CROP INSURANCE AND CLIMATE CHANGE

BALANCING STRUCTURE AND FLEXIBILITY TO IMPROVE ON-FARM MANAGEMENT OF CLIMATE RISK

PREPARED FOR: THE INSTITUTE FOR AGRICULTURE AND TRADE POLICY

PREPARED BY: NORA MORSE

MASTER OF PUBLIC POLICY CANDIDATE

THE SANFORD SCHOOL OF PUBLIC POLICY

DUKE UNIVERSITY

FACULTY ADVISOR: DR. ROBERT CONRAD

Executive Summary

Introduction

Crop insurance has become an important tool for managing economic and environmental risk in the agricultural sector, and one of the largest sources of Federal subsidies to agricultural producers. This research examines the near- and long-term risks to agricultural producers, and seeks to identify and evaluate potential policy opportunities within the federal crop insurance program to improve the climate adaptation capacity of insured farms. The crop insurance program contains several structural barriers to sustainable, adaptive management practices, including a lack of soil and water conservation requirements common to other farm support programs (remedied in the Agricultural Act of 2014), and stringent planting date requirements which discourage farmers from using cover crops to protect their soil from erosion and enhance fertility, as well as diversify their farms (both economically and biologically) and increase climate resiliency.

Policy Recommendations

1. Reinstate conservation compliance requirements for eligibility to receive federal subsidies towards crop insurance coverage (successfully passed in the Agricultural Act of 2014).

2. Provide farmers who plant cover crops with an additional "buffer" period after their policy's final planting date to allow appropriate termination of the cover crop without jeopardizing the insurance coverage on their primary crop.

Analysis & Methods

To evaluate the economic impacts of requiring conservation compliance for eligibility to receive crop insurance subsidies, I constructed a cost benefit analysis at the national scale, including cash flows for the economy as a whole, the government, and affected farmers. My analysis focuses on the marginal impact of the program, quantifying only the marginal costs and benefits of implementing the program on farms which are not currently participating in any other Farm Bill programs requiring conservation compliance, and which will be coming under the compliance requirement for the first time due to their use of subsidized crop insurance. This eliminates all farms which would be subject to the requirement whether or not it was added to the crop insurance program, and thus more accurately quantifies the impact of the policy change within the context of other interrelated farm support programs.

Due to the lack of data from the field regarding the dynamics of planting date restrictions and cover cropping decisions, I could not construct a national-scale cost benefit analysis to evaluate my second policy recommendation. I instead created a farm-scale cost benefit model to compare the performance of a commodity mono-crop with a dual, cover crop and commodity crop system. The model takes into account the unique economic, social, and biological attributes of the farm using yield, acreage, crop selection, planting dates, management practices, and insurance parameters to produce estimates of the costs and benefits at the farm level.

RESULTS

The results of my analysis show that conservation compliance, even under the most conservative scenario, provides a net benefit to farmers and to the economy as a whole for a comparatively modest initial investment on the part of farmers and the government. In my moderately conservative cost benefit analysis scenario, reinstating the conservation compliance requirements in association with crop insurance provides an incremental net benefit of at least $4,411 per acre in present value terms, with over $780 per acre of those benefits accruing to the farmer.

The cover crop analysis did not provide any generalizable results, however it does suggest that a buffer period within the planting date restrictions for farmers growing cover crops may help mitigate the risk of cover crops interfering with the profitability of farmers' primary commodity crop, and thus remove one of the barriers to adoption. I recommend a pilot test of this policy change, with rigorous measurement and evaluation of the impacts on farm revenue, insurance and subsidy payments, and environmental outcomes.

CONCLUSIONS

With impending near- and long-term threats of climate change, the crop insurance program should balance the need for rigid management requirements to ensure an appropriate baseline level of risk mitigation and management with the flexibility to allow farmers to experiment with new management practices to find what works best in their new climate context. The benefits of the conservation compliance requirement vastly outweigh the costs, and provide a cost-effective mechanism for improving adaptive capacity on already vulnerable agricultural lands. While the planting date buffer period is a promising mechanism for increasing the use of cover crops and improving farmers' capacity to develop new adaptive risk management strategies at the local level, additional research and field testing is needed to determine the impact of relaxing the constraint on actual adoption rates in the field.

INTRODUCTION

Insurance helps us manage all types of risk- car accidents, natural disasters, illness, and even death. Crop insurance helps farmer to manage risk and smooth their business's cash flows when extreme weather events or market fluctuations threaten their livelihood. Climate change introduces a significant new source of uncertainty and risk into the business of farming- with average temperatures increasing and extreme weather events becoming more common, crop insurance also forms an increasingly important part of the farm safety net. This research examines the near- and long-term risks to agricultural producers, and seeks to identify and evaluate potential policy opportunities within the federal crop insurance program to improve the climate adaptation capacity of insured farms. I propose several minor modifications to existing policy which provide incentives for farmers adopt strategies to mitigate climate-related risk. The analysis is composed of two parts:

1) Cost-benefit analysis of the re-instatement of the conservation compliance requirement for farmers receiving crop insurance subsidies (passed in the 2014 Farm Bill), at the national scale
2) Cost-benefit calculator at the farm level for farmers and insurers to compare the tradeoffs between cover crops and planting date requirements for crop insurance.

BACKGROUND

Federally funded crop insurance has been an integral part of the US Federal Government's package of agricultural supports since its creation in the 1930s. Together with other supporting policies included in the original Farm Bill, it helped get farmers through the brutal commodity market crashes of the Great Depression and the droughts that caused the Dust Bowl. Crop insurance was designed to reduce economic risk in the business of durable commodity crops, giving farmers some assurance that the investment they made at planting time would not be completely lost if the weather or markets caused loss of the crop or the value of the harvest.

The economic and environmental risks facing the US agricultural sector have changed considerably since the crop insurance program was initially developed. Globalization has expanded agricultural markets to a scope and complexity unimagined in the 1930s. An amenable climate (along with an adequate, but dwindling, supply of soil fertility and agricultural land) has provided a fairly stable foundation upon which agricultural communities have been built. Over the course of the twentieth century, rapid advances in agricultural technology increased yields and decreased losses, although intensification has also contributed to widespread environmental degradation on agricultural lands, including water pollution, soil compaction, erosion, and biodiversity loss.[1]

Climate change is one of the biggest challenges our agricultural sector will face in the coming century.[2] Although impacts will vary across different regions of the country, all of the primary agricultural regions are expected to experience greater variability in temperature and precipitation.[3,4] Higher variability translates into more frequent extreme weather events, including temperature and precipitation anomalies such as heat waves, droughts, and floods, which can drastically impact agricultural yield. As climate-related risk increases, the current crop insurance program could become a dangerous liability, draining the government of revenue and propping up unsustainable and damaging agricultural practices. On the other hand, with forethought and reform, the crop insurance program could smooth the transition between today's farming landscape and tomorrow's realities.

WHY IS CROP INSURANCE IMPORTANT FOR CLIMATE ADAPTATION?

Crop insurance is an important and widely used risk management tool in the agricultural sector, which helps farmers stabilize income from year to year. As climate change is expected to increase the frequency and severity of extreme weather events across the United States, crop insurance will very likely become even more important as a tool for managing climate-related risk. This is especially true if there continues to be a lack of other supporting policies for agricultural climate adaptation.

The crop insurance program has historically been tailored to monoculture commodity production, with few incentives (and some disincentives) to adaptive management behaviors, including:

- Lack of eligibility requirements excluding especially risky or ecologically valuable lands
- Emphasis on monoculture commodity crops, with high rates of subsidization and greatest variety of policies serving single-crop systems
- Few (and geographically limited) options for multi-crop, specialty crop, and value-added production

[1] Matson, P. A., et al. "Agricultural Intensification and Ecosystem Properties" Science, New Series, Vol. 277, No. 5325 (Jul. 25, 1997), pp. 504-509. http://www.jstor.org.proxy.lib.duke.edu/stable/

[2] Easterling, W.E., et al., "Food, fibre and forest products." Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 273-313.

[3] Ibid

[4] IPCC 2007, "Regional Climate Projection"

In order to adapt to new climate conditions, farmers will need to make significant transitions regarding what they grow and how they manage their land. Strategies for farmers to reduce the risk of crop loss in a climate of increasingly variable weather include:

1. Increasing the diversity of crops grown on a farm or integrating crop & livestock production
2. Switching crops that are better adapted for the new climate conditions or hardy to a wider range of climate variation
3. Implementing smart, resource-conserving crop rotations and cover crops
4. Diversifying on-farm production through value-added products
5. Improving water monitoring and management systems to deal with both drought and flood conditions[5]

Transitioning from one crop to another, or from a single monoculture crop to a diversified mix of crops and livestock, requires upfront investment and a high degree of confidence that such costs can be recouped in the long term. Farmers must make large initial investments in both durable infrastructure and in the annual planting of each crop, without any assurance that the harvest will yield enough (or the market will be strong enough) to recoup those costs. The financial risk is especially high when trying out a new crop or mix of crops for which you do not have experience and a reliable production history. Without crop insurance to stabilize income from year to year and buffer economic risk over the long term, many farmers may not be able to invest in additional infrastructure needed to improve their farm's long term sustainability.

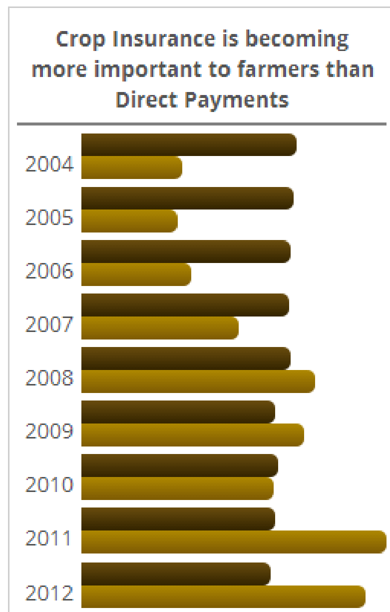

FIGURE 1. COMPARISON OF FEDERAL SUBSIDIES THROUGH DIRECT PAYMENTS AND THE CROP INSURANCE PROGRAM.

The Agricultural Act of 2014 (hereafter referred to as the Farm Bill) included significant provisions to address each of the above problems. The bill cut direct payments, which are subsidies delivered to large agricultural producers regardless of yield and price in a given year. As Figure 1 shows, during the past decade direct payments have dropped steadily as subsidies distributed through the crop insurance program have expanded. The crop insurance program has become the dominant method of farm support, culminating in the complete removal of direct payments in the 2014 bill.[6] The bill reinstated conservation

[5] Kleinschmit, Jim, Institute for Agriculture and Trade Policy, interview with Nora Morse, September 17, 2013.

[6] Clayton, Chris, "Crop Insurance Provisions in the New Farm Bill", The Progressive Farmer Magazine Ag Policy Blog, Published 2/6/2014. http://www.dtnprogressivefarmer.com/dtnag/common/link.do;jsessionid=9FF36FCB424C2AE4D903626579E9B02D.agfreejvm2?symbolicName=/ag/blogs/template1&blogHandle=policy&blogEntryId=8a82c0bc43a1ab8d014409a878f90406

compliance requirements (including erosion reduction, "Sodbuster", and "Swampbuster" provisions previously attached to direct payments in addition to other farm assistance programs) for eligibility to receive premium subsidies. Farmers out of compliance may still purchase crop insurance, but they forfeit the USDA subsidies which pay up to two thirds of the farmers' insurance premiums. It also requires the RMA to research and create new coverage options for additional specialty crops, effectively broadening the program's reach beyond the staple commodities. Subsidy rates were not changed from the previous bill.

The crop insurance program is well-situated to become the primary driver of agricultural adaptation to climate change, due to the two following factors: first, crop insurance is increasingly important to many farmers as a primary tool for managing economic risk, as evidenced by the rapid increase in insurance coverage in US agricultural land over the last 20 years, with over half of the total agricultural land in the country insured as of 2010[7,8]. Both farmers and taxpayers benefit from incorporating mechanisms for adaptive management of climate risk into the crop insurance program, as successful adaptation measures will reduce farmers' losses and premium payments, and reduce the scale of subsidies and disaster relief payments which rely on federal tax dollars.

LITERATURE REVIEW

This analysis draws on a highly interdisciplinary pool of literature, including history, economics, agronomy, climate science, and political theory. Accordingly, my literature review spans many disciplines, beginning with the political and economic history of the crop insurance program and moving through the projected impact of climate change on the continental United States, agricultural vulnerability to climate change, and the resulting potential impact of these climate changes on crop production.

HISTORY OF THE CROP INSURANCE PROGRAM

The crop insurance program was authorized by Congress as part of the federal response to the effects of the Great Depression and the Dust Bowl. The combined force of the environmental and economic catastrophes were devastating to farmers, who then made up a large portion of the population. The Federal Crop Insurance Corporation (FCIC) began implementation of an "experimental" crop insurance program in 1938. All crop insurance remained in the experimental phase until the passage of the Federal Crop Insurance Act of 1980.

[7] Shields, Dennis, "Federal Crop Insurance: Background and Issues," Congressional Research Service (CRS) Brief 7-5700 R40532 (2010). http://www.nationalaglawcenter.org/assets/crs/R40532.pdf
[8] Environmental Protection Agency (EPA), "Ag 101: Land Use Overview," Last updated 4/9/2013. http://www.epa.gov/agriculture/ag101/landuse.html

The original crop insurance programs were restricted to only the major commodity crops in the most significant production areas. The 1980 Act was the first major expansion of the program, allowing many additional crop types and expanding coverage to additional regions of the country. It also created a subsidy that paid 30% of the crop insurance premium for insurance coverage that reimburses the farmer for extreme losses, up to 65% of his expected yield.

Low rates of insurance coverage and a series of adverse weather events across the country prompted Congress to authorize disaster assistance bills in 1989, 1992, and 1993 to help cover farmers' losses, over and above crop insurance payments. In the interest in increasing participation in the crop insurance program, the Federal Crop Insurance Reform Act of 1994 made insurance coverage (at least at the minimum CAT level) mandatory for farmers to be eligible for price support programs, certain federally subsidized loans, and other Farm Bill benefits. In order to ease the burden of mandatory coverage, coverage of catastrophic losses was fully subsidized, meaning 100% of the actuarially sound premium is paid by the government, and no premium is paid by the farmer. CAT coverage pays indemnities when losses exceed 50% of the farmer's average historical yield, and reimburses at a rate of 60% of the established commodity price for the year. The Act also subsidized higher levels of coverage (protecting farmers from less serious losses) at lower rates (generally the higher the coverage, the less the premium is subsidized).

In 1996, the Risk Management Agency was created within the US Department of Agriculture to oversee the FCIC. Enrollment in the program had begun to grow rapidly after the passage of the Reform Act of 1994, and by 1998 total insured acreage in the US had doubled. In 2000, Congress authorized private sector insurance companies for the first time to develop new insurance products. Private insurers could then submit their own insurance products to the Board of the FCIC for reimbursement of research, development, and operating costs, while retaining the ability to own the product and charge fees to other insurers who wish to sell the same insurance product. This opened the doors for all insurance to be transitioned to private sector companies, 16 of which are now authorized to sell crop insurance products and receive subsidies.[9]

The crop insurance program experienced rapid growth (measured by the value of insured yield and gross subsidies) in the 2000s, not due to greater enrollment but due to the higher value of the insured harvest. This economic growth was spurred by the increase in corn prices from a relatively stable plateau around $2 per bushel in 2005 to over $6 per bushel in 2012 nominally, with short-term price spikes sending prices over $8 per bushel. The rapid increase in corn price was caused by many factors, but a primary driver was increased demand for ethanol production due to changes in federal biofuel policy. The value of the corn covered under crop

[9] All historical information in this section derives from the RMA's "History of the Crop Insurance Program," http://www.rma.usda.gov/aboutrma/what/history.html.

insurance thus more than tripled in nominal value in a few short years, dramatically increasing size of the insurance market and the subsidies that support it.[10]

CROP INSURANCE TODAY

The Risk Management Agency currently authorizes private insurance dealers to offer over a dozen major types of crop insurance. All types of crop insurance work on the same basic principles- a producer chooses an insurance product with a specific level of coverage that will pay out an indemnity in case of loss; the greater the coverage, the higher the premium charged to the producer (and the greater the absolute value of the subsidy, although generally the percentage of the premium that is covered by subsidy declines as coverage increases). Most of these insurance products fall into two basic categories. The first is yield insurance, which insures against loss of yield up to a certain percentage of average historical yield and pays up to a certain percentage of market the price. The second is revenue insurance, which insures against loss of revenue up to a certain percentage of the target revenue, either for a single type of crop or for the whole farm.[11] The main difference between the two categories is that yield insurance only covers decreases in actual production levels, while revenue insurance covers loss due to either declines in yield or market price. Although revenue insurance was only introduced as a small buy-up pilot program in 1997, it quickly gained popularity and now accounts for approximately 56% of all insurance policies sold (and over 75% of all premiums paid).[12]

As of 2010, about 255 million acres of farmland (over half of the roughly 400 million acres of cropland in the US) was insured. Three quarters of the acreage insured is planted in one of the four top commodity crops (soybeans, corn, wheat, or cotton). Unlike price supports, however, crop insurance is available for more than 100 "specialty crops" as well, including fruits, vegetables, livestock, fodder and hay, grazing land, and even nursery plants. Despite the apparent diversity of qualifying crops, specialty crop policies are generally very geographically limited, as each RMA office decides which products would be most profitable locally and thus selection varies significantly between regions. The rates of insurance are generally lower for specialty crops than the major commodities, with even the best-insured specialty crops reaching only 75% of total acreage insured in 2010, according to the FCIC. In comparison, the top four commodities were insured at consistently high rates- in 2010, 84% of soybean, 83% of corn, 86% of wheat, and 91% of cotton acreage in production were insured.[13]

---

[10] Worth, Thomas, Chief Actuary, Risk Management Agency. Interview with Nora Morse, August 1, 2013.

[11] Environmental Working Group (EWG), "Crop Insurance Primer," Farm Subsidy Tracker, Accessed 5 October, 2012. http://farm.ewg.org/crop_insurance_analysis.php

[12] Shields (2010)

[13] Shields (2010)

Because the large majority of crop insurance policies cover so few commodity crops, the payout of crop insurance indemnities (payouts to the farmer in response to claims filed), as well as the majority of premium subsidies and administrative subsidies, tend to flow to the epicenters of industrial agriculture. The regions receiving the highest annual and cumulative gross subsidy include the Midwest, the Corn Belt, and Texas, with smaller hotspots in the Southeast and Central Valley region of California, as the maps and table in Figures 2, 3, and 4 show below.

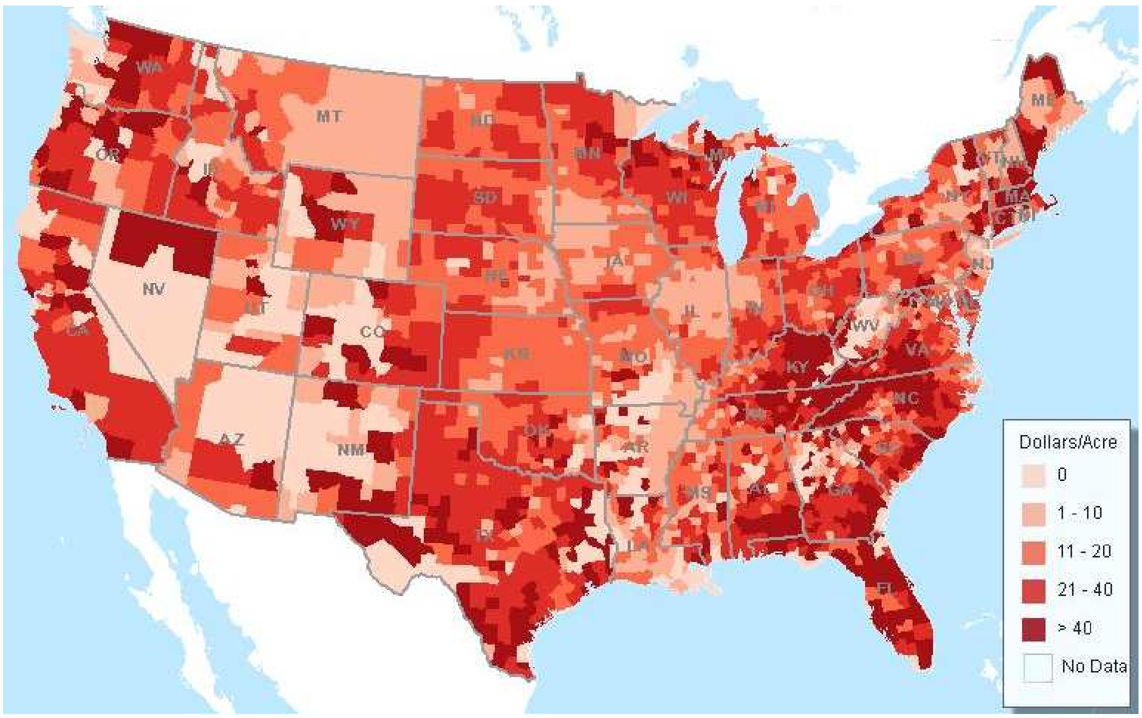

FIGURE 2. THE GEOGRAPHIC DISTRIBUTION OF INDEMNITIES PAID OUT BY THE RMA, ANNUAL AVERAGE INDEMNITY PAYMENT BY COUNTY FOR 2000-2009. [14]

[14] USDA Economic Research Service, "Farm Program Atlas", Last updated 11 July, 2012. Accessed 25 November, 2013. http://www.ers.usda.gov/data-products/farm-program-atlas/go-to-the-atlas.aspx#.U0vy6PldWSo

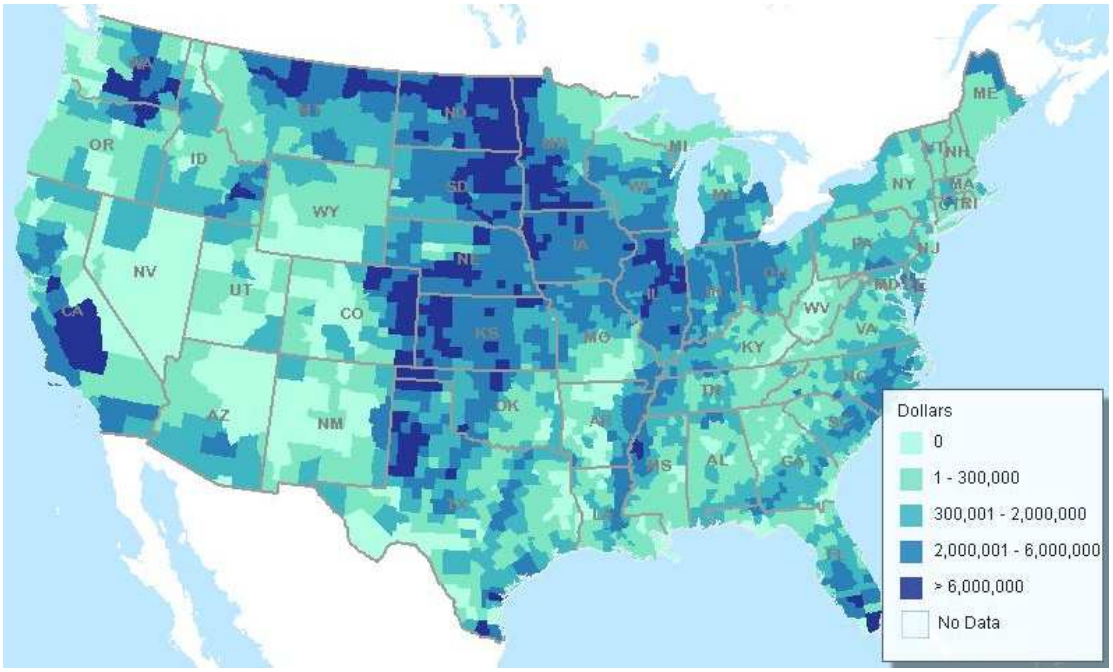

FIGURE 3. TOTAL PREMIUM SUBSIDIES PAID IN 2009 BY COUNTY.[15]

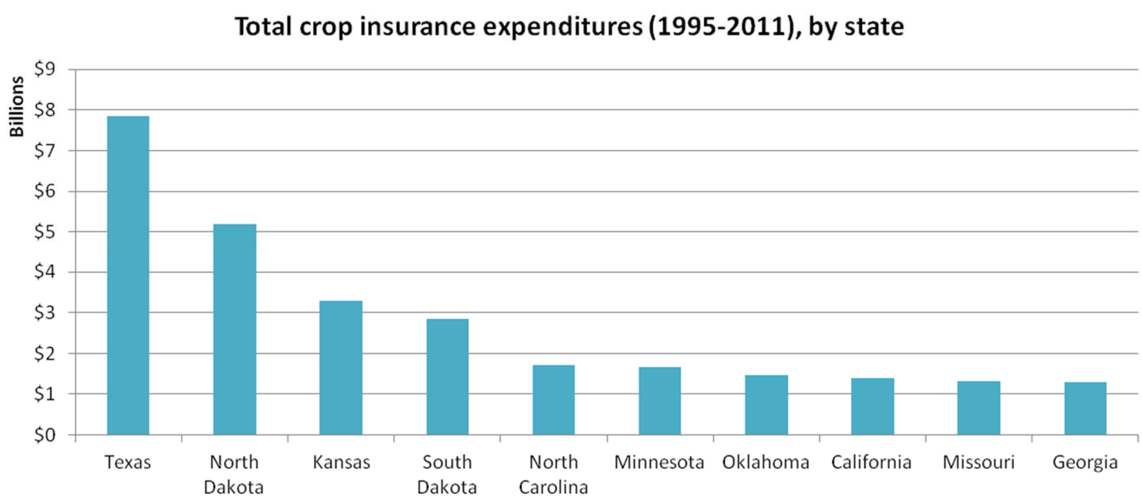

FIGURE 4. TOTAL CUMULATIVE FEDERAL EXPENDITURES ON CROP INSURANCE TOTAL INCLUDES PREMIUM SUBSIDIES, INDEMNITIES, ADMINISTRATIVE AND OPERATING COST REIMBURSEMENTS, DIRECT ADMINISTRATIVE COSTS, AND OTHER OPERATING EXPENSES. [16]

Policies are administered at the county level to enable sufficient location-specific tailoring of the policies and terms to account for regional variation in farming practices and to enable local

[15] Ibid.

[16] Data from EWG, "Total Costs by State," Accessed 6 October, 2012. http://farm.ewg.org/cropinsurance.php?fips=00000&summpage=TC_TOPREGIONS_STATE&statename=theUnited States

monitoring, which reduces adverse selection (farmers insuring only their riskiest lands). However, the program has several "weak links" which may allow adverse selection to occur. The average production level for the whole county can be substituted for actual production history (APH) [17], the basis for most yield- and revenue-based policies, which means that farmers can expand their use of marginal land while maintaining insurance for the county's average yield, even if it is greater than the actual expected yield for the land in question.

Coupled with skyrocketing corn and soy prices, the magnitude of crop insurance premium subsidies gives farmers incentives to expand their fields into areas with lower soil quality, reducing their farm's natural buffers (which provide valuable ecosystem services that contribute to overall yield) and often destroying high value for wildlife habitat. The Environmental Working Group estimates that approximately 23 million acres of grassland, shrub land and wetlands were destroyed between 2008 and 2011 in order to grow commodity crops, and much of this destruction has been fueled by Farm Bill subsidies like the crop insurance program.[18]

There are currently no eligibility requirements for purchasers of crop insurance (other than basic requirements to verify that you actively farm the land). Unlike other Farm Bill subsidies, crop insurance has no conservation requirements or incentives attached.[19] The program has no mechanism for promoting practices that could reduce the risk of yield loss in both the short and long term, such as diversification or use of climate-resilient crop types, and no limit to payouts for indemnities, subsidies, or administration. This combination of heavily subsidized insurance and a lack of incentives for long-term risk mitigation or resource conservation is especially problematic when we look ahead at the future of the crop insurance program, taking into consideration the way the climate will affect risk and production in the agricultural sector.

---

[17] New York State Department of Agriculture and Markets, "Crop Insurance For Beginning Farmers," (2011) http://www.agriculture.ny.gov/AP/cropins/NY_Beginning_Farmers_Handout_2011.pdf

[18] EWG, "High Crop Prices, Insurance Subsidies Trigger Destruction of Millions of Acres of Wildlife Habitat," Press release 6 August, 2012, http://www.ewg.org/release/high-crop-prices-insurance-subsidies-trigger-destruction-millions-acres-wildlife-habitat

[19] RMA Product Administration & Standards Division, "2011 Crop Insurance Handbook," FCIC 18010 (2010). http://www.rma.usda.gov/handbooks/18000/2011/11_18010.pdf

Climate change and the new landscape of risk in agriculture

One of the primary drivers of variation in federal expenditures on crop insurance is the climate-related risk that affects farmers' yields and revenues, as significant losses in either category trigger payout of indemnities. While premium subsidy rates remain fairly stable, indemnity payouts vary greatly from year to year. This interannual variation is driven by two primary factors: fluctuations in commodity prices and fluctuations in yield caused by adverse climate events, including abnormally high or low temperatures, droughts, and floods as shown in Figure 5 to the left.[20]

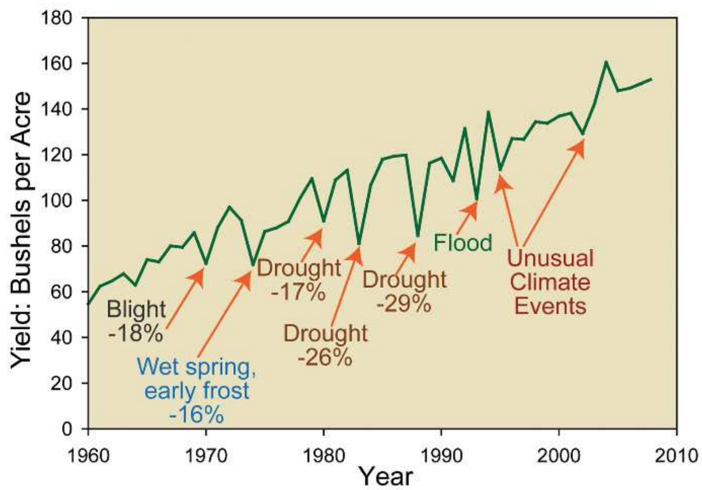

FIGURE 5. AVERAGE ANNUAL YIELD, IN BUSHELS PER ACRE, OF U.S. CROPS FROM 1960 TO 2010. LOSSES ARE NOTED BELOW THE TRENDLINE (EPA 2009).

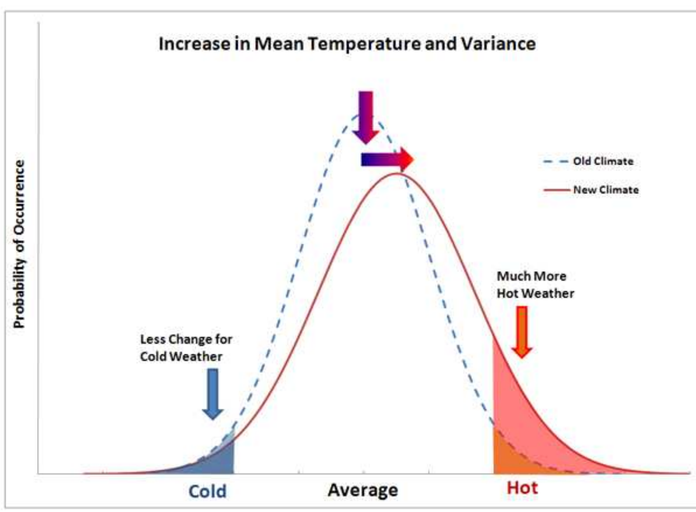

FIGURE 6. ILLUSTRATION OF HOW CLIMATE CHANGE AFFECTS THE DISTRIBUTION OF TEMPERATURES, WITH INCREASED MEAN AND VARIANCE (HUBER AND GULLEDGE 2011).

Climate models from the Intergovernmental Panel on Climate Change (IPCC) predict regional changes in the mean and variance of both temperature and precipitation across the United States, as shown in Figure 6, meaning that on average temperatures become hotter, and extreme heat events will become more frequent.[21] The IPCC's ensemble models project temperature increases throughout the country ranging from 2.5° to 7° C, with greater increases in northern states. If temperature increases reach the upper ranges predicted, yields of many crops could fall across all regions due to the

[20] Environmental Protection Agency (EPA), "Agriculture and Food Supply Impacts & Adaptation: Climate Change Impacts on Agriculture" (2009), accessed 4 October, 2012. http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html

[21] Huber, Daniel, and Jay Gulledge, "Extreme Weather and Climate Change: Understanding the Link and Managing the Risk" Center for Climate and Energy Solutions (2011). http://www.c2es.org/publications/extreme-weather-and-climate-change

physiological impacts of heat stress on plant development and reproduction.[22]

As Figure 7 below shows, precipitation is projected to increase in northern and eastern regions of the country, while decreasing in the southern and western regions. However, the variance in precipitation patterns and intensity of heavy precipitation events is expected to increase in all regions, multiplying the risk of destructive droughts and flooding throughout the continental United States. High temperatures will have greater adverse impacts in areas that are already hot and dry- specifically the South and the Western states. Higher precipitation on average, coupled with a slight fertilization effect due to increased available carbon dioxide, could potentially boost yields on farms in the Upper Midwest and Northeast, but this effect could be cancelled out by the adverse impacts of increased variability in weather patterns.

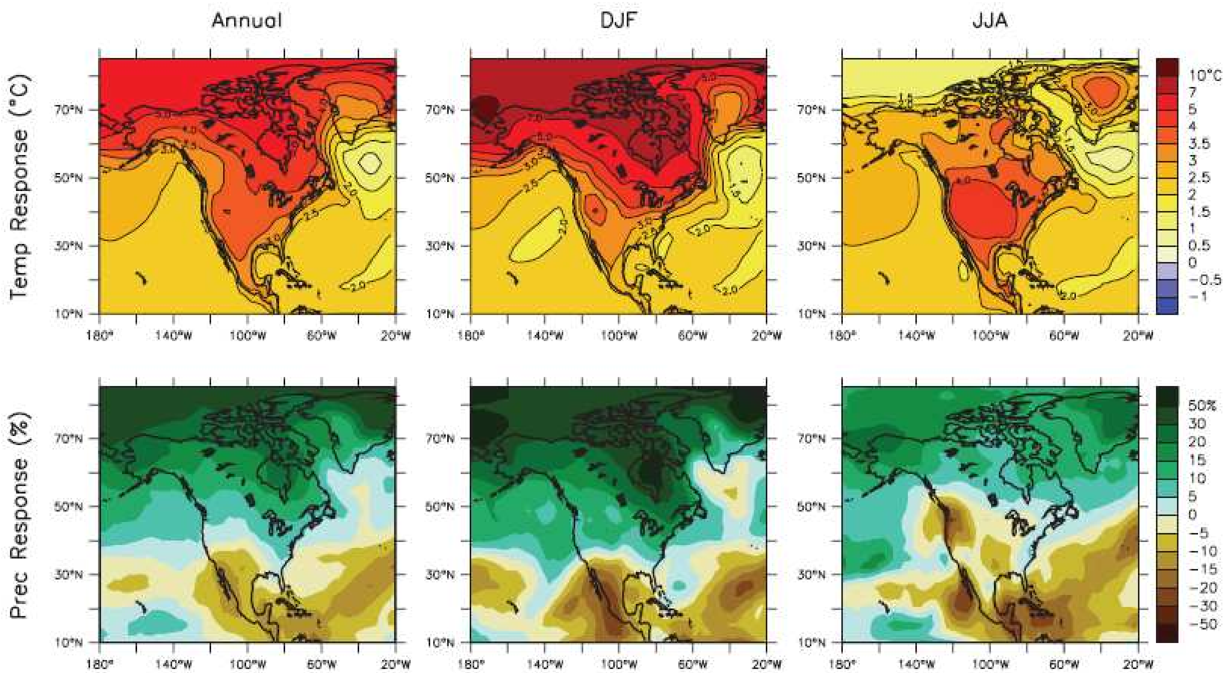

FIGURE 7. PREDICTED TEMPERATURE AND PRECIPITATION CHANGES FOR NORTH AMERICA; COMPARISON OF RESULTS FROM THREE REGIONAL CLIMATE MODELS. [23]

VULNERABILITIES TO CLIMATE EXTREMES

All crops have a range of temperatures and moisture levels for which they are optimally adapted. Continued exposure to temperatures or moisture conditions outside of this optimal

[22] Gornall, Jemma, et al. "Implications of climate change for agricultural productivity in the early twenty-first century," Philosophical Transactions of the Royal Society of Biology (2010) 365, 2973-2989.

[23] Christensen, J.H., et al., "Regional Climate Projection," *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on ClimateChange. Cambridge University Press: New York, NY, 2007, Figure 11.12, p.890.

range of conditions often reduces yield. Every crop has one or more "critical thresholds", beyond which yield drops dramatically. Crops are particularly sensitive to heat stress and drought stress during certain stages of development, such as anthesis or grain set.[24,25,26]

The threshold temperatures at which yields start to decline are lower than one might think. The threshold for corn is around 29°C or 84°F, while soybeans' threshold is around 30°C or 86°F.[27] Thresholds for wheat are significantly lower, 21°C or 69.8°F. The impact of climate change will vary significantly regionally based on the proximity of current temperatures to the critical threshold of the crops currently grown in each region. For example, the upper Midwest is currently cool enough for most growing season weather to fall below the optimal growth temperature for staple crops such as corn, soybeans, and wheat. Warming trends are thus not necessarily detrimental for farmers growing those crops in this region, and could potentially benefit all producers by lengthening the growing season and decreasing the frequency of freezing temperatures during the early spring and late fall (which interfere with planting, crop development, and harvest). A small additional benefit is the projected increase in crop vigor through carbon dioxide fertilization.[28] Combined, these positive impacts of climate change could give farmers in Minnesota and their neighbors throughout the upper Midwest a boost in production and an advantage over farmers in areas which may more frequently exceed the critical temperature thresholds of staple crops.

On the other hand, farmers trying to take advantage of these benefits may be hampered by less helpful climate changes which come along with rising temperatures. As the air warms it is able to hold more water vapor, which may cause a sizeable increase (up to 30%) in winter and spring precipitation which can interfere with planting, and decreases in summer and autumn precipitation during the plant growing season, which could translate to lower crop yields.[29] Overall annual precipitation rates are expected to increase, with a higher frequency of heavy rainfall events followed by periods of little or no rainfall.[30] In addition, some studies suggest that warmer temperatures could cause increases in flooding as ice melts earlier in the spring, adding to the already elevated amount of water in streams from the additional heavy rains and increased spring precipitation. These changes in precipitation and resulting dramatic fluctuations in water availability may force farmers to invest in drainage systems to mitigate water damage in

---

[24]Challinor, A. J., T. R. Wheeler, J. M. Slingo, P. Q. Craufurd, and D. I. F. Grimes. "Simulation of Crop Yileds Using Era-40: Limits to Skill and Nonstationarity in Weather-Yield Relationships." Journal of Applied Meteorology 44, no. 4 (04/2005 2005): 516-31.

[25] Porter, J. R., and M. A. Semenov. "Crop Responses to Climatic Variation." [In eng]. Philos Trans R Soc Lond B Biol Sci 360, no. 1463 (Nov 29 2005): 2021-35.

[26] Schlenker, W., and M. J. Roberts. "Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change." [In eng]. Proc Natl Acad Sci U S A 106, no. 37 (Sep 15 2009): 15594-8.

[27] Ibid.

[28] Wuebbles, Donald J., and Katharine Hayhoe. "Climate Change Projections for the United States Midwest." Mitigation and Adaptation Strategies for Global Change 9 (2004): 335-63.

[29] Ibid.

[30] Ibid.

the spring, while also simultaneously increasing demand for irrigation infrastructure to combat water shortage during the summer and autumn.

There is a tentative consensus in the field that warmer temperatures will have a net benefit in increasing agricultural yield in the United States, especially in the upper Midwest. These benefits will vanish, however, if the climate continues to warm past the critical thresholds for crop production, at which point increasing temperatures will lead to heat stress and lower agricultural production.[31] If the geographic distribution of crops remains as it is today, crop yields could decrease by 30 – 46% (conservatively) by the end of the century, depending on the climate scenario (losses were up to 63-82% using less conservative projections).[32] This result implies that the genetically modified crops that helped increase yields so dramatically over the past 50 years (and now account for over 90% of both corn and soybeans grown in the US) may increase the US agricultural sector's vulnerability to the effects of climate change due to the loss of diversity which may have helped crop species evolve towards higher temperature thresholds.[33]

O'Neal, et al. (2005) predicted that farmers will adapt to changes in climate by altering which crops are planted and when during the season[34]. Smaller family farms generally have limited cash flow and need to have some form of economic stability in order to make those kinds of investments. The crop insurance program should balance the desire to incentivize conservative risk management with the need to allow farmers to experiment with alternative crop mixes and management practices to find the best strategies to cope with changing climate conditions.

---

[31] Schlenker, W., and M. J. Roberts. "Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change." [In eng]. Proc Natl Acad Sci U S A 106, no. 37 (Sep 15 2009): 15594-8.

[32] Roberts, Michael J. , and Wolfram Schlenker. "The Evolution of Heat Tolerance of Corn: Implications for Climate Change." In The Economics of Climate Change: Adaptations Past and Present, edited by Gary D. Libecap and Richard H. Steckel. 1-36. Chicago, IL: University of Chicago Press, 2011.

[33] Ibid.

[34] O'Neal, Monte R., M. A. Nearing, Roel C. Vining, Jane Southworth, and Rebecca A. Pfeifer. "Climate Change Impacts on Soil Erosion in Midwest United States with Changes in Crop Management." Catena 61, no. 2-3 (2005): 165-84.

ANALYSIS

My analysis will focus on two of the key policy reforms needed to increase the diversity and resilience of agricultural ecosystems and to improve the economic viability of adaptive management techniques.

POLICY PROPOSAL #1: CONSERVATION COMPLIANCE REQUIREMENTS

Require conservation compliance in order to receive premium subsidies (enacted through the Agricultural Act of 2014).

Conservation compliance provisions help to protect the ecosystem services that will be increasingly important to farm viability as climate change increases the stress on natural and agro-ecological ecosystems. Farms which have stronger provision of key ecosystem services, such as healthy pollinator populations, natural predation of pest populations, soil structure necessary to absorb and retain water, and erosion control, out-perform farms with weaker ecosystem services when environmental stressors increase, as we expect to see in the coming decades due to climate change.

"Conservation compliance" is a general term for 3 distinct requirements which seek to encourage best management practices to reduce erosion, as well as mitigate the destruction of valuable wetland and native prairie habitat. The three components of compliance are as follows: 1) Requires an approved soil conservation plan for highly erodible land (HEL), 2) Prohibits cultivation of HEL that was not already cropland in 1985 without an approved conservation plan and reduces subsidy levels for acreage that was recently broken from native sod, and 3) Prohibits draining wetlands for crop production unless area is less than 5 acres, in which case farmers can choose to pay 150% the cost of mitigation to USDA conservation program funds in lieu of on-site mitigation.

Shifting the conservation compliance requirement to federally subsidized crop insurance only impacts two types of farms:

A) Farms that will need to maintain existing compliance:
    a. currently in compliance due to enrollment in direct payment programs that are being phased out
    b. do not participate in other Farm Bill programs that require conservation compliance
    c. do receive premium subsidies for crop insurance
B) Farms that need to comply for the first time:
    a. do not participate in any of the federal agricultural support programs with pre-existing conservation compliance requirements

b. do purchase crop insurance

The farms in Group B are those on the "margin"- those for whom the conservation compliance requirement for crop insurance subsidies represents a change in the policy environment from the 2008 Farm Bill status quo. For the purposes of this analysis, I will treat those farms in Group A, whose conservation compliance requirement has only shifted from one Farm Bill program to another, as functionally equivalent to the 2008 Farm Bill status quo in the context of crop insurance, since no new compliance requirement is being imposed. My cost benefit analysis will look at the marginal impact of the program, thus focuses exclusively on the marginal costs and benefits of bringing the farms in Group B under compliance for the first time.

POLICY PROPOSAL #2: RELAX PLANTING DATE RESTRICTIONS FOR FARMERS WITH COVER CROPS

Planting date restrictions consist of:

1. Earliest planting date- crops planted before this date are not eligible for insurance coverage if an adverse event causes the farmer to replant later in the season
2. Final planting date- crops planted after this date lose a percentage of the coverage of the insurance policy every day following the final planting date, after 25 days coverage remains at 60% of the policy's elected level for the duration of the season
3. Prevented planting- if a crop cannot be planted before the final planting date due to factors outside of the farmer's control, the farmer may be eligible for prevented planting payments only if he/she does not plant an alternative crop

Cover crops are defined as crops planted before or after the commodity crop, which are not harvested for sale but used for forage or tilled in as "green manure" to enrich the soil. Despite well-researched environmental benefits, cover crops are currently used by less than 3% of farms on an average of less than half of the farm's total acreage, with the resulting net rate of cover crop use coming in at less than 1% of total US cropland acreage[35]. Planting date restrictions on crop insurance policies for the primary cash crop are a significant impediment discouraging farmers from planting cover crops prior to the cash crop's growing season. Cover crops must be terminated using an approved method prior to planting of the primary cash crop; improper or late termination may push a farmer past the final planting date for his/her crop insurance policy and thus jeopardize insurance coverage for the cash crop, making cover crops a risky gamble for most producers.

An additional disincentive to farmers who might otherwise plant cover crops is the difficulty of estimating their economic benefits, beyond direct use for hay harvest or grazing. The most

[35] Wallander, Steven. "Soil Tillage and Crop Rotation." USDA Economic Research Service, February 2013.

significant benefits of cover crops are their ability to enhance the quality and health of the soil, prevent erosion, increase water retention, reduce soil compaction, and increase soil organic matter. These benefits have been found to produce a "yield bump" of in the production of primary commodity crops, especially in times of water stress.[36]

Providing a flexible "buffer" on planting date restrictions for farmers growing cover crops, such as a 7 day buffer for a subsequent corn crop or 10 day buffer for a subsequent soy crop (based on the relative sensitivity of corn and soy yields to planting delays) may improve cover crop adoption with minimal impact on farm revenue or indemnity payout rates, in theory. This alternative should be implemented on a limited scale and evaluated using a pilot program to measure true impacts in the field over a period of several years.

METHODS

Analysis of these two very different policy changes requires a multi-pronged methodological approach, including both qualitative and quantitative elements. As mentioned above, while the adoption of conservation compliance requirements is relatively straightforward to analyze on a nation-wide basis, the benefits of additional flexibility in insurance policies designed to encourage cover-cropping are highly variable based on local climate impacts, on-farm management preferences, and adoption rates. I will therefore take two different methodological approaches to analyze the two different policy recommendations, as outlined below:

1. Quantitative evaluation of the potential costs and benefits of the marginal change in conservation compliance requirements to the economy as a whole, farmers impacted by this marginal change, and the federal government's budget.

   ***NOTE- this analysis is only measuring the net present value (NPV) of the marginal change in conservation compliance requirements, and does not account for the costs or benefits of maintaining compliance on farms already subject to conservation requirements associated with other Farm Bill programs.*
2. Creation of a cost-benefit model to compare the costs and benefits of different cropping decisions, cover crops, and insurance provisions. The model is parameterized at the farm level, which allows for easy adjustment to reflect the local context of the user.

   ***NOTE-This model is theoretical (uses generalized parameters from the literature) and should be subject to ground-truthing through pilot implementation of the proposed cover crop buffer.*

[36] Werblow, Steve. "2012-2013 Cover Crop Survey Results: June 2013 Analysis" USDA North Central Sustainable Agriculture Research and Education Program.

CONSERVATION COMPLIANCE ANALYSIS

METHODS

To evaluate the economic impact of conservation compliance requirements I use cash flows and cost-benefit analysis, which are used to quantify the magnitude, timing, and incidence of costs and benefits of a policy change. The end result of this analysis is a net present value (NPV), which quantifies the positive or negative net impact of the policy change in present value terms. I also examine the distributional impacts of the policy, specifically the marginal impact upon the cash flows of affected farmers and upon government expenditures.

This analysis will treat 2014 as "Year 0" in which the policy was enacted, after which farmers have 5 years to develop and implement approved conservation plans. After this 5 year implementation period the program is assumed to be in a steady state in which existing conservation plans are implemented with little investment in further improvement. This assumption is supported by findings that erosion was reduced drastically upon the initial implementation of the conservation requirements introduced in the 1985 Farm Bill and then plateaued due to lack of any type of "ratchet" mechanism requiring improvement of conservation plans or additional erosion mitigation actions.[37] In the continued absence of any such mechanism, I will assume that the group of farmers newly under compliance requirements due to changes in the 2014 Farm Bill will behave in a similar manner and erosion reductions will plateau after the initial implementation phase and continue into perpetuity.

PARAMETERS AND ASSUMPTIONS

The cost-benefit analysis is structured to assess the marginal impact of the transfer of conservation compliance requirements from direct payments to crop insurance subsidies. The breakdown of farms impacted by this switch are shown in Figure 8 below, with the groups of farmers specifically impacted by the insurance compliance requirement highlighted in bold.[38]

[37] Claassen et al. "Environmental Compliance in U.S. Agricultural Policy: Past Performance and Future Potential" USDA Economic Research Service, Agricultural Economic Report No. 832, June 2004.

[38] Claassen, Roger. "The Future of Environmental Compliance Incentives in U.S. Agriculture: The Role of Commodity, Conservation, and Crop Insurance Programs" USDA Economic Research Service. Economic Information Bulletin Number 94, March 2012.

Enrollment in federal Ag programs in 2010	*% of farms*	*% of land*	*Effect of removal of direct payments*
Direct payments (DPs) only, not enrolled in conservation programs, no insurance	7%	8%	Lose compliance requirement, no effect from crop insurance requirement
DPs + crop insurance, no other conservation program payments	**9%**	**36%**	**Maintain compliance due to crop insurance requirement**
Direct payments + conservation payments	6%	28%	Maintain compliance, no effect from crop insurance requirement
Insurance only, no DPs, no conservation	**8%**	**5%**	**New compliance requirement**

FIGURE 8. MARGINAL IMPACT OF REINSTATEMENT OF CONSERVATION COMPLIANCE REQUIREMENT FOR CROP INSURANCE, GIVEN THE REMOVAL OF DIRECT PAYMENTS (CLAASSEN 2012)[37]

I parameterized the model by using the following metrics to estimate the costs and benefits of conservation compliance. The parameters, base assumptions, and data sources are shown in Tables A and B of Figure 9, below.

Parameters

	A. Quantities	**Total US**	**Notes**	**Source**
1	Percentage of insured farmland already in conservation compliance	36%		Claassen, 2012
2	Percentage of insured farmland not currently in conservation compliance	5%		Claassen, 2012
3	Total farmland in US (acres)	336,000,000		Claassen, 2012
4	Total area requiring new conservation compliance plan & implementation (mil acres)	16,800,000		Claassen, 2012
5	Maximum number of farms requiring new conservation compliance plan	53,000		Claassen, 2012
6	Total farmland currently in compliance (acres)	319,000,000		Claassen, 2012
7	Gov. labor (in hours/farm) for new conservation plan	2	No available estimates in the literature.	My estimate
8	Farm labor (in hours/farm) for new conservation plan	10	No available estimates in the literature.	My estimate

9	Labor (in hours/new farm) required for enforcement of compliance	0.02	No available estimates in the literature. Estimate based on 2010-2012 monitoring rates (average ~1%), assuming an average time expenditure of 2 hours per farm selected for monitoring.	My estimate
10	Quantity of erosion in 2007 (millions of tons per year)	1725		NRCS Natural Resource Inventory, 2007
11	Mean quantity of erosion in 2007 (tons per acre per year)	4.8		
12	Quantity of erosion before enactment of conservation compliance (mil. tons per year)	3061		Moseley, 2013
13	Mean quantity of erosion 1982 prior to compliance (tons per acre)	7.3		
14	Change in quantity of erosion (total, mil. tons per year	1336	Difference between erosion rates, before and after policy implementation	
15	Change in quantity of erosion (per acre, per year)	2.5		
16	USDA estimated reduction in erosion due to conservation compliance (tons per year)	295000000		Moseley, 2013
17	Minimum estimate of wetlands preserved (acres)	1500000		Moseley, 2014
18	Maximum estimate of wetlands preserved (mil acres)	3300000		Moseley, 2015
20	Mean percentage of acres out of compliance in annual enforcement spot-checks (without an exemption or variance	1%		Claassen, 2004
21	Total farmland insured in 2010	264000000		Claassen, 2012

B. Input and Output Prices

22	Mean cost of compliance implementation per acre	$5.19	National mean estimated at $2.15 per acre in 1982 dollars. Converted to 2013 dollars using the Bureau of Labor Statistics' adjustment. Note- this value is highly variable between regions- some areas have much higher costs.	Huang, 1989
23	Labor cost ($/hour)- farmer	$34.65	National mean wage rate in 2010 for farm, ranch, and other agricultural managers, adjusted to 2013 dollars	Bureau of Labor Statistics, 2014
24	Labor cost ($/hour)- government	$45.85	National mean wage rate in 2010 for soil and agricultural scientists, adjusted to 2013	Bureau of Labor Statistics, 2014
25	Profit margin ($/acre/year)- liberal	$50.00	Lower bound of sustainable profit margin	
26	Profit margin ($/acre/year)- conservative	$300.00	Upper bound of profit margins- estimated using mean profit margin for Iowa corn in 2012 (high corn prices, high yield)	NRCS & Iowa Extension, 2013
27	Cost of remediation of water quality ($/ton of eroded sediment)	$4.93	Varies regionally, accounts for drinking water remediation only, other sediment damages not included	NRCS & Iowa Extension, 2013
28	Cost to farmer of erosion ($/ton/acre)	$34.30	Est. rent value reduction of $295/acre, divided by erosion savings rate of 8.6 tons/acre to get rent reductions/acre	NRCS & Iowa Extension, 2013
29	Mean cost of wetland remediation ($/acre)	$74,535.00	Data from wetland offset banks- national mean excluding tidal wetlands. Credits range from $3,000 - $653,000 per acre.	Ecosystem Marketplace, Inc.
30	Total crop insurance subsidies in 2010	$10,000,000,000		Claassen, 2013
31	Wage growth rate	5%	Based on mean growth rate of real wages between 2007 and 2010 for Farm Manager and Soil Scientists	Bureau of Labor Statistics, 2014
32	Interest rate	10%		

FIGURE 9. PARAMETERS USED TO ESTIMATE COSTS AND BENEFITS IN CASH FLOW (RELEVANT SOURCES NOTED FOR EACH PARAMETER).

The parameter tables above show the nominal value of inputs and outputs based on market prices, not the true social value. Differences between market values and social values arise when the market does not adequately value certain public goods or services, such as clean water, beautiful views, wildlife habitat, ecosystem services, or long-term food security benefits from soil conservation. I have made no effort to estimate the true social value of these positive externalities of erosion mitigation and habitat preservation via shadow pricing, thus these public benefits are undervalued in my analysis.

Three cash flows were computed using the above parameters: cash flow to the economy as a whole, cash flow to farmers, and cash flow to government. The cash flow to the economy as a whole includes public goods such as water quality and avoided destruction of wetlands. The value of these services is distributed to many different actors throughout the economy, and does not accrue exclusively to either farmers or the government, therefore does not appear in the distributional analysis.

I have assumed a conservative position whenever possible in my estimation of parameters for which there is a high degree of uncertainty in the literature. In order to estimate the full range of potential values of cost and benefit parameters, I include a scenario-based sensitivity analysis with NPV estimates for the most conservative, moderately conservative, and most liberal cases, evaluated at different inflation rates.

RESULTS

My cost benefit analysis shows that the marginal effect of adding conservation compliance requirements to the crop insurance program in the absence of direct payments is highly positive for the national economy as a whole, producing net benefits of over $4,400 per acre added to the program. Despite the up-front investment required to create conservation plans and implement new management practices, the policy change also produces significant net benefits for farmers as well (upwards of $780 per acre added to the program). For the government, the costs of implementing the policy slightly outweigh the benefits (resulting in a net negative NPV of -$0.25/acre), however it is important to remember that this analysis does not include the true social value of the health, aesthetic, and ecological benefits provided by conservation compliance, as described in the Methods section above. Therefore the value to the government of these non-market public goods would only need to exceed $0.25 per acre in order to make the NPV positive from the government's perspective.

Tables 1, 2, and 3 below show the full cash flows to the economy, the agricultural sector, and the government. Tables 4 and 5 show the sensitivity analysis and the parameter values used in each scenario.

Table 1. Cash Flow: Economic Point of View (in millions of dollars)

	Time	0	1	2	3	4	5	6 to Forever
1	**Cash In**							
2	Avoided water quality remediation							$207.06
3	Avoided wetland remediation							$5,888.03
4	Avoided loss of soil quality due to erosion							$1,440.60
5	Total Cash In	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$7,535.69
6								
7	**Cash Out**							
8	Labor cost to create conservation plan		$4.88	$5.12	$5.38	$5.65	$5.93	
9	Implementation of conservation plan							$87.19
10	Labor cost to monitor conservation compliance							$0.05
11	Opportunity cost of foregone production (wetlands)	$23.70	$23.70	$23.70	$23.70	$23.70	$23.70	$23.70
12	Total Cash Out	$23.70	$28.58	$28.82	$29.08	$29.34	$29.63	$110.94
13								
14	**Net Cash Flow**	**($23.70)**	**($28.58)**	**($28.82)**	**($29.08)**	**($29.34)**	**($29.63)**	**$7,424.75**
15	**Present Value**	**($23.70)**	**($25.98)**	**($23.82)**	**($21.85)**	**($20.04)**	**($18.40)**	**$74,247.52**
16	**Net Economic Present Value**	**$74,113.74**		**NPV ($/acre)**	**$4,411.53**			

	Table 2. Cash Flow: Government's Point of View (in millions of dollars)							
	Time	0	1	2	3	4	5	6 to Forever
1	**Cash In**							
2	Avoided crop insurance subsidies for non-complying farms							$0.06
3	Total Cash In							$0.06
4	**Cash Out**							
5	Labor to assist in creation of conservation plan		$1.02	$1.07	$1.13	$1.18	$1.24	
6	Labor to monitor and enforce compliance							$0.07
7	Total Cash Out	$0.00	$1.02	$1.07	$1.13	$1.18	$1.24	$0.07
8	**Net Cash Flow**	**$0.00**	**($1.02)**	**($1.07)**	**($1.13)**	**($1.18)**	**($1.24)**	**($0.00)**
9	**Present Value**	**$0.00**	**($0.93)**	**($0.89)**	**($0.85)**	**($0.81)**	**($0.77)**	**($0.01)**
10	**Net Present Value**	**($4.25)**		**NPV ($/acre)**	**($0.25)**			

	Table 3. Cash Flow: Agricultural Sector's Point of View (in millions of dollars)							
	Time	0	1	2	3	4	5	6 to Forever
1	**Cash In**							
2	Avoided loss of soil quality due to erosion							$1,440.60
3	Total Cash In	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$1,440.60
4	**Cash Out**							
5	Labor to create conservation plan		$3.67	$3.67	$3.67	$3.67	$3.67	
6	Cost to implement conservation plan							$87.19
7	Foregone production (wetlands)	$23.70	$23.70	$23.70	$23.70	$23.70	$23.70	$23.70
8	Lost crop insurance subsidies due to non-compliance							$0.06
9	Total Cash Out	$23.70	$27.37	$27.37	$27.37	$27.37	$27.37	$110.95
10	**Net Cash Flow**	**($23.70)**	**($27.37)**	**($27.37)**	**($27.37)**	**($27.37)**	**($27.37)**	**$1,329.65**
11	**Present Value**	**($23.70)**	**($24.88)**	**($22.62)**	**($20.56)**	**($18.70)**	**($17.00)**	**$13,296.45**
12	**Net Present Value (mil)**	**$13,168.99**		**NPV ($/acre)**	**$783.87**			

Table 4. Sensitivity Analysis- Net present value (NPV) to each party (in mil $)

Scenario	Interest rate	2%	4%	6%	8%	10%	12%
Conservative *Max. cost and min. benefit estimates*	Economy as a whole	$48,598.56	$24,209.71	$16,085.66	$12,027.29	$9,594.82	$7,975.05
	Farmers	$34,663.83	$17,248.62	$11,448.60	$8,551.90	$6,816.21	$5,660.79
	Government	($10.72)	($9.09)	($8.26)	($7.66)	($7.17)	($6.75)
Moderate *Mean cost and benefit estimates*	Economy as a whole	$542,125.40	$270,984.83	$180,609.42	$135,424.84	$108,316.28	$90,245.52
	Farmers	$60,736.93	$30,294.01	$20,150.87	$15,082.24	$12,043.14	$10,018.58
	Government	($4.72)	($4.41)	($4.16)	($3.93)	($3.72)	($3.53)
Optimistic *Min. cost and max. benefit estimates*	Economy as a whole	$5,764,479.10	$2,882,209.74	$1,921,455.14	$1,441,079.07	$1,152,854.28	$960,705.05
	Farmers	$71,528.84	$35,735.71	$23,806.44	$17,842.97	$14,265.70	$11,881.45
	Government	$0.48	($0.31)	($0.54)	($0.62)	($0.66)	($0.66)

Table 5. Parameter values for sensitivity analysis scenarios

Parameter	Conservative	Moderate	Optimistic	Parameter	Conservative	Moderate	Optimistic
Benefits				*Costs*			
Cost of remediation of water quality ($/ton of eroded sediment)	$1.00	$4.93	$8.86	Gov. labor (in hours/farm) for new conservation plan	3	1.75	0.5
				Farm labor (in hours/farm) for new conservation plan	15	11.5	8
Cost to farmer of erosion ($/ton/acre)	$29.07	$31.68	$34.30	Labor (in hours/new farm) required for enforcement of compliance	0.03	0.02	0.01
Cost of wetland remediation ($/acre)	$3,000	$74,535	$653,000	Mean cost of compliance implementation ($/acre)	$29.54	$5.19	$0.00
Wetlands protected from development by Swampbuster (acres)	1,500,000	2,400,000	3,300,000	Profit margin ($/acre/year) from agricultural production	$350.00	$300.00	$50.00
				Wage growth rate	7%	5%	3%

The results of my analysis show that conservation compliance, even under the most conservative scenario, provides a net benefit to farmers and to the economy as a whole for a comparatively modest initial investment on the part of farmers and the government.

Cover Crop Decision Model

Methods

Any analysis of the costs and benefits of modifications to the crop insurance system to increase flexibility for cover crops is subject to a number of different sources of uncertainty:

1. Adoption is currently very low, and the farmers planting cover crops are a small, self-selected group of producers, many of whom plant cover crops for environmental (not economic) reasons.[39] It is unlikely that this group is representative of the wider body of conventional farmers, so observed costs and benefits cannot be easily extrapolated to the broader community.
2. Crop insurance planting restrictions are only one of the barriers facing farmers who might decide to plant cover crops, therefore we cannot predict the impact of removing this one barrier on overall adoption rates.
3. Climate change may make cover cropping or double cropping more economically attractive to many producers, but climate projections and the subsequent changes in adaptive management preferences of farmers are nearly impossible to forecast accurately, and no such attempt has been made in the literature with results suitable for use in cost-benefit analysis.
4. Agricultural prices (which are key in determining the economic benefits of specific cropping choices) are highly volatile and cannot be accurately projected on long time horizons.

Given the weaknesses of a conventional cost benefit analysis in this context, I have constructed as an alternative a financial decision model to compare options at the farm level. Farm-level analysis allows specificity in parameterization of the model and removes a lot of the uncertainty involved in generalization of the model to a larger geographic region. The implication of this methodological decision is that the results are not generalizable in any way- implementation and evaluation of a pilot program is needed in order to evaluate the potential costs and benefits of such a policy shift on a national scale.

[39] Werblow, Steve. "2012-2013 Cover Crop Survey Results: June 2013 Analysis" USDA North Central Sustainable Agriculture Research and Education Program.

My cover crop decision model is based on a planting decision model developed through the "FAST Tools" Farmdoc program at the University of Illinois, with funding from the Risk Management Agency.[40] The tool was originally designed to help farmers decide between late planting and prevented planting payments, based on expected yield and insurance penalties vs. forgone production and subsequent prevented planting payments. I have adjusted the tool and added cover crop options to provide a method for comparing three different planting options: standard single-crop planting of corn or soy, cover crop followed by commodity crop (corn or soy), or prevented planting payments. The expected yield is calculated based on the difference between the planting date and the optimal planting date, adjusting for yield loss due to delayed planting for every day past the optimal planting date.[41]

RESULTS

The cover crop decision model can be used to determine the circumstances in which planting cover crops may be economically advantageous to farmers. The model requires the user select the location, appropriate insurance plan and coverage level, average production history, commodity price per bushel, and planting date specific to his or her farm. The values of these parameters will be unique to a given farm and a given year; therefore, the results included in this analysis are for illustration purposes only. Optimal planting dates for different crops vary significantly based on local climate conditions, and therefore are likely to fall earlier and earlier in the spring as the climate warms. As optimal planting dates fall earlier, the growing season is expanded, the economic benefits of planting a cover crop or double cropping will increase.

---

[40] FAST Tools "Planting Decision Model", University of Illinois, last updated 5/30/2013. Download available at http://farmdoc.illinois.edu/fasttools/

[41] USDA National Agricultural Statistics Service, "Field Crops: Usual Planting and Harvest Dates" Agricultural Handbook Number 628, October 2010. http://usda01.library.cornell.edu/usda/current/planting/planting-10-29-2010.pdf

Planting Decision Tool

County: Adams

Option	$ per Acre	With cover crop
Plant corn	$478	$665.86
Plant soybeans	$283	$452.32
Take prevented planting payment[1]	$305	$455.44

	Plant corn		Plant soybeans		Prevented planting		Cover crops		
Insurance policy									
Type	RA-HP		CRC				*Cover crop type*		Alfalfa
APH yield	160		49		*Prevented Crop*				
Base price	$4.04		$8.80		*corn*		*Drought conditions expected?*		Severe drought
Date planted	Before 6/6		Before 6/21				Est revenue impact (corn)*:		$77.48
Coverage level	80%		80%				Est revenue impact (soy)*:		$59.22
Guarantee	$582		$416						
Revenue per acre							Used for hay/grazing?		Yes
Yield (bu. per acre)	172		41				Yield (tons per acre)		2
Harvest price	$4.55		$10.60				Price/ton sold or grazed:		$75.00
Basis	-$0.45		-$0.50						
Cash price	$4.10		$10.10				Total feed value		$150.00
Crop revenue	$704		$414				Total addt'l revenue:		
Insurance revenue	0		0		349		Corn		$227.48
Crop and insurance rev.	$704		$414		$349		Soy		$209.22
Costs yet to be incurred		*Budget*		*Budget*		*Budget*			*Budget*
Direct costs		*Defaults*		*Defaults*		*Defaults*			*defaults*
Fertilizers	0	*120*	0	*35*	0				*0*
Pesticides	25	*42*	15	*30*	6	*6*			*0*
Seed	80	*58*	40	*38*	0			25	
Drying	15	*6*	1	*1*	0				*0*
Storage	0	*2*	0	*1*	0				
Crop insurance	35	*35*	15	*8*	35	*35*			*0*
Power costs									
Machine hire	5	*5*	5	*5*	3	*3*		5	*5*
Field cultivate	9	*9*	9	*9*	0				*0*
Plant	10	*10*	10	*10*	0	*10*		10	*10*
Spray	3	*3*	3	*3*	0				*0*
Combine	35	*35*	30	*30*	0				*0*
Trucking	9	*5*	3	*3*	0			0	*0*
Costs yet to be incurred	$226		$131		$44			$40	
Revenue less costs	$478		$283		$305		Corn		$187.48
							Soy		$169.22

1 Assumes a CRC or RA policy has been purchased. Prevented planting payments are not available for GRP, GRIP, or CAT policies. Prevented planting is available for APH but is not modeled here.

* Estimated yield impacts for corn and soy from Werblow, Steve. "2012-2013 Cover Crop Survey Results: June 2013 Analysis" North Central SARE.

Projected Yields

	Corn	Soybeans
Optimal Planting Yield	200	55
Daily yield loss between		
May 1 through 10	0.4	0.10
May 11 through 20	0.6	0.23
May 21 through 31	1.0	0.36
After June 1	1.2	0.54
	0	

Use Yield Defaults

Default yield losses from Nafziger, Emerson. *Illinois Pert Management Bulletin.* University of Illinois. ("Corn Planting Date Revisited", April 10, 2009), ("Soybeans from April Showers Bring May …", May 1, 2009)

CONCLUSIONS

This analysis suggests two different, equally valuable, approaches to increasing adaptive capacity in the agricultural sector: regulation via requirements for voluntary participation in subsidy programs, resulting in clear, nation-wide environmental benefits, and conversely loosening program constraints for farmers to experiment with adaptive management practices, creating opportunities for highly localized adaptive planting decisions, environmental and economic optimization.

Climate adaptation does not have to wait for national climate legislation. The policy alternatives I explored in this analysis are just two of many options for climate adaptation which leverage existing policy to increase resiliency at the national scale with comparatively small investments in political capital and funding. This proverbial "low-hanging fruit" of the adaptation world provides the opportunity to take those critical first steps towards a future of vibrant rural communities and secure food supply. The Agricultural Act of 2014 took some of these first steps, including re-instatement of conservation compliance requirements to the crop insurance program. The results of this analysis show that these investments will pay for themselves many times over and contribute real wealth to the economy.

The opportunities for future research are vast. This analysis has only scratched the surface of climate adaptation possibilities in the crop insurance program, which is itself only a small part of the broader group of federal and state farm support programs which have the potential to be used as tools for climate adaptation. A comprehensive analysis and comparison of the costs and benefits of a much broader suite of policy options is needed in order to identify the best opportunities for policy interventions to increase adaptive capacity in the agricultural sector.

Huge gaps exist in the literature quantifying the costs and benefits of conservation compliance to the farmer, which is symptomatic of a larger issue in the field. Many evaluations of environmental regulation focus exclusively on the environmental impacts; although the environmental impact is the ultimate goal of the policy intervention, it is critically important to understand the costs of implementing such programs to the agricultural sector. Successful policy design must improve environmental performance but also must benefit the farmer and increase the long-term sustainability of his or her agricultural enterprise in order to sustain improved management practices over time. While the benefits of conservation compliance have been indisputably positive and the requirements have been successful in helping farmers achieve unprecedented levels of erosion reduction, an understanding of the demands that the program places on farmers will be key to any future efforts to "ratchet up" the requirements to achieve further environmental gains. Any attempt to increase the stringency of the requirements of the program will fail without considering the burden of such a change on the farming communities and designing any policy changes to maximize on-farm benefits and minimize costs.

REFERENCES

Babcock, Bruce, "Examining the Health of the U.S. Crop Insurance Industry," Iowa Ag Review 15:4 (2009). http://www.card.iastate.edu/iowa_ag_review/fall_09/article1.aspx

Challinor, A. J., T. R. Wheeler, J. M. Slingo, P. Q. Craufurd, and D. I. F. Grimes. "Simulation of Crop Yileds Using Era-40: Limits to Skill and Nonstationarity in Weather-Yield Relationships." Journal of Applied Meteorology 44, no. 4 (04/2005 2005): 516-31.

Christensen, J.H., et al., "Regional Climate Projection," *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on ClimateChange. Cambridge University Press: New York, NY, 2007, Figure 11.12, p.890.

Claassen, Roger, Vince Breneman, Shawn Bucholtz, Andrea Cattaneo, Robert Johansson, and Mitch Morehart. "Environmental Compliance in U.S. Agricultural Policy: Past Performance and Future Potential" USDA Economic Research Service, Agricultural Economic Report No. 832, June 2004.

Claassen, Roger. "The Future of Environmental Compliance Incentives in U.S. Agriculture: The Role of Commodity, Conservation, and Crop Insurance Programs" USDA Economic Research Service. Economic Information Bulletin Number 94, March 2012.

---,---. "Have Conservation Compliance Incentives Reduced Soil Erosion?" Amber Waves, Volume 2, Issue 3, p. 30, June 2004.

Clayton, Chris, "Crop Insurance Provisions in the New Farm Bill", The Progressive Farmer Magazine Ag Policy Blog, Published 2/6/2014.
http://www.dtnprogressivefarmer.com/dtnag/common/link.do;jsessionid=9FF36FCB424C2AE4D903626579E9B02D.agfreejvm2?symbolicName=/ag/blogs/template1&blogHandle=policy&blogEntryId=8a82c0bc43a1ab8d014409a878f90406

Easterling, W.E., et al., "Food, fibre and forest products." Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007) M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 273-313.

Environmental Protection Agency (EPA), "Agriculture and Food Supply Impacts & Adaptation: Climate Change Impacts on Agriculture" (2009), accessed 4 October, 2012. http://www.epa.gov/climatechange/impacts-adaptation/agriculture.html

---,---. "Ag 101: Land Use Overview," Last updated 4/9/2013. http://www.epa.gov/agriculture/ag101/landuse.html

Environmental Working Group (EWG), "Crop Insurance Primer," Farm Subsidy Tracker, Accessed 5 October, 2012. http://farm.ewg.org/crop_insurance_analysis.php

---,---. "High Crop Prices, Insurance Subsidies Trigger Destruction of Millions of Acres of Wildlife Habitat," Press release 6 August, 2012, http://www.ewg.org/release/high-crop-prices-insurance-subsidies-trigger-destruction-millions-acres-wildlife-habitat

---,---. "Total Costs by State," Data for all states accessed 6 October, 2012. http://farm.ewg.org/cropinsurance.php?fips=00000&summpage=TC_TOPREGIONS_STATE&statename=theUnitedStates

---,---. "Total Costs of the Crop Insurance Program in the United States," Data for all states accessed 5 October 2012. http://farm.ewg.org/cropinsurance.php?fips=00000&summpage=TC_BY_YEAR&statename=the UnitedStates

Farmdoc, "FAST Tools Planting Decision Model", University of Illinois, last updated 5/30/2013. Download available at http://farmdoc.illinois.edu/fasttools/

Kleinschmit, Jim, Institute for Agriculture and Trade Policy, interview with Nora Morse, September 17, 2013.

Matson, P. A., et al. "Agricultural Intensification and Ecosystem Properties" Science, New Series, Vol. 277, No. 5325 (Jul. 25, 1997), pp. 504-509. http://www.jstor.org.proxy.lib.duke.edu/stable/

New York State Department of Agriculture and Markets, "Crop Insurance For Beginning Farmers," (2011)
http://www.agriculture.ny.gov/AP/cropins/NY_Beginning_Farmers_Handout_2011.pdf

Olmstead, Julia and Jim Kleinschmit, "A Risky Proposition: Crop Insurance in the Face of Climate Change", *Farm Bill 2012: What's at Stake? Series*, Institute for Agriculture and Trade Policy (2012) http://www.iatp.org/documents/a-risky-proposition-crop-insurance-in-the-face-of-climate-change

O'Neal, Monte R., M. A. Nearing, Roel C. Vining, Jane Southworth, and Rebecca A. Pfeifer. "Climate Change Impacts on Soil Erosion in Midwest United States with Changes in Crop Management." Catena 61, no. 2-3 (2005): 165-84.

Porter, J. R., and M. A. Semenov. "Crop Responses to Climatic Variation." [In eng]. Philosophical Transactions of the Royal Society of Biological Science 360, no. 1463 (Nov 29 2005): 2021-35.

Risk Management Agency, US Department of Agriculture. "Crop Indemnity Maps," 2011 Crop year: July 23, 2012. http://www.rma.usda.gov/data/indemnity/2011

---, "History of the Crop Insurance Program,"
http://www.rma.usda.gov/aboutrma/what/history.html.

---, Product Administration & Standards Division, "2011 Crop Insurance Handbook," FCIC 18010 (2010). http://www.rma.usda.gov/handbooks/18000/2011/11_18010.pdf

Roberts, Michael J. , and Wolfram Schlenker. "The Evolution of Heat Tolerance of Corn: Implications for Climate Change." In *The Economics of Climate Change: Adaptations Past and Present*, edited by Gary D. Libecap and Richard H. Steckel. 1-36. Chicago, IL: University of Chicago Press, 2011.

Sciammacco, Sarah, "Downfall of Direct Payments," Environmental Working Group (2013). http://www.ewg.org/downfall-direct-payments

Schlenker, W., and M. J. Roberts. "Nonlinear Temperature Effects Indicate Severe Damages to U.S. Crop Yields under Climate Change." [In eng]. Proc Natl Acad Sci U S A 106, no. 37 (Sep 15 2009): 15594-8.

Schnepf, Max. "Conservation Compliance: A retrospective... and look ahead" Environmental Working Group, February 2012.

Shields, Dennis, "Federal Crop Insurance: Background and Issues," Congressional Research Service (CRS) Brief 7-5700 R40532 (2010).
http://www.nationalaglawcenter.org/assets/crs/R40532.pdf

USDA Economic Research Service, "Farm Program Atlas", Last updated 11 July, 2012. Accessed 25 November, 2013. http://www.ers.usda.gov/data-products/farm-program-atlas/go-to-the-atlas.aspx#.U0vy6PldWSo

USDA National Agricultural Statistics Service, "Field Crops: Usual Planting and Harvest Dates" Agricultural Handbook Number 628, October 2010. http://usda01.library.cornell.edu/usda/current/planting/planting-10-29-2010.pdf

Wallander, Steven. "Soil Tillage and Crop Rotation." USDA Economic Research Service, February 2013.

Werblow, Steve. "2012-2013 Cover Crop Survey Results: June 2013 Analysis" USDA North Central Sustainable Agriculture Research and Education Program.

Worth, Thomas, Chief Actuary, Risk Management Agency. Interview with Nora Morse, August 1, 2013.

Wuebbles, Donald J., and Katharine Hayhoe. "Climate Change Projections for the United States Midwest." Mitigation and Adaptation Strategies for Global Change 9 (2004): 335-63.