Cost of Maintaining CRP in Presence of Biofuels

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Abstract

We analyze the effect of an emergence of biofuel industry on the Conservation Reserve Program. The government expenditure on Conservation Reserve Program needs to increase dramatically to keep the current scale of CRP program when the biofuel industry is considered. We propose that the development of bioenergy crops on expiring CRP land is a potential way to reconcile the conflict between a sharp increase in government CRP budget and its environmental protection goal. CRP program can also be combined with the Biomass Crop Assistance Program (BCAP) to achieve the goal of environmental protection and low carbon society at the same time.

Key Words: Conservation Reserve Program (CRP), Soil Rental Rate, Bioenergy Crops

1. Introduction

Since its inception from the 1985 Farm Bill, Conservation Reserve Program (CRP) has existed for over twenty years. CRP successfully protects environmentally sensitive land, water quality and wildlife habitat though 10-15 years contract with landowners. Landowners set aside their land from agriculture and get rental payment throughout the 10-15 year contract span. From 2010, 46.4% of CRP land will expire in the following three years[1] and people are interested in the fate of these expiring CRP land especially in the emergence of biofuel industry. Landowners with expiring CRP acres may face a new set of options. Traditionally, they may either re-enroll into the CRP program with an updated soil rental rate or return to traditional crop production such as corn and soybean production. We now examine the incentives for a third possibility for landowners --- planting dedicated bioenergy crops that can be used to produce cellulosic biofuels.

In recent five years, the rapid expansion of corn ethanol causes an increase in crop prices and food prices. The price of corn increases from $2 per bushel in 2005 to over $4 per bushel in 2009. This increase in crop prices makes the current soil rental rate no longer attractive to farmers with expiring CRP land. Secchi, et al. (2009) analyze the impact of higher crop prices on CRP land in Iowa and find that an increase in commodity prices has a large impact on the CRP enrollment and dramatic reduction in CRP land is expected without a substantial increase in soil rental rate.

In order to keep the same amount of CRP acres, soil rental rate will need to increase correspondingly to provide incentives for expiring CRP acres to re-enroll in the program; thus increasing the budgetary cost of the CRP. According to our estimation, the soil rental rate should increase at a rate of 5.5% each year to attract the farmers to reenroll into the CRP program which means a sharp increase in budget. Otherwise, landowners will opt out of the CRP program and convert the retired CRP land to crop production with an expectation of rising food prices which negates the objective of conservation.

At the same time, the ambitious targets for advanced biofuel production set by the Energy Independence and Security Act of 2007 are going to increase demand for land to grow bioenergy crops. Several perennial grasses like switchgrass and miscanthus have the potential to meet these targets for advanced biofuels. They also provide other environmental benefits such as enhancing soil carbon sequestration, reducing nitrogen run-off and reducing soil erosion while providing wildlife habitat with a

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[1] See Figure 1 for the distribution of expiring acres in the following 10 years.

sustainable harvest system (Sanderson, et al. (2006)). These grasses could potentially be grown on CRP land and harvested for bioenergy while maintaining the water quality benefits provided by existing perennial cover crops grown on CRP acres. If farmers are allowed to grow bioenergy crops on their CRP land, the competition for cropland between food and fuels would be reduced. Food consumers would benefit from lower commodity prices. On the other hand, farmers can increase their income from growing these crops while the government can also reduce its spending on the CRP program.

Only a few studies have examined the effects of using CRP acres for crop production and determining the extent to which CRP acres can provide and the cost at which they will do so. Secchi, et al. (2009) derive supply curves of CRP land in Iowa under alternative crop prices by comparing soil rental rates and net returns from cropping. Their results show that higher CRP payments would be needed to keep lands in the program. However, their focus is mainly on corn crops instead of perennial bioenergy crop production. Walsh, et al. (2003) estimate the economic potential of using CRP land for bioenergy crop production in the U.S. with switchgrass, poplar and willow as potential bioenergy feedstocks. De La Torre Ugarte, et al. (2000) evaluate the impact of biofuel production on the quantities, prices and locations of traditional crops and farm income. They also calculate the biomass price required to make bioenergy crops competitive with traditional crops.

In the present study, we consider the potential to grow bioenergy crops such as switchgrass and miscanthus on CRP land and its economic implications for CRP program cost, food and fuel prices and farm income. Specifically, this paper has three objectives. First, we examine the economic potential of using CRP land for biofuel production and the effects on food and fuel prices, land use, social welfare and GHG emissions under alternative scenarios for increasing soil rental rates for CRP enrollment. When a CRP contract expires, farmers can decide either to stay in the CRP, convert the land to conventional crops, or convert the land to the production of energy crops. Their decisions depend on the payments offered by the government and net returns from producing commercial crops or bioenergy crops. For instance, if the net return from growing energy crops is greater than the payments provided by the government, expiring CRP land would be used to produce bioenergy crops. Second, we explore the economic effects if current CRP rules can be modified to grow bioenergy crops on expiring CRP land. The government could provide cost-share payments like Biomass Crop Assistance Program (BCAP) which provides establishment and annual payments to the producers of bioenergy crops. When bioenergy crops become mature and produce biomass, farmers can sell the biomass and receive income. We examine to what extent these policy modifications will induce the production of bioenergy crops and its implications for the budgetary costs of the CRP payments if soil rental rates are reduced as bioenergy crop revenue increases. We also analyze the implications of the policy modifications for food and fuel prices, mix of biofuels and GHG reduction benefits. Third, we assess the government expenditure on maintaining CRP land as required by the Food, Conservation, and Energy Act (FECA) when crop prices increase and necessitate higher soil rental rates.

In order to address these research questions, we first use econometric analysis to determine the relationship between soil rental rate and prices of major crops controlling for the social-economic characteristics and weather conditions at the county level. Results from our econometric analysis suggest that soil rental rate is significantly affected by crop price index. A one percent increase in crop price index increases the soil rental rate by 0.05 percent points controlling for temperature, precipitation and soil erosion index. We then incorporate this relationship in a dynamic, multi-market equilibrium model, the Biofuel and Environmental Policy Analysis Model (BEPAM) and determine the impact of various CRP policies on markets for fuel, biofuel, food/feed crops and livestock for the period 2009-2022. Food and fuel prices are endogenously determined by the model for each year of the planning horizon and used to update price expectations, cropland acreage and soil rental rates for the subsequent year. Three policy options are evaluated in this paper. The first one is to maintain the same amount of CRP land using an updated county-specific soil rental rate. The second one is to allow bioenergy crops to grow on CRP land. The last one is to incorporate annual rental payment as well as cost-share assistance for initial establishment of bioenergy crops. The result of this analysis shed light on the implications of government policy about CRP for food, fuel, and land use and the costs and benefits of linking CRP policy with biofuel policy.

This paper is organized as follows. The second section is the description of the data set we are using and major variables used in the econometric analysis. We use Arellano-Bond dynamic panel data model to estimate the soil rental rate employed in CRP payment. Then it is followed by the Biofuel and Environmental Policy Analysis Model and its simulation results under different policy scenarios. The fourth section concentrates on the environmental considerations of planting bioenergy crops on the CRP land. The final section concludes the paper with policy recommendations.

2. Economic Analysis

2.1 Data

We collect contract data from the U.S. Department of Agriculture Farm Service Agency Conservation Reserve Program monthly contract report. The data contains 2332 counties of 36 states from year 1995 to year 2009. There are some missing observations in this data set due to privacy restrictions required by the Farm Security and Rural Investment Act of 2002. The total non-missing observation number is 14,400. The variables in this data set include average rental rate at each signup, total CRP acres at each signup and average soil erosion index[2].

In addition to the contract data, we also collect the price and yield information of major crops such as corn, soybean, wheat, sorghum, and hay in these regions in the period of 1995-2007 from U.S. Department of Agriculture National Agricultural Statistics Service. In order to understand the impact of environmental factors on the soil rental rate, we compile climate data from PRISM Climate Group. It contains monthly temperature and monthly precipitation information of each county in year 1995-2008.

The soil rental rate is also related to the alternative uses of the land. Cropland cash rent is assembled from U.S. Department of Agriculture National Agricultural Statistics Service. The cropland cash rent reflects the alternative use of the cropland and it can also be considered as an opportunity cost of CRP. The soil rental rate is the response variable while independent variables include soil erosion rate, cropland cash rent, corn yield, corn price and CRP acres.

The descriptive statistics are summarized in Table 1 in the Appendix. The summary statistics show that the average soil rental rate is $88.89/acre with a standard deviation of 46.84. The standard deviation of soil rental rate is high because there are both large spatial and temporal variations. The average soil rental rate at Iowa is the highest at $145.98/acre while in Utah the average soil rental rate is only at $31.94/acre. The erosion index has a mean of 4.83 with a standard deviation of 8.47. Land erosion changes dramatically over time. At the beginning of 1995, the average erosion index is 15.3 while after 2003 the erosion is close to 0 which shows a big improvement in soil characteristics. Corn yield and soybean yield are 123.58 and 37.49 bushel per acre, respectively. Corn price and soybean price are $2.6 and $6.3 per bushel, respectively. Mean summer temperature is 22.95 °C and mean summer precipitation is 93.93 mm. Average cropland cash rent is $71/acre with a standard deviation of 324. The cash rent can be considered as opportunity cost of the CRP land.

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[2] Erosion index is the ratio of potential erosion and the soil loss tolerance value (T), which is the rate of soil erosion above which long term productivity may be adversely affected.

2.2 Econometric Method

Since we use panel data, we first run a fixed effect model to estimate the soil rental rate within each county. The basic model takes the following form:

$$SRR_{it} = X_{it}\beta + \alpha_i + \varepsilon_{it} \tag{1}$$

Where $i = 1, \dots 14{,}400$ counties and $t = 1995, \dots, 2009.$ SRR_{it} is the soil rental rate in county i in year t. X_{it} is a vector of independent variables. β_2 is a vector of coefficients associated with each independent variable. The error terms is composed of two parts: α_i represents unobserved county effect with $E\alpha_i = 0$ and ε_{it} is an independent and identically distributed disturbance term for county i in year t with $E\varepsilon_{it} = 0$. In the fixed effect model, we assume that the independent variables are exogenous with respect to random error. The independent variables used in the fixed effect model include: cropland cash rent, CRP Acres, erosion, corn yield, corn price, summer[3] temperature and summer precipitation.

In order to better capture the dynamic feature of the soil rental rate, we are more interested in estimating the coefficient of the following equation.

$$SRR_{it} = \beta_1 SRR_{it-1} + X_{it}\beta_2 + \alpha_i + \varepsilon_{it} \tag{2}$$

In this example, the independent variables may not be strictly exogenous of error term. This is the case because the cropland cash rent has an impact on the soil rental rate while the soil rental rate will also affect the cropland cash rent. CRP enrollment acres affect the soil rental rate while the soil rental rate will also influence the enrollment acres. The causality goes in both directions. The unobserved county effects (α_i) may also be correlated with explanatory variables. In order to correct for the endogeneity of the model, we use Arellano-Bond GMM Model which allows independent variable X_{it} to be endogenous. Follow the work of Holtz-Eakin, et al. (1988) and Arellano and Bond (1991) , we use Arellano-Bond dynamic panel-data estimation method to estimate our econometric model. We employ the Arellano-Bond GMM estimator also because the panel data we used has a short time horizon (T=15) while a large county dimension (N=2332). We first differentiate both sides and transform equation (1) into the following form:

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[3] Summer refers to June, July and August which is the most important growing season for most of the major crops.

$$\Delta SRR_{it} = \beta_1 \Delta SRR_{it-1} + \Delta X_{it} \beta_2 + \Delta \varepsilon_{it} \tag{3}$$

Then we use instrumental variables and GMM estimators to estimate the coefficients β_1 and β_2. The instrumental variables we choose are average summer temperature and average summer precipitation because these two variables are correlated with explanatory variables such as corn yield conditional on other covariates but not correlated with the error term.

In general, we expect that the soil rental rate goes up when the corn price increases. If corn production is more profitable, farmers would require a higher soil rental rate to stay in the CRP program. The sign of coefficient associated with corn yield is also expected to be positive. The erosion index is expected to have a negative impact on the soil rental rate because the higher erosion a land has, the lower soil rental rate is paid. Landowners with highly erodible land are willingness to enroll into the program with a lower soil rental payment because their opportunity cost is relative low and they also expect the land quality could improve throughout the contract period. We also expect a positive sign on the coefficient of cropland cash rent. If the cropland cash rent is high, the soil rental rate should also be high enough to compensate farmers who enroll into the CRP program. Otherwise they will opt out of the program and rent out their land for other purposes. The sign on the CRP acres is ambiguous to us. It can either be positive or negative. The lagged soil rental rate is expected to have a positive effect on the current soil rental rate.

2.3 Results

Regression results of the fixed effect model are summarized in table 2. In the first model, we run a fixed effect model of soil rental rate on the cropland cash rent, CRP enrollment Acres, soil erosion index, corn yield, and corn price. The variables can explain 32% of the variation in soil rental rate. The cropland cash rent has a significant positive effect on the soil rental rate. With 1 dollar increase in the cropland cash rent, the soil rental rate goes up by 0.10 dollars. The CRP enrollment acres also have a small positive effect on the soil rental rate. The erosion index has a significant negative impact on the soil rental rate. This is consistent with our expectation. The land with a large erosion index tends to get less soil rental rate than the land with a low erosion index. The yield does not affect soil rental rate significantly. The price of corn is a significant determinant of the soil rental rate. Corn price increases by 1 dollar per bushel, the soil rental rate goes up by 1 dollar per acre.

In the second model, we use one year lagged values as independent variable. All the lagged values have significant positive effect on the soil rental rate. The goodness of fit of the second model is improved compared with the first model. In the third model, we use two year lagged model instead of one year lagged model as explanatory variables. The third model is not as good as the second model in terms of model fitting. The fourth model includes both one year lagged variable and two year lagged variable. The fifth model uses one year, two year and three year lagged variables as independent variables. The sixth model uses one year, two year and three year lagged variables as well as temperature and precipitation variables as explanatory variables. Using R-squared as a criteria, model five gives us a best fit of the data. Across these models, corn price has a significant positive impact on the soil rental rate and summer temperature, summer precipitation has s positive effect on the soil rental rate.

We present the estimation result of Arellano-Bond dynamic panel-data estimation in table 3. Compared with the fixed effect model, the GMM model includes the lagged soil rental rate in the model. We find that the lagged soil rental rate has a significant positive effect on the current soil rental rate. The second year lagged soil rental rate does not have significant influence on the soil rental rate. The signs of other variables are similar to the fixed effect model. Of the five GMM model specifications, the first model and the third model have better explanatory power than the rest of models.

After the GMM estimation, we also perform the Arellano-Bond test for autocorrelation. The result does not show significant autocorrelation in differenced residuals.

3. Simulation Models

In order to predict the future pattern of soil rental rate for CRP land, we need to analyze the change in each of the independent variables in our econometric model and especially the change of corn prices and corn yield. We should put our analysis into a bigger background because the recent change in corn price is caused by biofuel policies. During 2001-2009, corn production increased by 30%, while the proportion of corn used in ethanol production increased from 7% to 33%.[4] Ethanol industry is booming in the recent years mainly because of the consideration of energy security and GHG reduction. Several policies have been launched to promote a low carbon society. Among them, Renewable Fuel Standard (RFS) set by the Energy Independence and Security Act (EISA) is the most important one. The RFS sets

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[4] Data source: USDA Feed Grains Database and USDA Production, Supply and Distribution electronic Database.

annual targets for the blending of specific categories of biofuels with transportation fuels; these categories are defined on the basis of the feedstock used and the GHG intensity of the biofuel, with the share of advanced biofuels[5] in annual biofuel production increasing over time to 58% by 2022. The RFS requires the total renewable fuel production to be at least 136 Billion liters in 2022. The amount of advanced biofuels in this must be 80 Billion liters, of which at least 60 Billion liters should be cellulosic biofuels. The remaining portion of total renewable fuel not met with advanced biofuels is allowed to be corn-based ethanol. EISA sets an upper limit of 56 Billion liters annually for corn ethanol in 2015 and beyond. There is no specific corn-ethanol mandated volume; thus, any advanced biofuel produced above and beyond the advanced biofuel requirements could reduce the amount of corn ethanol needed to meet the total RFS. The RFS quantity mandates imply a maximum cumulative production of 800 Billion liters of corn ethanol over the 2007-2022 period and at least 420 Billion liters of advanced biofuels.

To analyze the influence of these policies on the commodity price, production and social welfare, we use a multi-market, multi-period, price-endogenous, nonlinear mathematical programming model, namely, the Biofuel and Environmental Policy Analysis Model (BEPAM), which simulates the U.S. agricultural and fuel sectors and formation of market equilibrium in the commodity markets including trade with the rest of the world. BEPAM incorporates producers' and consumers' behavior when simulating the formation of market equilibrium. Market clearing prices and quantities of major crop commodities, biomass crops, and transportation fuels are determined by the model in a simultaneous way. We consider a representative consumer that demands crop and livestock products and vehicle kilometers travelled (VKT). The behavior of the consumer is characterized by linear demand functions for each of these commodities and for VKT. Demand for VKT is a function of a weighted average of alternative fuel prices. The primary crop commodities are consumed either domestically or traded with the rest of the world

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[5] Advanced biofuels specifically exclude ethanol derived from corn starch; they include other types of ethanol derived from renewable biomass, including ethanol made from cellulose, hemicellulose, lignin, sugar or any starch other than corn starch, as long as it achieves a lifecycle GHG emission displacement of 50%, compared to the gasoline or diesel fuel it displaces. Sugarcane ethanol imported from Brazil qualifies as an advanced biofuel. Cellulosic biofuel is renewable fuel, not necessarily ethanol, derived from any cellulose, hemicellulose, or lignin each of which must originate from renewable biomass. It must also achieve a lifecycle GHG emission reduction of at least 60%, compared to the gasoline or diesel fuel it displaces. Lifecycle GHG emissions include direct emissions from all stages of fuel and feedstock production, delivery of feedstock to refinery, conversion from biomass to biofuels and distribution of it and the use of finished fuel by the ultimate consumers. It also includes indirect emissions from land use changes (EISA, 2007).

(exported or imported), processed to consumer products (such as oil and fuel), or directly fed to various animal categories. Likewise, livestock commodities are either consumed domestically or traded with the rest of the world. Like domestic commodity demand functions, export demand functions and import supply functions for tradable commodities are also specified assuming linear price-quantity relationships. Both domestic and export demand functions are shifted exogenously over time due to increased demand resulting from population and income growth. We solve for equilibrium prices and quantities in each of the markets by maximizing the sum of producers' and consumers' surpluses subject to material balance constraints equating supply and demand of individual commodities, regional resource use and availability constraints, and technological constraints underlying crop production. With the assumption of linear functional forms, this approach leads to a quadratic programming model that determines the optimal land allocation for production of food/feed commodities and energy crops in such a way that the optimum supplies by producers are consistent with the market prices that consumers would be willing to pay for fuel, biofuel, food/feed and livestock commodities. Takayama and Judge (1971) and McCarl and Spreen (1980) explain why this approach establishes simultaneous market equilibria.

Given that the US biofuels policies are stated for the period 2007-2022, we consider a multi-period planning horizon and find the market equilibrium prices and supply/demand quantities for each year of the above period considering year-to-year dynamic relationships between resource availability and planting decisions for traditional row crops, dedicated energy crops, and livestock activities all of which compete for agricultural land. The crops and livestock sectors are linked to each other through two factors. First, crop production provides feed (grains and byproducts of processing corn and oilseeds for ethanol and oil, respectively) to the livestock sector. Second, the two agricultural production activities compete for land because grazing land needed by dairy and beef cattle can also be used for crop production, particularly feedstock for biofuels production.

The fuel sector includes a downward sloping demand curves for VKT with three types of vehicles that use gasoline or its substitutes as fuel; conventional vehicles (CVs), flex fuel vehicles (FFVs) and gasoline-hybrid vehicles (HVs). It also includes a downward sloping demand curve for VKT by all on-road transport vehicles, heavy duty trucks and light duty vehicles that use diesel and diesel substitutes as fuel. A demand curve for VKT using electric vehicles (EVs) is also included but the amount of VKT with them is fixed exogenously. The demand for VKT by each of the other types of vehicles endogenously generate demands for liquid fossil fuels and biofuels given the energy content of alternative fuels, the fuel economy of each type of vehicle and limits on the extent to which the two can be blended in particular types of vehicles.

We include upward sloping supply curves for domestic gasoline production and for gasoline supply from the rest of the world (ROW). The excess supply of gasoline to the U.S. at various prices is determined by specifying a demand curve for it by the ROW. In the case of diesel we assume that it is produced domestically only and include an upward sloping supply curve to represent its marginal costs of production and price responsiveness.

The biofuel sector includes several first and second generation biofuels; the former include domestically produced corn ethanol and soy diesel as well as imported sugarcane ethanol. Second generation biofuels are produced from cellulosic biomass that can be obtained from crop or forest residues and from dedicated energy crops, miscanthus and switchgrass. Biomass from these feedstocks can be converted to either lignocellulosic ethanol (LE) that can be blended with gasoline or to produce biomass to liquids (BTL) using the Fischer-Tropsch process that can be blended with diesel.

BEPAM has a fine spatial disaggregation compared to other models analyzing the economic implications of biofuel production (see review in Chen, et al., 2010). As the spatial decision units, the model uses crop reporting districts (CRD) (each being a cluster of about 10 counties on average) in 41 contiguous U.S. states in five major regions. We assume that each CRD is represented by an aggregate producer who makes planting decisions to maximize total net returns under the resource availability and production technology constraints (crop rotation possibilities, dynamics of perennial crops, etc.) specified for that CRD. Both crop and livestock production activities are represented using constant input-output relationships (Leontief production functions) and constant cost coefficients. We estimate and use region-specific cropland supply functions to allow cropland expansion through the conversion of marginal lands which are not currently being used for crop production. The cropland supply response is based on econometrically estimated elasticities that relate cropland acreage to a composite crop price index (see Huang and Khanna, 2010).

The perennial nature of energy crops switchgrass and miscanthus requires a special treatment of these crops since instead of annual net returns farmers would consider a continued income stream over years, which depends on annual variable costs and yields and fixed startup costs of establishing these crops.

This is fundamentally different from net return consideration when making planting decisions for annual crops. Furthermore, since we consider a finite horizon in the model, the economic value of a standing biomass crop beyond the terminal year of the planning horizon (i.e. the present value of net returns after the terminal year until the productive life of the energy crop) needs to be taken into account when making production decisions. Otherwise, returns obtained over a few years may not cover the production costs (including fixed and variable costs) and therefore for the last few years of the planning horizon the model would not produce a solution that includes perennial crops in it. To address this issue, we use a 10-year rolling horizon where for each year of the 2007-2022 period the model determines crop production decisions and the corresponding dynamic market equilibrium for the next 10 years starting with the year under consideration. After each run, we take the production decisions and the associated market equilibrium for the first year of the 10-year period, and use this information to update some of the key model parameters, such as the overall crop price index and expected prices, land supplies in each region, and crop yields for major crops. We then run the model again for another 10-year period starting with the subsequent year and thus have a rolling horizon.

The endogenous variables determined by the model include: (1) gasoline, biofuel and commodity prices; (2) production, consumption, export and import quantities of commodities, gasoline and biofuels; (3) land allocations and production practices for row crops and perennial crops (namely, rotation, tillage and irrigation options) for each year of the 2017-2022 planning horizon and for each region. The model also calculates ex-post economic welfare measures including producers' and consumers' surpluses, government revenues/costs and net welfare effects, and environmental impact indicators including GHG emissions.

We consider two types of land, existing cropland and idle land/pasture land that can be used for conventional crops and bioenergy crops. A change in crop prices triggers changes at the extensive margin and leads to a shift in acreage between cropland and idle land/pasture land. The remaining idle land/pasture land can be used for bioenergy crops, but this occurs at a conversion cost. In the absence of an empirically based estimate of the ease of conversion of marginal land for perennial grass production, for each CRD we assume a specific conversion cost that is equal to the returns from the land by producing the least profitable annual crop in that CRD. This ensures consistency with the intuitive decision rule for land conversion, namely in a land market equilibrium all lands with non-negative excess profits from annual crop production vis-à-vis bioenergy feedstock production, would be utilized for annual crop production. As annual crop prices increase, the cost of conversion increases also; the “supply curve” for idle marginal land is, therefore, upward sloping.

Using the results from the econometric model and simulation model, we compute the government expenditure on CRP in the future 10 years based on updated soil rental rate. If the government wants to keep the current scale of the CRP land, their total expenditure on CRP program will increase by 55.37% in the following ten years. That is a huge burden to the government, especially under the condition of budget deficit.

If the soil rental rate does not keep pace with the increase in corn prices, we divide our analysis into two different land quality scenarios. We use Figure 3 to illustrate our result in scenario one and Figure 4 to demonstrate our results from scenario two. In the first scenario the soil quality improves a lot through the CRP program and the expiring CRP land exhibits medium soil quality, which means the productivity of the soil is comparable to the medium cropland. Our results suggest that 28.28% of the CRP land will stay in the program. In addition, 36.87% of the expiring CRP land will be converted into corn production, 18.70% be converted to wheat production, 11.35% of the expiring CRP land will switch to miscanthus production, and 4.79% will be converted into soybean production.

Under the second scenario, the productivity of the expiring CRP land is only two thirds of the normal cropland. 47.15% of the expiring CRP land will be kept in the program with the current soil rental rate. 25.98% of the land will be converted into miscanthus production, 17.63% will be switched to corn production, 6.52% into wheat production and the remaining 2.71% will be put into soybean production. The results from the two scenarios differ mainly because the bioenergy crops such as miscanthus is less demanding in terms of land quality. The bioenergy crops can be grown in marginal land and achieve almost the same yield as cropland. In contrast, traditional crops are much more sensitive to land quality.

We also demonstrate the regional distribution of land uses in Table 4. The results show different land use patterns in different regions[6]. In the Atlantic region, over half of the expiring CRP land will be converted into corn production and one thirds of the expiring land will be converted into miscanthus production under scenario one. Under scenario two, the majority of the land will switch into miscanthus production and the remaining land will stay in the CRP program. In the Midwest region, the majority of the expiring CRP land will be converted into corn production under scenario one. Only one thirds of the land will be converted into corn production, one thirds converted into miscanthus production, the land

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[6] We divide U.S. into five regions: Atlantic, Midwest, Plains, South and Western.

remaining in the CRP program increased by 10% in scenario two compared with scenario one. In the Plains region, the major land uses under scenario one is CRP (21%) , Corn (42%) and Miscanthus (16%), while the land uses change into CRP (44%), Miscanthus(22%) and Corn(26%) under scenario two. In the South region, the main land uses are composed of Miscanthus (57%), Corn (14%) and Soybean (20%) in scenario one. It changes into Miscanthus (75%), CRP (17%) and Corn (7%) under scenario two. In the Western region, the expiring land are used to produce wheat (33%) and stay in the CRP (67%) program under scenario one. Under scenario two, only a small proportion of the land will be dropped out of the CRP program, the majority of the expiring land will continue to stay in the program.

We can see that under both scenarios, a large proportion of the land will be dropped out of the CRP program if the soil rental rate is not competitive to the crop price. How to achieve a balance between increasing government budget and losing CRP acres with the current budget? One possibility is to modify the current CRP rule and allow energy crops to be grown on the expiring CRP land. We will analyze the policy part in the following section.

4. Policy Considerations

Since the overarching goal of the Conservation Reserve Program (CRP) is to protect environmentally sensitive land through improvement in the quality of water, prevent soil erosion and enhance wildlife habitat, we need to take environment aspect into consideration when we evaluate our policy.

We compare the environmental effects of crop planting and bioenergy crop planting and find that the bioenergy crop is superior to traditional crops in terms of environmental service. If the government runs a constrained CRP budget, the next best choice is to allow bioenergy crops to be produced on CRP land in terms of environmental protection.

One key feature of the CRP program is to minimize soil erosion. Compared with traditional row crops, perennial grasses provide year-round soil cover which limits soil erosion even with continued biomass harvest (Kort et al. 1998). They also find that perennial grasses improves soil productivity by increasing soil organic matter, improving soil structure and by increasing soil water and nutrient holding capacity because it involves less extensive tillage than row crops.

Bioenergy crops are perennial crops with a lifespan of 10-20 years. It requires less fertilizer and less pesticide than annual crops. The nitrogen runoff is a lesser problem for bioenergy crops than annual crops. The environmental benefits of bioenergy crops also include the reduction of GHG emission compared with traditional crops.

There are some studies in this line of research. Most of the current research concentrates on the effect of bird species of bioenergy crops. For example, Robertson et al. (2010) find that the bird species richness and density increased with patch size in prairie and switchgrass but not in corn and that perennial grass can provide a wildlife habitat for bird than traditional corn-ethanol crops.

In addition to the RFS which set a mandate for the ethanol production, the Food, Conservation, and Energy Act (FCEA) 2008 provides various types of financial support to grow and harvest renewable biomass with the purpose of accelerating the production of advanced biofuels and reduce their costs to fuel blenders and consumers of mandated quantities. The FCEA 2008 seeks to directly encourage the production of biomass for advanced biofuels. A key source of renewable biomass is expected to be dedicated energy crops, typically long-lived perennials that involve significant upfront fixed costs of establishment as well as lags between establishment and first harvest times during which landowners have to forego potential income from other uses of that land. The lag between planting and harvesting of dedicated energy crops require coordination between producers, bio-refineries and blenders and forward planning to plant the energy crops before they are needed. Landowners, on the other hand, have incentives to delay planting these crops; uncertainty about biomass prices over the life-time of these crops together with high upfront costs creates an incentive for producers to wait until the expected returns are high enough to provide an option value premium (Song, et al., 2009). The decision to invest in these crops also suffers from the “chicken- and-egg” dilemma, since producers are likely to delay investment in these crops until there is a biomass conversion facility that will purchase the biomass, while investment in conversion facilities is unlikely in the absence of an assured supply of feedstock.

The FCEA 2008 seeks to overcome these barriers and accelerate production of new feedstocks by authorizing the Biomass Crop Assistance Program (BCAP) which provides establishment and annual (E&A) payments to producers of energy crops. These include cost-share payments for establishing dedicated energy crops in designated project areas and annual payments to cover the foregone income from alternative uses of the land. BCAP also provides payments to cover the costs of collecting, harvesting, storing and transporting (CHST payments) eligible material to qualified biomass conversion facilities for production of heat, power or advanced biofuels.

If perennial bioenergy crops are allowed to plant and harvest in the CRP land, the environmental function can be partially preserved. Moreover, the government expenditure on the CRP program will be reduced. According to our result shown in Table 5, the total CRP spending over the period of 2007-2020 will be dropped to 4.7 billion dollars if bioenergy crops are allowed to grow on expiring CRP acres under scenario one. Since the bioenergy crops generate their own profits, the government only needs to pay the difference in profit between bioenergy crops and row crops if the row crops are more profitable for farmers. The Plains and Midwest region have the highest CRP payment because row crops are relatively more profitable than energy crops compared with other regions. The Western region also requires a large amount of CRP payment because that area is not suitable for bioenergy crop production. Under the second scenario, the CRP payment would drop to 3.2 billion dollars since more acres switch to bioenergy crops instead of row crops.

The government can also use the BCAP program to assist farmers to establish and harvest bioenergy crops at the beginning period of time. The combination of these two policies will achieve both economic benefit and environmental benefit.

4. Conclusions

In order to keep the current scale of CRP program, the government expenditure will increase dramatically with the booming of biofuel industry. It is predicted that the spending will go up 50% compared to 2010 level.

Another conclusion is that if the soil rental rate paid to landowners with expiring CRP land does not catch up with the increase in crop prices, 64.94% will opt out of the CRP program under medium land quality scenario. Under low land quality scenario, we predict that 45.09% of the expiring CRP land will be dropped out of the program and used for crop production.

One possibility to tackle the problem is to allow bioenergy crops be planted and harvested in the CRP land and compensate the farmers only the remaining part of the expenditure. This is environmentally friendly and economically feasible. In this way, the conflict between the sharp increase in CRP spending and environmental service can be partly reconciled. If the government runs constrained CRP budget, switching CRP land to bioenergy crops is a better choice than to traditional crops in terms of environmental function.

Another policy recommendation is that the CRP program be combined with the BCAP program to provide initial establishment sharing for the framers who would like to grow energy crops in the CRP land. The target of the CRP program is mainly to protect land from erosion and provide wildlife habitat, while the main target of the BCAP policy is to help farmers plant bioenergy crops. The targets of the two policies can be achieved at the same time.

Appendix

Table 1 Summary Statistics of Major Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Rental Rate ($/Acre)	14400	88.88657	46.83706	7	488.01
Erosion Index	14400	4.826958	8.460649	0	326
Corn Yield (Bushel/Acre)	16008	123.5798	36.21634	0	246
Soybean Yield (Bushel/Acre)	13312	37.49052	9.683151	5	64.4
Corn Price ($/Bushel)	18431	2.607505	.7496069	1.53	5.3
Soybean Price($/Bushel)	17439	6.299998	1.698366	4.05	11.9
Summer Temperature	17878	22.94884	3.097099	2.439091	32.15691
Summer Precipitation	17878	93.93138	36.62584	.0012333	301.9964
Cash Rent ($/Acre)	15451	71.1319	324.4878	0	40,000

Table 2 Regression Result from the Fixed Effect Model

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Rental Rate	Rental Rate	Rental Rate	Rental Rate	Rental Rate	Rental Rate
Cash Rent	0.0954***					
	(0.0191)					
CRP Acres	-0.000576***					
	(8.55e-05)					
Erosion	-0.0558*					
	(0.0301)					
Corn Yield	0.0126					
	(0.00826)					
Corn Price	13.49***					
	(0.393)					
L.Cash Rent		0.0768***		0.103***	0.0759***	0.0175
		(0.0133)		(0.0175)	(0.0146)	(0.0156)
L.CRP Acres		0.000588***		0.000476***	0.000307*	-0.000163
		(0.000110)		(0.000157)	(0.000185)	(0.000142)
L.Erosion		0.350***		0.140*	-0.0841	0.0591
		(0.0607)		(0.0778)	(0.0552)	(0.0658)
L.Corn Yield		0.138***		0.142***	0.112***	0.0235
		(0.0105)		(0.0130)	(0.0176)	(0.0161)
L.Corn Price		19.49***		18.25***	25.98***	36.37***
		(0.524)		(0.532)	(1.200)	(1.673)
L2. Cash Rent			-0.00650	-0.0652***	-0.0683***	-0.0360*
			(0.0148)	(0.0197)	(0.0230)	(0.0213)
L2. CRP Acres			0.00111***	0.000697***	0.000232	8.17e-05
			(0.000147)	(0.000196)	(0.000250)	(0.000234)
L2. Erosion			-0.483***	-0.306***	-0.557***	-0.0395
			(0.0572)	(0.0571)	(0.0865)	(0.0594)
L2. Corn Yield			0.127***	0.118***	0.0625***	0.0557***
			(0.0119)	(0.0124)	(0.0182)	(0.0162)

L2. Corn Price			19.25***	2.975***	-7.560***	16.58***
			(0.559)	(0.608)	(1.456)	(1.892)
L3.Cash Rent					0.0153	-0.00108
					(0.0226)	(0.0183)
L3.CRP Acres					-0.000329*	-0.000355*
					(0.000194)	(0.000181)
L3.Erosion					0.0867	0.110*
					(0.0799)	(0.0636)
L3.Corn Yield					0.0476***	0.0155
					(0.0179)	(0.0157)
L3.Corn Price					19.33***	19.46***
					(2.310)	(2.961)
Sum Temp						7.001***
						(0.319)
Sum Preci						0.0516***
						(0.0125)
Constant	50.67***	31.59***	42.81***	16.72***	-13.04**	-234.7***
	(1.768)	(2.270)	(2.612)	(3.908)	(6.187)	(10.89)
Observations	9,820	7,446	7,159	5,468	4,435	3,396
R-squared	0.323	0.441	0.353	0.518	0.603	0.526
Number of fips	1,510	1,205	1,276	979	883	857

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3 Regression Result from Arellano-Bond GMM Model

VARIABLES	(1) Rental Rate	(2) Rental Rate	(3) Rental Rate	(4) Rental Rate	(5) Rental Rate
L.Rental Rate	0.195***	-0.0237	0.542***	-0.110**	-0.306***
	(0.0510)	(0.0512)	(0.0492)	(0.0544)	(0.0513)
L2.RentalRate	0.0174	-0.268***	0.259***	-0.310***	-0.181***
	(0.0403)	(0.0510)	(0.0546)	(0.0575)	(0.0484)
Cash Rent	0.286***				
	(0.0852)				
CRP Acres	-0.00170***				
	(0.000354)				
Erosion	0.113				
	(0.0729)				
Corn Yield	-0.0124				
	(0.0167)				
Corn Price	9.419***				
	(0.922)				
L.Cash Rent		0.0647**		0.0660***	0.0503**
		(0.0281)		(0.0233)	(0.0202)
L.CRP Acres		0.000948***		0.00129***	0.000251
		(0.000260)		(0.000383)	(0.000198)
L.Erosion		0.779***		0.265*	0.321
		(0.163)		(0.139)	(0.201)
L.Corn Yield		0.184***		0.167***	0.0676***
		(0.0188)		(0.0196)	(0.0246)
L.Corn Price		19.06***		23.20***	33.26***
		(0.995)		(1.306)	(1.852)
L2.Cash Rent			-0.0909**	-0.109***	-0.106***
			(0.0438)	(0.0420)	(0.0396)
L2.Erosion			-0.663***	-0.170*	-0.479**
			(0.138)	(0.0954)	(0.211)
L2.Corn Yield			0.102***	0.106***	0.0450*
			(0.0269)	(0.0217)	(0.0235)
L2.Corn Price			15.18***	-8.502***	-8.675***

			(1.555)	(1.765)	(2.035)
L2.CRP Acres				0.00241***	0.000398
				(0.000550)	(0.000340)
L3.Cash Rent					0.0302
					(0.0318)
L3.CRP Acres					0.000166
					(0.000242)
L3.Erosion					0.431***
					(0.116)
L3.Corn Yield					0.0350
					(0.0267)
L3.Corn Price					29.98***
					(4.489)
Constant	33.01***	48.90***	-13.66*	66.54***	4.363
	(7.844)	(8.774)	(8.279)	(11.91)	(15.91)
pseudo R-squared	0.67	0.007	0.78	0.06	0.07
Obs.	4,877	4,457	3,997	3,973	3,100
Number of fips	881	878	875	868	777

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

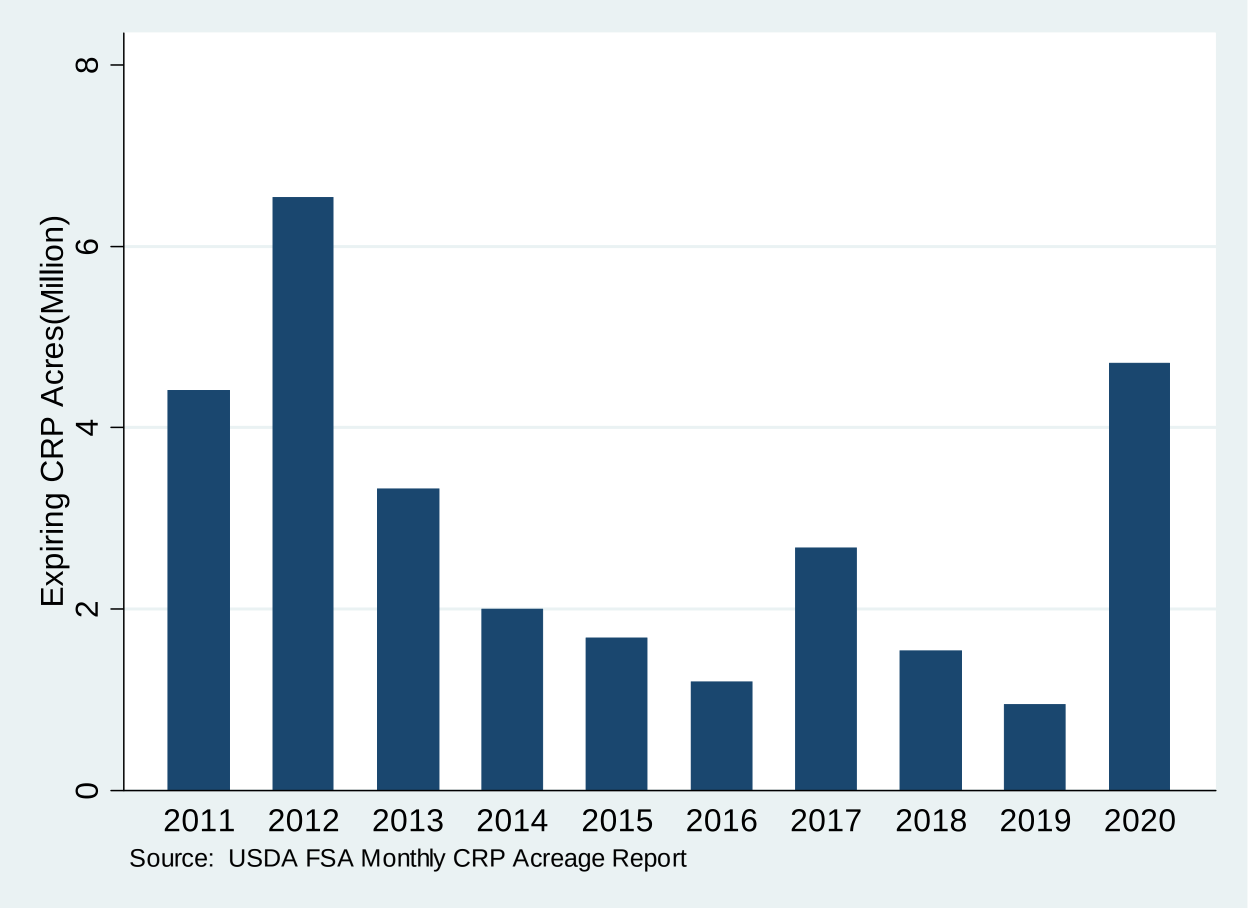
Table 4 The distribution of land uses after the CRP contract expires.

Land Area (Acres)	Atlantic	Midwest	Plains	South	Western
Land Quality=Low					
CRP	9,529.90	23,763.20	2,074,904.00	50,027.30	5,917,769.00
Corn	513,944.20	5,544,577.00	4,096,377.00	310,411.60	61,392.40
Miscanthus	286,423.70	157,705.20	1,579,164.00	1,218,081.00	0
Soybean	1,839.50	435,760.10	495,656.20	434,282.80	0
Switchgrass	944.50	0	0	0	0
Wheat	80,593.70	720,026.70	1,490,578.00	136,548.50	2,912,160.00
Land Quality=Low					
CRP	121,427.80	674,494.60	4,261,758.00	368,215.90	8,036,627.00
Corn	40,148.40	2,694,434.00	2,145,862.00	154,022.00	0
Miscanthus	727,032.30	2,561,865.00	2,521,729.00	1,608,362.00	0
Soybean	0	351,417.90	403,894.50	18,751.30	0
Switchgrass	944.50	0	0	0	0
Wheat	3,722.50	599,621.10	403,436.00	0	854,695.30

Table 5 New CRP payment assuming bioenergy crops are allowed in the CRP land

Region	Land Area needs CRP payment (in Million Acres)	CRP Spending (in Million Dollars)
Land Quality=Medium		
Atlantic	0.606852	51.75253
Midwest	6.724127	1300.138
Plains	8.296342	1890.681
South	0.977601	97.86331
Western	8.891322	1355.059
Total	25.49624	4695.494
Land Quality=Low		
Atlantic	0.169611	11.91218
Midwest	4.537195	584.3745
Plains	7.503515	1290.745
South	0.608674	52.50423
Western	8.891322	1239.135
Total	21.71032	3178.671

Figure 1 Expiring CRP Acres in 2011-2020



Source: USDA FSA Monthly CRP Acreage Report

Figure 2 Predicted CRP spending assuming CRP acres are fixed at 2010 amount

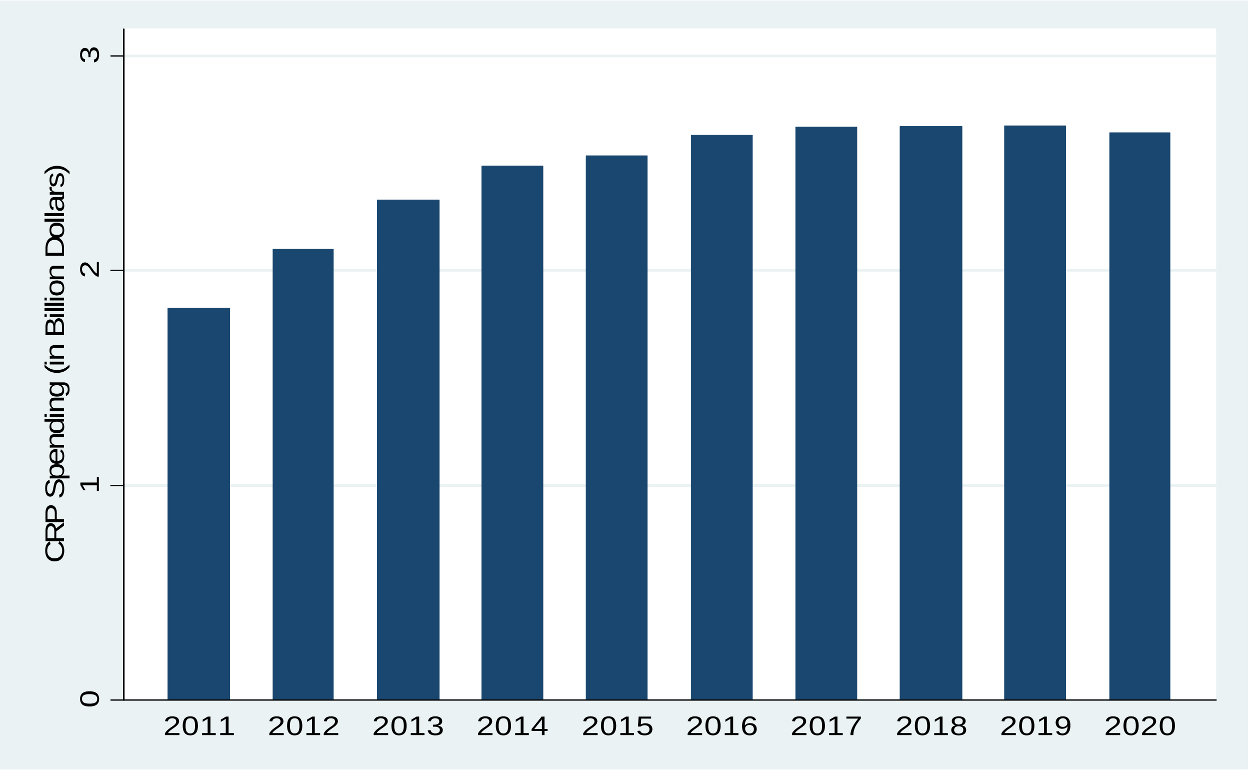


Figure 3 Distribution of Land Use after CRP contract expires (land quality=medium).

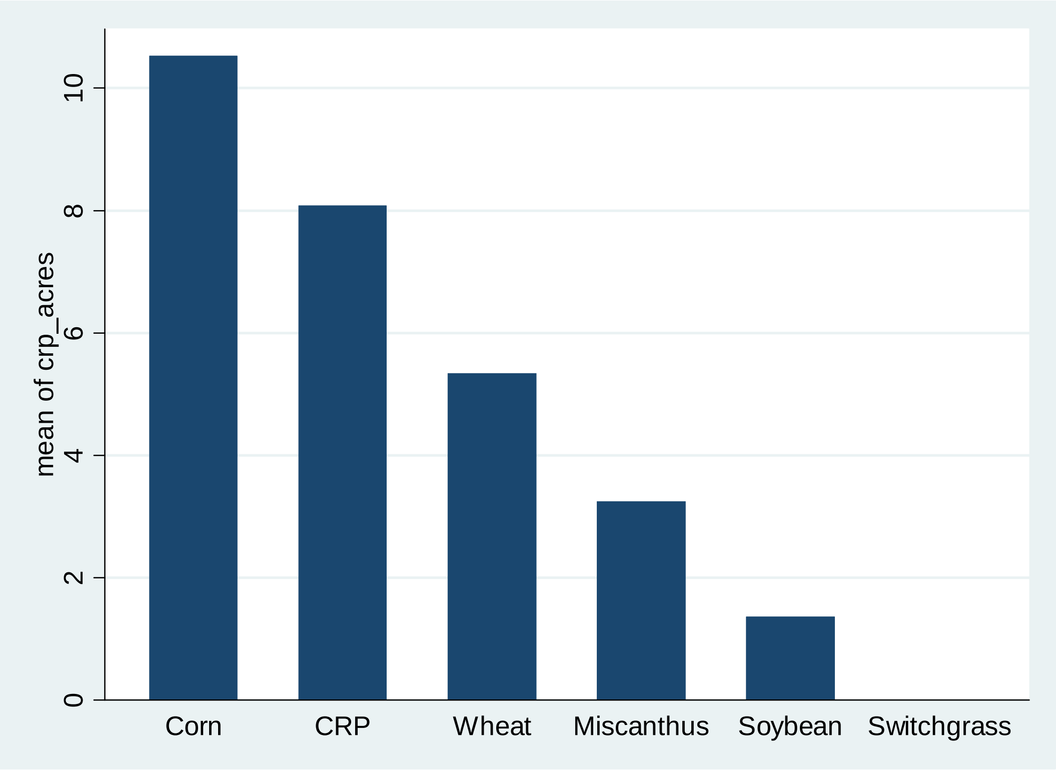
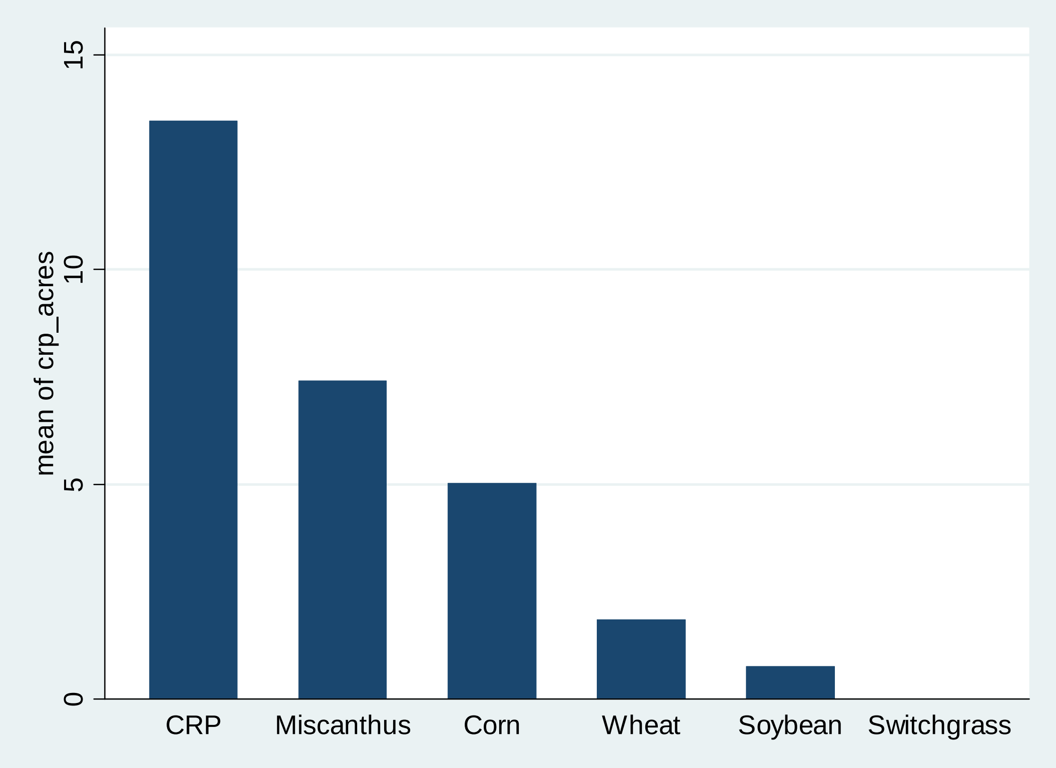


Figure 4 Distribution of Land Use after CRP contract expires (land quality=low).



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