Greenhouse Gas Mitigation from the Conservation Reserve Program:

The Contribution of Post-Contract Land Use Change

by

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Introduction

In 2010, agriculture and forestry contributed around 8 percent (531.6 Tg CO_2e) of total annual U.S. gross CO_2e emissions (including on-farm energy use), while net additions to carbon soil or biomass sinks in agriculture and forestry –through land use change and land management activities that sequester carbon in soils or biomass – offset 14 percent (940.3 Tg CO_2e) of U.S. gross emissions annually (U.S. EPA 2012). Various best management practices on crop and pasture lands, as well as land use change from crop to pasture or forest uses, provide an opportunity to increase carbon sequestration and/or to reduce GHG emissions in the agriculture sector. A number of current USDA conservation programs provide financial assistance to agricultural (and forestry) land owners or operators to voluntarily retire crop land from production or adopt environmentally-friendly practices.[2]

Among the USDA conservation programs, the Conservation Reserve Program (CRP) is by far the largest in terms of hectares enrolled and budget. CRP provides annual rental payments to farmers who voluntarily retire environmentally-sensitive cropland from production over a 10-15 year contract period, as well as cost-share assistance for establishing approved grassland or tree cover on the enrolled land. In 2008, 14 million hectares were enrolled in the CRP at an approximate annual rental cost of $1.8 billion (averaging $125.4/ha), with 88 percent planted to grasses, and 10.5 percent planted to trees, and the small residual dedicated to wetland restoration (USDA–FSA 2008). The 2008 Farm Bill reduced maximum enrollment to about 13 million hectares beginning October 2009.

[2] With projected total net outlays of $24 billion, conservation programs collectively comprised about 8 percent of Farm Bill outlays over 2008-2012 (Monke and Johnson 2010). Most of USDA funding for federal conservation, commodity and farm support policies, as well as other rural, food, and farm-related provisions, derives from multi-year, omnibus laws “farm bills”, which must be renewed every 5 years. The 2008 Farm Bill is formally known as the Food, Conservation, and Energy Act of 2008.

When CRP was originally established in the Food Security Act of 1985, the stated purpose was to assist owners and operators of agricultural land in conserving and improving soil, water and wildlife resources; at the same time, an implicit goal was to incentivize land set-asides in a time of low agricultural commodity prices. Though greenhouse gas (GHG) mitigation only recently has been included among the six ranking criteria used to prioritize lands for enrollment, conversion of croplands to grasses or trees are potent sources of GHG mitigation. During the period 1997-2008, CRP grasslands increased carbon sequestration annually by an estimated 16 Tg of CO_2e (USDA OCE 2011).

Since discussions about national cap and trade legislation stalled in the U.S. Senate in 2010, existing agricultural conservation policies provide one of the few existing tools available to policymakers to incentivize increased mitigation in the agricultural sector. CRP appears to be an attractive program to incentivize additional GHG mitigation; however for voluntary conservation programs, questions arise regarding the extent of additionality, leakage, and carbon reversals, which may reduce their apparent contributions. (For more information about these terms, see Box *Challenges to Environmental Integrity in Voluntary GHG Mitigation Programs* at back.) The program relies on term contracts – and existing program carbon sequestration estimates are based solely on GHG implications of currently enrolled lands and ignore the potential lack of permanence of carbon sequestration following CRP contract termination. Nonetheless, CRP could potentially provide a greater contribution to the extent that post-program activities do not release the sequestered carbon.

As a first step, in this paper we provide - to the best of our knowledge - the first estimates in the literature of post-CRP carbon retention/releases arising from observed behavior of subsequent land use decisions. This paper focuses on land enrolled in grasses in the CRP, which represents the dominant share of CRP lands. We plan to consider CRP forest contracts in follow-on work. The closest prior analysis is a study conducted by Roberts and Lubowski (2007), which estimates cropland conversion rates following exit from CRP in the period 1993-1997 using data from the National Resource Inventory (NRI). Employing NRI data through 2007, we examine land use changes spanning a longer time period, include all land for which the contract expired – including land that immediately re-enrolled in CRP (not just those that exited), and use a more disaggregated set of post-CRP land use categories designed to take into account differential carbon implications. This allows us to follow land use choices after the expiration of the CRP contract for the Roberts/Lubowski cohort of lands with CRP contracts expiring between 1993 and 1997 for 15 years after rather than 5, and perhaps more significantly, to observe post-contract behavior over periods of high and low agricultural prices. Using a carbon accounting methodology based on IPCC GHG inventory parameters, we calculate carbon sequestration and carbon release implications of participation in CRP and the following years. This research sets the stage for more formal modeling of post-CRP contract decisions: predicting land use changes and subsequent GHG releases that may occur under various assumptions about program size, commodity prices, and other factors that affect land use decisions.

The paper is organized as follows. In the next section, we present the data, methods and findings regarding the land use transitions for grass land enrolled in CRP. In the following section, we discuss current estimates of GHG accounting for CRP. We then present the data, methods and findings regarding our analysis covering our carbon accounting for the periods during CRP and following conclusion of the first CRP contract. The final section provides a discussion of the results, including various caveats, and outlines next steps in the analysis including the inclusion of forest CRP lands.

CRP land use and land use transitions

Following an initial period of implementing the CRP (1986-1990), land enrolled in the program has fluctuated between 12.1 – 14.9 million hectares through 2008. (See figure 1). Most contracts are for 10 year periods. At the time of contract expiration, the land owner may choose to seek re-enrollment in the program or to apply the land to another use. Re-enrollment is not guaranteed: the program must also accept the bid from the land owner.

Economics of land use decision-making has been well-developed in the literature (eg, see Lubowski, Plantinga and Stavins 2008) and we do not repeat formal derivations here. Following CRP contract expiration, the choice of land use will depend upon the relative economic returns of the alternative uses – which include crop, hay, pasture, range, forest, re-enrollment in CRP (though re-enrollment is not automatic), or conversion to developed land. A primary factor affecting the attractiveness of returning land to cropland after a period in the CRP is the relative prices of agricultural commodities.

Agricultural prices were low when the program was initiated but have varied over the years of the program. Though agricultural prices have followed a long-term downward trend over the 20^{th} century, they spiked in the late 1970s and early 1980s. Since then, the amplitude of the variations from the downward trend has declined. Troughs have included 1987, 1992, and 2001, after which the combination of increased global demand for biofuel feedstocks and various weather crises has led to a generally increasing trend in prices; in 2011, a real price index for global agricultural crops was higher than observed since 1982.

As with most of the research studying patterns of land use change (including participation in CRP) in the U.S., we employ the panel data in USDA's National Resources Inventory (NRI). NRI is a survey of all non-Federal land that was conducted every 5 years between 1982 and 2002, and then annually (on a subset of fields). Because the same fields are sampled over time, land use transition matrices can be constructed to identify land use decisions following the conclusion of a CRP contract.

In prior research, Roberts and Lubowski (2007, p. 526) explored land use transitions following exit from CRP, but at the time NRI data were only available through 1997. For lands in CRP grass cover in 1992 and out of CRP in 1997, they estimated that 65.8 % had converted to cropland by 1997. The other exiting land was in pasture (23.5%) or range (8.8%) in 1997, with a small residual in forest, urban or "other". In their cropland category, Roberts and Lubowski include hay land; however, conversion to hay is associated with an increase in carbon sequestration relative to CRP land, because hay involves more inputs but no tillage. The scale of additional carbon sequestration that occurs when CRP land is converted to hay is comparable to the scale associated with conversion to pasture, and more than the additional sequestration for range (which involves less intensive input use). Also Roberts and Lubowski do not include in their population the CRP lands with a terminating contract that were subsequently re-enrolled in CRP.

We report land use transitions following the end of a CRP contract for 3 cohorts of CRP participants: lands for which their CRP contract in 1992 ended before 1997, lands for which their CRP contract in 1997 ended before 2002, and lands for which their CRP contract in 1997 ended before 2002. The number of observations of land use declines from 3 to 1 for the respective cohorts.

Given that most CRP contracts are for 10 years, and that a small number of hectares entered in the early years of 1986-1989, only a small share of current participants would have contracts expire by 1997. Of 12.9 million hectares in CRP grass contracts as of 1992, 1.3 million hectares had their 1992 CRP contract expire by 1997 (Table 1). In our (1992 CRP) cohort, we include land that was re-enrolled in the CRP between 1992 and 1997, and we distinguish hay from cropland. With this formulation, we estimate 48 % of the land converted to cropland by 1997, and about 57% had ever-converted to cropland through 2007.[3] The next largest share of exiting land went in 1997 to pasture and range (33%) followed by hay and other setaside (14%). Of the remaining lands, about .2 million hectares were re-enrolled in the CRP, though some of this land was cropped before re-enrollment (.06 million hectares).

The pattern is quite different from the cohort of 12.3 million hectares in CRP grass contracts as of 1997. By 2002, 11.7 million hectares had their contract expire (Table 2). However agricultural prices had fallen between 1997 and 2002; consequently, for this cohort a much smaller proportion, 18%, converted to cropland by 2002, and a total of 21% had ever-converted to cropland through 2007 (Table 4). In contrast, 63% re-enrolled in CRP. About 1/5 of the CRP re-enrollments (13% of cohort) experienced a subsequent contract change during 2002-2007, though they remained enrolled in the program. This reflects the policy adjustments to avoid wide scale cropland conversions at the end of the decade.

During the 2007-2010 period, a significant percentage of the 11.38 million hectares of enrolled land was in contracts set to expire at a time of relatively high commodity prices, as noted earlier. USDA offered current contract holders priority to re-enroll with 10-15 year contracts or to extend their contracts for 2-5 years. As a result, USDA was able to re-enroll or extend 82 percent of expiring contract land. Though the effect is somewhat visible in the 1997 CRP cohort (table 2), it is most clear in the cohort with CRP grass contracts in 2002 that expired or otherwise ended by 2007, where 89 % of CRP hectares planted to grasses were re-enrolled (table 3). A very limited amount of land in CRP grass contracts as of 2002, 3%, converted to cropland within 5 years of contract expiration.

[3] We calculate that 66% of grass contracts exiting CRP after 1992 (ie, not re-enrolling) converted to either cropland or hay by 1997, consistent with Roberts and Lubowski (2007).

Carbon accounting for CRP

For the period 1997-2008, USDA GHG Inventory (USDA OCE 2011, p.61) estimated that that CRP grass lands increased carbon sequestration by an average of 16 Tg of CO_2e per year using a GHG accounting methodology based on a combination of Tier 2 and Tier 3 methods, including the DayCent model. Because the CRP has been operating at its current scale since 1990, the average annual sequestration rates for grasslands have declined following the first decade of the program due to the carbon stock equilibration process (see box below) (USDA 2011).

These estimates are based solely on GHG implications of currently enrolled lands, and do not take into account questions regarding potential lack of additionality, leakage and carbon reversals following exit from the CRP (see Box for a discussion of these terms).[8] Lubowski et al. (2008) estimate that 15 percent of CRP land enrolled through 1997 would have been converted from crops to pasture, range, or forests even in the absence of CRP, due to economic considerations, and consequently did not contribute additional mitigation. Estimates of leakage have been inconclusive: estimates of the share of cropland enrolled in the CRP that was offset by land conversion from another use to cropland elsewhere range from 20 percent (Wu 2000, 2005) to 53 percent (Leathers and Harrington 2000), depending on the estimation method and the geographic and temporal scope of the analysis. However, Roberts and Bucholtz (2006) raise questions about the effectiveness of both studies in statistically identifying land leakage.[9]

When CRP land is returned to cropping after the contract expires, the stock of carbon sequestered in the soil and in forest biomass during program participation in prior periods generally will be released; for accurate accounting of program GHG impacts, these carbon releases should be deducted from the carbon gains from current period enrollments.[10]

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[8] The GHG accounting for the sector reported in the Inventory, however, does reflect the performance sector-wide and overtime; consequently it picks up leakage and carbon reversals, but does not attribute them to post-CRP exit behavior.

[9] We also note that, to estimate the GHG emissions that results from land leakage requires an additional step – since the land entering and leaving production may sequester carbon and emit nitrous oxide from fertilizers at different rates.

[10] In contrast, the emission reductions in prior periods due to lower fertilizer use when land is converted to grass are not subject to reversals; consequently, when the land is returned to cropping, the credits for reduced N_2O stop, but no deductions against past credits are needed.

Data and methods

The Intergovernmental Panel on Climate Change (IPCC) developed an approach, coefficients, and information to estimate soil carbon (C) stock changes based on land use and management activities that could be applied using varying levels of detailed land use and management data (IPCC 1997). The IPCC uses information about soil characteristics, climate, biomass input (crop intensity and permanence of biomass), and other inputs to apply fixed factors (land use, input, and management) to estimate the change in soil organic carbon (SOC) stock to a depth of 30 cm in two time periods relative to the SOC stock under native vegetation (IPCC 1997). Eve et al. (2001, 2002) applied the IPCC (1997) approach to estimate soil carbon stocks on U.S. agricultural soils based on existing land use and management and Sperow et al. (2003) used the IPCC approach to estimate the potential for increasing soil carbon stocks on U.S. agricultural soils by implementing activities that enhance soil carbon storage. National Resources Inventory (NRI) observations throughout the conterminous U.S. (Nusser and Goebel, 1997) provided the required input data for dominant soils, climatic regions, and land use (e.g., crop rotations) by Major Land Resource Region (NRCS 1981).

The IPCC documentation was updated in 2006 to reflect additional research that was used to modify the coefficients used to adjust SOC storage as a result of land use and management changes (IPCC 2006). For the current analysis, the IPCC method was modified to incorporate the 2006 IPCC coefficients and to account for five year inventory periods rather than the 15 to 20 year inventory periods applied in previous analyses by Eve et al. (2001, 2002) and Sperow et al. (2003). Individual points (areas with the same soil, climate region, and crop rotation) were tracked from 1982 through 1997, when the first contracts began expiring. The estimated change in SOC storage that resulted from land exiting CRP in 1997 was used to establish the SOC change for land that exited CRP in 2002 and 2007. Since our data only identify the post-CRP-contract land use (not land use prior to enrollment, or precise location), we could not apply a unique change in SOC stock that varied by the crop rotation (or other land use) or management activity (e.g., tillage intensity: conventional till, reduced till or no till) for the land leaving CRP. To capture as much variability in the SOC stock change as possible, a weighted average SOC storage rate change (Mg C ha^{-1} yr^{-1}) for each USDA-ERS defined Farm Production Region (FPR) was estimated based on the land use when it exited CRP in 1997. The weighted average captures a portion of the variability in SOC storage rates from different climatic regions and soil characteristics.

Data for the tillage intensity on cropland as the post-CRP land use are not available at the point-level in the NRI. Consequently, we applied the distribution of tillage intensity by IPCC derived climatic region and crop rotation based on long-term tillage patterns (greater than five years) established by Eve et al. (2001). Gelfand et al. (2011) indicate that no-till soybean is recommended for the initial post-CRP crop, however, our data do not indicate that soybeans represent the predominant crop planted after exiting CRP. The initial post-CRP tillage influences the SOC stored under CRP, with more intensive tillage resulting in greater losses of the SOC gained during the previous ten years.

Findings

In this first analysis, we focus on the cohort with the dominant share of CRP contracts that had ended by 2002: the 11.7 million hectares in contracts in 1997 and exited before 2002. In order to identify the carbon reversal rates with crop conversion, we estimate the changes in SOC during the CRP period (including 1997) and in the period after the contract ended.

We note that, using the simplified (Tier 1) method, we estimated that CRP grass lands (in grass contracts in 1997) increased carbon sequestration an average of 17 Tg of CO_2e per year - comparable to the estimate of annual sequestration based on DayCent (Table 4).

For the lands that were ever-cropped after their CRP contract ended (21% of the cohort), an estimated 68% of the carbon was released. Among that group, the reversal rate was very different depending upon whether than land was cropped in both periods, or not. Cropping in both periods was the dominant pattern (82% of ever-cropped): the carbon reversal rate was 91% for those lands. The remainder of the ever-cropped lands mixed cropping one period with another land use: either CRP or other high-residue land uses (hay, pasture or range) that sequester carbon at a greater rate than CRP. On the former set of lands (less than 1% of ever-cropped), the carbon reversal rate was much lower; on the ever-cropped lands that were in hay, pasture or range during part of the post-CRP period, additional carbon was stored.

Most lands in this cohort (79%) were not cropped following the conclusion of the CRP contract (in place in 1997). In this group, we estimate that the a comparable quantity of soil organic carbon was sequestered in the post (initial) contract period as in the first contract period. Re-enrollment in CRP (covering both periods) was the dominant pattern (78% of never-cropped). The increase in soil organic carbon was lower among those lands than for those that include hay, pasture or range among the land uses. (Note we did not calculate the changes in soil organic carbon for the post-contract land uses of forest, urban/development or other.)

The prior cohort of CRP contract exits: the 2.9 million hectares in CRP in 1992 but exiting by 1997 have a very different pattern of post-CRP land use, dominated by conversion to cropland. We anticipate the reversal rates for each category of post-CRP land use will be comparable. (This is one of our next analyses). However, the overall pattern will vary because the distribution across the different land use sequences is so different.

Discussion and next steps

Our analysis shows how post-contract land uses have varied over time, as agricultural prices and CRP policy responses have varied. The high level of cropland conversion reported in the literature – based on data from the cohort that exited in 1996-97 - are not representative of subsequent cohorts. Further a portion of what was counted as cropland conversion was conversion to hay, a land use that sequesters carbon relative to CRP, much less relative to actively cropped land because hay is managed with more inputs than CRP and less soil disturbance than cropland.

The reversal rate of carbon sequestered during CRP is high for lands continuously in crops following exit from CRP – the dominant land use pattern observed among the ever-cropped lands. For the small share of ever-cropped lands that shift between cropping and CRP or hay, pasture and range, the alternative land uses result in sequestration that offsets partially or more than fully the losses from cropping.

In the next stage of our analysis, we will include forested land uses in the analysis. We also will turn to the question of what would be the implications if the program were to shrink, including if all the contracts were allowed to expire.

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BOX: Challenges to Environmental Integrity in Voluntary GHG Mitigation Programs

Several factors need to be considered when estimating the resulting total net reduction in GHG. These issues arise in the accounting for GHG emissions associated with voluntary conservation programs, as well as with voluntary GHG offsets.

- **Leakage** occurs when a GHG-mitigation activity (such as setting aside cropland under a conservation program) displaces GHG-emitting activities to other sectors or geographic locations not within the scope of the program, or – in the case of a voluntary program -- to other sources that have chosen not to enroll. For example, a program that compensates farmers for converting highly erodible crop land to grass land, or induces use of crops for energy feedstocks, may induce land in other uses to be cleared for agriculture. In this case, the GHG emissions from the additional cropland conversion would offset, at least in part, the gains from emission reductions by program participants. When calculating the net GHG impacts of a program, a full accounting of impacts would include emission increases associated with any expansion of activities and/or shifts in their location as a result of the program. The limited empirical studies on the topic suggest that voluntary participation in forest land preservation (taking it out of production) is most likely to induce compensatory planting elsewhere; taking cropland out of production is likely to generate less leakage because conversion tends to occur on lower productivity land; and finally, adoption of land management practices such as conservation tillage or reduction in fallow crops is least likely to reduce crop supply on participating land and generate a compensatory response (Murray et al. 2007).

- **Additionality**. The additionality of net GHG emission reductions signifies that the reductions are *beyond* what would have occurred under business-as-usual conditions without the program. For example, if a farmer would have adopted no-till without being compensated, then the GHG emission reductions from no-till adoption as a conservation program participant are not additional. Conversely, if a farmer would have abandoned conservation tillage without the program, then continued conservation tillage would be additional. Mitigation actions mandated by policies already in place would be considered as "business-as-usual", and consequently not additional.

- **Carbon sequestration reversals (lack of permanence)**. With the termination of carbon-sequestering activities such as conservation tillage or forest land use, not only does the sequestration stop (as occurs when an energy-efficiency technology is terminated), but - in addition - the carbon sequestered during an earlier time period will be released. A full accounting of the GHG impacts of a program would include the increases in emissions resulting from any future reversals of the sequestering activities.

- **Carbon-stock re-equilibration.** Over time and under relatively constant environmental and management conditions, rates of carbon additions and emissions tend to equilibrate and the amount of organic carbon in soils stabilizes at a constant or steady-state level (i.e., the carbon-stock equilibrium). If the relationship between additions and losses subsequently changes due to a change in soil management or land use, the soil will gradually move to a new carbon-stock equilibrium, at which point additional sequestration (or emissions) will essentially cease (Paustian et al. 2006). For set-aside lands in grass land use, sequestration is highest in first decade, declines in the second decade, and is negligible in subsequent years.

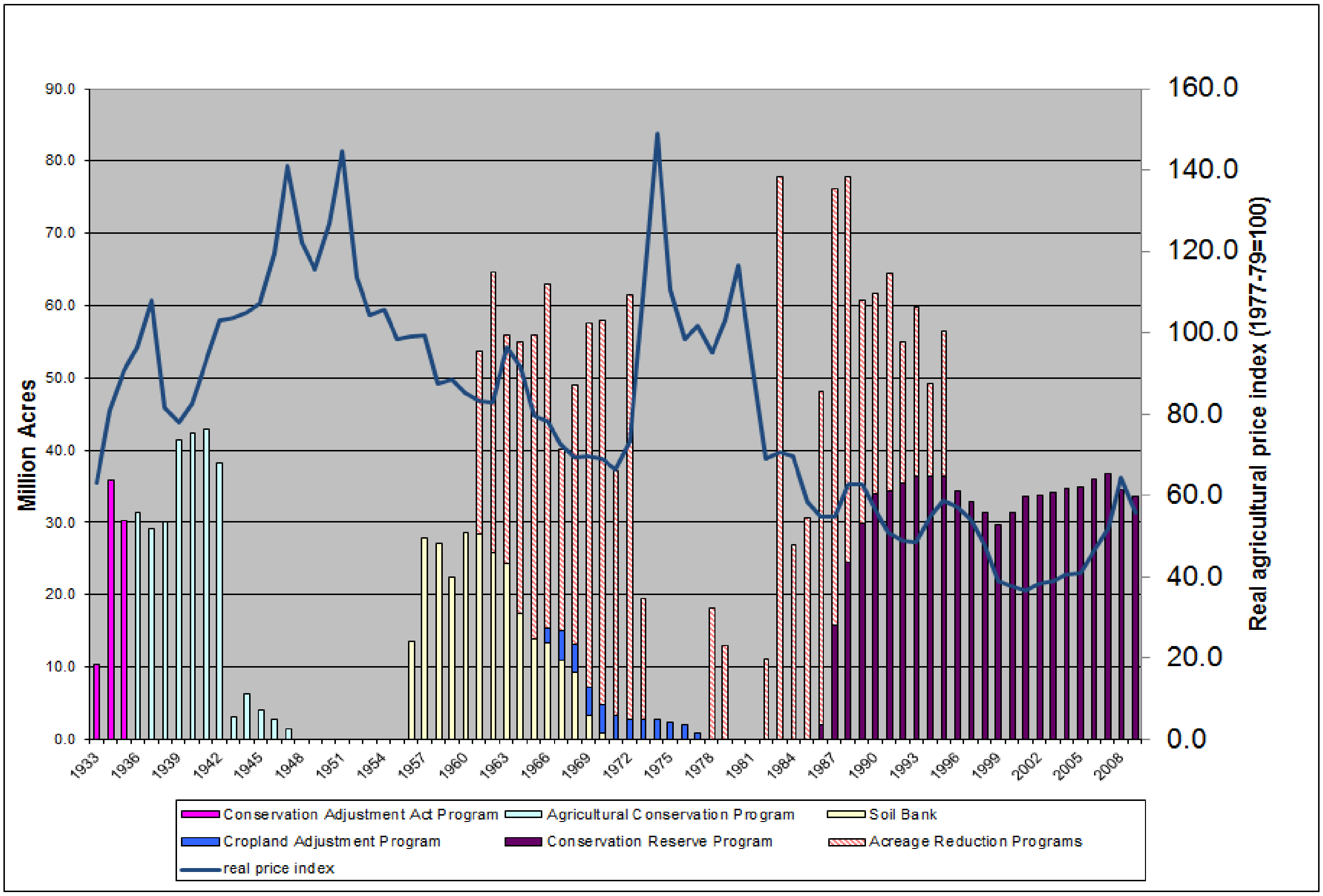

Figure 1. Cropland acres by setaside program type and global crop real price index, 1933-2009 (1977-79 = 100).

Sources: Setaside acres: Nickerson, C. , R. Ebel, A. Borchers, and F. Carriazo, 2011; global agricultural prices: Fuglie and Wang, 2012.

Table 1. 1992 CRP GRASS CONTRACTS - POST CRP LAND USE TRANSITIONS

	Land cover/use in 1997 (in hectares)											
CRP use in 92	crops-row, close grown,	row cotton/fallow	rice/hay/ pasture	remained in CRP	re-enrolled in CRP by 2002	range	forest	developed	other & water	**1992 total**		expired or re-enrolled by 1997
												-
CRP grasses	574,735	56,737	526,578	11,591,145	35,734	98,703	20,720	*2,711*	13,436	12,920,499		1,329,354
	(5,001)	(2,200)	(4,750)	(13,396)	(4,056)	(2,677)	(803)	*(187)*	(1,283)			
	574,735	56,737	526,578	11,591,145	35,734	98,703	20,720	2,711	13,436	12,920,499		1,329,354
% of expired or re-enrolled land	43%	4%	40%		3%	7%	2%	0%	1%			100%

For CRP Land that expired by 1997 or was re-enrolled by 1997

	Land cover/use in 2002 (in hectares)									
	close grown, veg/truck	row cotton/fallow	rice/hay/ pasture	remained in CRP from 1997	re-enrolled in CRP by 2002	range	forest	developed	other & water	**1997 total**
crops-row, close grown, veg/truck	452,399	18,170	48,562		53,297	-	*324*	-	*1,983*	574,735
	(4,019)	(1,081)	(1,158)		(2,335)	-	*(80)*	-	*(358)*	
row cotton/fallow	28,571	12,990	*1,659*		13,517					56,737
	(1,816)	(769)	*(186)*		(1,021)					
rice/hay/pasture	73,410	9,996	318,488		106,878	*8,944*	*2,711*	*5,180*	*971*	526,578
	(1,889)	(711)	(3,823)		(2,030)	*(804)*	*(251)*	*(285)*	*(141)*	
CRP	*4,735*	*4,978*	-	*1,416*	*23,957*	-	647		-	35,734
	(568)	*(1,071)*	-	*(318)*	*(3,839)*	-	(141)		-	
range	*405*	*1,376*	*4,492*		*14,488*	77,943				98,703
	-	*(271)*	*(838)*		*(1,122)*	(2,076)				
forest	-	-	-		-	-	20,518	*202*	-	20,720
	-	-	-		-	-	(804)	*(50)*	-	
developed	-	-	-		-	-	-	*2,711*	-	2,711
	-	-	-		-	-	-	*(187)*	-	
other & water	*364*	*1,942*	-		*6,192*	*567*	-	-	*4,371*	13,436
	(67)	*(374)*	-		*(1,278)*	*(99)*	-	-	*(372)*	
	559,883	49,453	373,202	1,416	218,328	87,453	24,200	8,094	7,325	1,329,354
% of expired lanc	42%	4%	28%	0%	16%	7%	2%	1%	1%	100%
% staying in same land use	79%	23%	60%	4%		79%	99%	100%	33%	

	Land cover/use in 2007									
	crops-row, close grown, veg/truck	row cotton/fallow	rice/hay/ pasture	remained in CRP from 2002	re-enrolled in CRP by 2007	range	forest	developed	other & water	**2002 total**
crops-row, close grown, veg/truck	497,036	33,953	23,108	-	4,978	-	-	-	809	559,883
	(3,861)	(1,879)	(750)	-	(897)	-	-	-	(171)	
row cotton/fallow	29,016	20,437	-	-	-	-	-	-	-	49,453
	(1,592)	(1,093)	-	-	-	-	-	-	-	
rice/hay/pasture	44,151	1,295	309,018	-	5,868	7,649	4,775	-	445	373,202
	(1,101)	(184)	(4,065)	-	(967)	(453)	(265)	-	(104)	
CRP	850	-	3,723	167,297	47,186	567	-	121	-	219,745
	(109)	-	(342)	(4,470)	(2,608)	(137)	-	(43)	-	
range	-	-	-	-	-	87,453	-	-	-	87,453
	-	-	-	-	-	(2,155)	-	-	-	
forest	-	-	-	-	-	-	24,200	-	-	24,200
	-	-	-	-	-	-	(857)	-	-	
developed	-	-	-	-	-	-	-	8,094	-	8,094
	-	-	-	-	-	-	-	(332)	-	
other & water	-	-	809	-	-	-	-	647	5,868	7,325
	-	-	(164)	-	-	-	-	(134)	(453)	
	571,053	55,685	336,659	167,297	58,032	95,668	28,976	8,863	7,122	1,329,354
% of expired lanc	43%	4%	25%	13%	4%	7%	2%	1%	1%	100%
% staying in same land use 2002-07	89%	41%	83%	76%		100%	100%	100%	80%	

Source: ERS calculations based on NRI data

Note: std errors in parentheses. Estimates in italics are based on 20 or fewer observations and reliability may be suspect.

Table 2. 1997 CRP GRASS CONTRACTS - POST CRP LAND USE TRANSITIONS

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	Land cover/use in 2002 (in hectares)										
CRP use in 97	crops-row, close grown, veg/truck	row cotton/fallow	hay/ pasture	remained in CRP	re-enrolled in CRP by 2002	range	forest	devel-oped	other & water	1997 total	expired or re-enrolled by 2002
											-
CRP grasses	1,862,083	284,980	1,777,989	620,910	7,340,928	372,473	67,340	8,053	8,539	12,343,295	11,722,385
	(15,211)	(8,401)	(14,024)	(14,325)	(20,380)	(6,814)	(2,347)	(436)	(493)		
	1,862,083	284,980	1,777,989	620,910	7,340,928	372,473	67,340	8,053	8,539	12,343,295	11,722,385
% of expired or re-enrolled land	16%	2%	15%		63%	3%	1%	0%	0%		100%

Note: std errors in parentheses

For CRP Land that expired by 2002 or was re-enrolled by 2002:

	Land cover/use in 2007 (in hectares)									
Land cover/use in 2002	crops-row, close grown, veg/truck	row cotton/fallow	hay/ pasture	remained in CRP from 2002	re-enrolled in CRP by 2007	range	forest	devel-oped	other & water	2002 total
crops-row, close grown, veg/truck	1,532,264	207,604	97,287		15,540	*3,116*	*2,630*	*769*	*2,873*	1,862,083
	(8,398)	(10,004)	(2,284)		(854)	*(153)*	*(408)*	*(144)*	*(394)*	
row cotton/fallow	176,807	61,350	*4,613*		*42,209*					284,980
	(6,972)	(1,997)	*(348)*		*(4,068)*					
hay/pasture	210,073	26,021	1,474,313		23,431	32,375	*9,955*	*1,052*	*769*	1,777,989
	(4,783)	(1,524)	(11,719)		(2,991)	(1,907)	*(1,159)*	*(228)*	*(165)*	
CRP	26,588	*2,064*	76,607	5,791,141	1,405,354	22,136	14,812		*2,226*	7,340,928
	(692)	*(256)*	(1,647)	(26,160)	(17,637)	(1,490)	(681)		*(237)*	
range	*1,174*		*81*		*364*	370,854				372,473
	(257)		*(28)*		-	(6,837)				
forest							67,340			67,340
							(2,347)			
developed								8,053		8,053
								(437)		
other & water							*2,266*		*6,273*	8,539
							(245)		*(464)*	
	1,946,905	297,040	1,652,901	5,791,141	1,486,898	428,482	97,003	9,874	12,141	11,722,385
% of expired land	17%	3%	14%	49%	13%	4%	1%	0%	0%	100%
% staying in same land use 2002-07	82%	22%	83%	79%		100%	100%	100%	73%	

Source: ERS calculations based on NRI data

Note: std errors in parentheses. Estimates in italics are based on 20 or fewer observations and reliability may be suspect.

Table 3. 2002 CRP GRASS CONTRACTS - POST CRP LAND USE TRANSITIONS

Table 3. 2002 CRP GRASS CONTRACTS - POST CRP LAND USE TRANSITIONS											
	Land cover/use in 2007 (in hectares)										
CRP use in 02	crops-row, close grown,	row cotton/fallow	rice/hay/ pasture	remained in CRP	re-enrolled in CRP by	range	forest	developed	other & water	**2002 total**	expired or re-enrolled by 2007
CRP grasses - acre	98,743	3,399	167,135	9,139,758	2,570,243	31,161	14,609	*121*	3,278	12,028,449	2,888,691
	(1,763)	(283)	(2,637)	(27,075)	(24,080)	(1,673)	(607)	*(43)*	(304)		
	98,743	3,399	167,135	9,139,758	2,570,243	31,161	14,609	121	3,278	12,028,449	2,888,691
% of expired or re-enrolled land	3%	0%	6%		89%	1%	1%	0%	0%		100%

Source: ERS calculations based on NRI data

Note: std errors in parentheses. Estimates in italics are based on 20 or fewer observations and reliability may be suspect.

Table 4. 1997 CRP Grass Contracts: Estimated Average Annual Change in Soil Organic Carbon (SOC) during CRP Contracts and in post-CRP-Contract Land Uses

Sample = Land in CRP grass contracts in 1997, for which the contract expired by 2002 (11.7 mi ha.)

Land use in 2002 and 2007	ha	During CRP contract (covering 1997)	Post-CRP contract period (1998-2007) [1]	Ratio of changes in SOC: post-contract to during contract [2]
	%	*average annual Tg CO2-e*		
Ever-cropped post-CRP	**20.5%**	**3.59**	**(2.49)**	**-0.69**
Only cropped	16.9%	2.92	(2.70)	-0.92
Mixed crop and (hay/pasture or range)*	2.9%	0.53	0.24	0.45
Mixed crop and CRP	0.7%	0.13	(0.03)	-0.20
No cropping post-CRP reported*	**78.5%**	**13.61**	**15.12**	1.11
Only CRP	61.4%	10.65	10.65	1.00
Only hay/pasture or range	16.0%	2.80	4.24	1.52
Mixed (hay/pasture or range) and CRP	1.0%	0.16	0.23	1.39
Subtotal	**99.0%**	**17.20**	**12.63**	0.73
No GHG accounting post-CRP/too small for reporting	**1.0%**			
Forest	0.8%	50,398	31,666	
Urban/development	0.1%	-	3,735	
Other	0.1%	-	4,615	
Total	**100%**			

SOURCE: Calculations of the authors using NRI data and a model employing IPCC Tier 1 and Tier 2 GHG accounting methods.

1/Annual average is calculated for all points in CRP in 1997 whose contract expired before 2002. The calculation is based on 2 NRI observations of land use (in 2002 and 2007). We assume land use reported for NRI observation continues for the 5 year period until the next observation.

2/ The calculation of the ratio implicitly assumes the CRP contract is in place for the same time period as the post-contract observation (10 years).

3/ Not reported in CRP, forest, development, other land use.