	106.4	19.7	-20.5	85.0	127.7	19.7	-20.2
Delaware	58.4	57.6	39.5	29.4	62.5	65.3	39.5	29.4
Florida	14.9	-2.2	0.7	-5.0	14.9	-2.1	0.6	-5.0
Georgia	1.7	8.5	-13.2	-13.6	2.1	8.5	-13.1	-13.5
Idaho	0.7	-0.2	0.8	-5.8	4.0	4.1	14.3	-0.7
IllinoisN	15.8	-9.5	-2.0	11.0	16.3	-5.7	-2.5	11.4
IllinoisS	30.7	-2.1	27.6	19.6	29.7	0.0	24.3	23.1
IndianaN	36.4	2.6	20.0	15.8	36.4	6.2	19.7	16.0
IndianaS	28.4	4.9	43.1	21.9	28.4	13.4	43.1	21.9
IowaCent	27.7	28.7	-5.6	9.0	29.9	28.7	-5.6	7.6
IowaNE	3.4	-13.9	-23.6	2.3	3.4	-13.9	-23.6	2.3
IowaS	25.1	29.7	11.7	3.8	32.0	29.5	11.6	5.7
IowaW	38.9	41.0	1.3	7.0	38.2	41.0	1.3	7.0
Kansas	-6.4	3.5	13.0	17.1	16.3	7.1	14.8	29.4
Kentucky	21.3	-1.4	-2.6	14.8	21.1	-1.4	-2.8	16.2
Louisiana	15.6	42.1	3.1	-13.6	18.1	42.3	8.1	-13.1
Maine	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
Maryland	30.5	35.5	20.4	10.6	30.7	38.4	20.3	10.4
Massachusetts	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
Michigan	3.0	-16.5	3.8	9.0	2.4	-17.5	3.4	8.8
Minnesota	33.1	3.6	-16.0	11.7	34.8	3.0	-18.0	11.7
Mississippi	5.7	8.0	-12.5	-4.0	5.6	8.0	-12.6	7.6
Missouri	27.1	-2.7	27.5	10.6	29.1	-1.8	26.9	12.8
Montana	9.5	-14.7	-26.8	0.1	13.8	-0.4	-16.4	-2.8
Nebraska	-6.2	0.4	6.3	1.3	5.6	0.1	1.5	1.6
Nevada	3.1	13.1	-4.5	11.5	7.6	16.9	7.1	-1.6
NewHampshire	28.6	26.5	19.4	1.1	31.0	29.6	19.5	0.4
NewJersey	-26.9	-70.0	-40.2	46.8	-8.3	27.9	-37.3	18.6
NewMexico	49.4	9.3	-16.4	-0.4	50.3	9.9	-16.0	-0.4
NewYork	13.1	12.2	-19.8	10.7	13.0	12.3	-19.7	10.8
NorthCarolina	-3.2	2.1	-32.9	11.4	14.7	15.9	-24.7	14.0
NorthDakota	23.6	4.9	13.2	12.4	23.9	8.5	13.2	12.4
OhioNE	19.9	-7.1	9.6	7.5	20.3	-6.2	9.6	7.5
OhioNW	13.5	15.2	16.2	8.9	13.4	18.8	16.3	9.0
OhioS	2.0	10.4	3.8	14.3	11.9	15.7	7.2	12.5
Oregon	-5.8	7.2	0.6	-6.7	-4.4	6.0	-1.2	-8.1
Pennsylvania	24.0	22.4	13.4	0.7	26.3	24.1	13.4	0.3
RhodeIsland	-13.1	27.6	20.1	8.3	-13.2	27.7	19.9	4.8
SouthCarolina	14.9	3.2	-35.1	-14.8	14.9	3.2	-35.1	-14.8
SouthDakota	-13.1	-7.2	-22.0	0.6	19.6	-9.5	-15.3	11.8

FASOM Region	Dryland				Irrigated			
	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2	CGCM3.1	GFDL-2.0	GFDL-2.1	MRI-CGCM2.2
Tennessee	18.6	0.1	-10.5	0.8	17.4	0.7	-10.5	20.2
TxCntBlack	-2.5	3.1	-15.6	10.4	0.6	6.6	-17.5	6.6
TxCoastBe	-3.0	-1.2	-4.5	6.3	-3.0	2.0	2.1	6.1
TxEast	11.6	-24.7	1.3	17.7	11.8	-18.6	2.0	17.7
TxEdplat	-20.6	-26.7	-28.5	-0.1	7.1	27.4	-41.3	-9.6
TxHiPlains	-39.9	-49.4	-22.0	-3.1	30.9	5.5	17.5	16.9
TxRolingPl	-18.3	4.3	-15.9	-6.7	3.8	38.4	-8.2	14.4
TxSouth	10.9	58.3	-36.8	-22.0	9.8	95.5	52.4	11.2
TxTranspec	22.0	-32.5	-6.7	105.8	17.8	13.3	0.0	13.6
Utah	-40.5	49.4	14.5	14.7	21.1	69.6	22.4	0.2
Vermont	74.3	106.4	19.7	-20.5	85.0	127.7	19.7	-20.2
Virginia	15.5	18.8	-3.2	6.9	16.7	20.1	-3.0	7.1
Washington	11.3	12.8	0.3	18.0	15.9	13.9	2.7	-2.0
WestVirginia	51.8	17.6	28.6	14.7	51.8	16.8	27.0	15.7
Wisconsin	11.4	-15.5	-7.8	6.5	9.6	-14.6	-7.6	6.2
Wyoming	10.8	5.8	-23.4	-4.5	10.0	-4.2	-22.3	-5.4