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Impact of the Fruit and Vegetable Planting Restriction on Crop Allocation in the United States

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Abstract

Eligibility requirements for farm payments include restrictions from planting certain horticultural crops on base acres, and there has been pressure to remove such restrictions in recent Farm Bill discussions and as part of World Trade Organization negotiations. We measure the effects of the planting restriction on acres planted to horticultural and program crops using U.S. county-level data from the Censuses of Agriculture taken before and after the initial policy was introduced in 1990 using a difference-in-difference estimator. Our results indicate that the planting restriction has crowded out fruit and vegetable acreage nationally and most notably in selected Sunbelt states, a region that specializes in horticultural crop production.

Keywords: Farm Bill, Policy analysis, Difference in difference model, Fruits and vegetables, Planting restriction; World Trade Organization.

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Introduction

The 1990 Farm Bill introduced provisions for farmers enrolled in federal farm support programs to receive payments while moving some of their base acreage away from specific program crops.[1] As a condition of eligibility for payments, producers with a demonstrated history of planting program crops were obligated to continue to plant the historical program crop on at least 75% of base acreage; producers were allowed to plant up to 25% of base acreage (so-called "flex" acres) in an alternate crop, but were explicitly prohibited from planting certain specialty crops on that land, including fruits, vegetables, tree nuts, and wild rice.[2, 3] The 1996 Farm Bill extended planting flexibility to all base acres, but maintained the prohibition on fruit and vegetables. The planting restriction received widespread support from fruit and vegetable producers, who were concerned that unrestricted direct payments would subsidize new production of these specialty crops and lead to decreased prices.

Producers in violation of the planting restriction would lose payments on those acres planted in fruits and vegetables, plus receive a financial penalty equal to the market value of the restricted fruit or vegetable crop. Further, the producer in violation could lose its contract for federal farm support programs. Exceptions to the planting restriction were made under any of three conditions: (1) farmers with a demonstrated history of planting restricted fruit or vegetable crops could plant them on base acres; (2) land with a demonstrated history of growing restricted fruit or vegetable crops could be used by farmers to produce restricted crops; and (3) regions with a history of double-cropping patterns (where one of the crops is fruits or vegetables). In all three exceptions, producers would forfeit program payments on all base acres planted in restricted crops. Thus, in any case, the planting restriction imposes a potentially important disincentive to produce restricted crops on base acres.[4]

The planting restriction, if binding, affects use of farm land by encouraging production of program crops and discouraging production of specialty crops. The effect of the planting restriction on land use is ultimately an empirical question. Previous work on the planting restriction falls into two categories. Johnson et al. (2006), Young et al. (2007) and Thornsbury et al. (2007) are descriptive studies that highlight geographic regions where competition for land in alternate uses is likely to be greatest, discuss barriers to switching to fruit and vegetable crops, and present anecdotal evidence of the policy's effects. Two other studies use a simulation approach to analyze acreage response to a hypothetical removal of the planting restriction. Fumasi et al. (2006) uses calculated changes in per acre returns (including government payments) for alternative crops as inputs into a representative-farm simulation model to predict changes in optimal crop mix. Patterson and Richards (2006) use a market simulation model to predict market-level changes in land use. These studies conclude that the planting restriction results in small to modest reductions in acreage for select crops in select regions.

Figure 1 shows the changes in program crop acres between 1987 and 1997; this represents a span that includes a time period just prior to the introduction of the planting restriction on fruits and vegetables and a time period a few years after the provision was in place. Census data that describe detailed county-level land use information are only available every five years, and therefore data are also available in 1992. We use the data from 1997 rather than 1992 as it allows us to observe the changes over a time period that is long enough for producers to adjust their production to the policy change in the 1990 Farm Bill. Figure 1 shows that there are eastern and western regions in the United States that experienced a decrease (of 5% or more) in acreage used to produce program crops. There are also regions along the east coast and in the mid-west that increased acreage (by 5% or more) devoted to program crop production over this time period. Figure 2 shows the county-level percent changes in fruit and vegetable acres between 1987 and 1997. Here we see decreases (of 5% or more) in acreage in counties in several southern and eastern counties and an increase (of 5% or more) in selected counties throughout the country. In particular, we observe decreases in acreage in counties in various Sunbelt states, and many of the Sunbelt states are major producers of horticultural crops. State Agricultural Departments in New Mexico, Florida, Arizona, California, and Texas (known as NFACT) have become organized in recent Farm Bill discussions and have been strong advocates of implementing policies to support specialty crops (CDFA 2011; NASDA 2001). We will examine the impacts of the planting restriction in these states more closely below.

Recent Policy Debate

In 2004 the planting restriction was the basis for a World Trade Organization (WTO) complaint filed by Brazil and other countries that asserted that the U.S. cotton program (and, by extension, direct payments for all program crops) was distortionary (Young et al. 2007).[5] The United States had filed direct payments made under these commodity programs as “green box” (minimally distorting) because they are not tied to current market prices or production, and are not tied to a specific crop. But the WTO ruled in favor of Brazil because of the fruit and vegetable planting restriction. In subsequent farm policy debates, U.S. farm interests have considered eliminating the restriction, with notable opposition from fruit and vegetable producers who fear entry of subsidized competitors.

Several consumer advocates have suggested that farm subsidies encourage the production of corn, wheat, and soybeans at the expense of fruit and vegetable production (e.g., Pollan 2003; Nestle 2007; Pollan 2007). Such arguments claim that farm policies encourage higher production of calorie dense foods that use grains and oilseeds as ingredients, and discourage production of healthier crops such as fruits and vegetables. Furthermore, Tillotson (2004), Muller, Schoonover and Wallinga (2007), Ludwig and Pollak (2009) and Popkin (2010) have attributed the growth in U.S. obesity rates to agricultural policies, and advocated a reorientation of government spending away from corn and wheat to fruits, vegetables and whole grains. Social critics have also highlighted the seemingly contradictory messages embedded in different USDA programs and initiatives, namely that USDA expenditures are used to subsidize grain and oilseed crops (which are considered to be the key ingredients in unhealthy foods by food policy critics) while other expenditures are used to promote nutritional guidelines and diets rich in fruits and vegetables. The planting restriction on fruits and vegetables, in particular, has been described as a farm policy that exemplifies this contradiction (e.g., Wilde 2007).

In response to the WTO complaint and to concerns about sourcing raw commodities from processing vegetable processors in the Great Lakes region, the 2008 Farm Bill introduced a Planting Transferability Pilot Program (Pilot Program) to better understand the impact of the planting restriction, and to see how producers would respond to such a change. The Pilot Program allows planting of up to 75,000 acres of seven key processing vegetables on base acres in seven states—Indiana, Illinois, Iowa, Michigan, Minnesota, Ohio, and Wisconsin—between 2009 and 2012. These seven states account for approximately 20% of total U.S. acreage used to produce (fresh and processed) vegetables.

There has been renewed interest in eliminating the fruit and vegetable planting restriction as part of the 2012 Farm Bill negotiations. The Senate Bill, S. 3240 (United States Committee on Agriculture, Nutrition, and Forestry 2012) and the House Bill, H.R. 6083 (House Committee on Agriculture 2012) both proposed to repeal direct payments as part of Title I, and this would effectively eliminate the fruit and vegetable planting restriction. This is a controversial issue and one that is expected to continue to be debated as part of domestic and international agricultural policy discussions. Relatively little is known about the economic effects of removing this provision, and how removal will impact land use; existing studies are either descriptive in nature or are based on a number of assumptions. One way to better understand the effects of removing the fruit and vegetable planting restriction is to examine the effects on land use when the provision was first introduced in 1990. In this paper we look for systematic evidence for how the planting restriction has impacted land used for both program crops and horticultural crops. We employ county-level data that describes specific uses of land in 1987 and 1997 in a difference-in-difference econometric framework to measure the impact of the fruit and vegetable planting restriction provision on the crop mix.

Econometric approach for measuring policy effects on land use

There is a large literature that examines the effects of commodity policy on land use in the United States (e.g., Lee and Helmberger 1985; McDonald and Sumner 2003; Key, Lubowski, and Roberts 2005), in Canada (e.g., Miranda, Novak, and Lerohl 1994) and in the European Union (e.g., Guyomard, Baudry, and Carpentier 1996). However, as argued in Gardner, Hardie, and Parks (2009) and supported by Moss and Schmitz (2003), the empirical estimation of linkages between farm policies and crop allocation have been inconclusive. One reason may be that previous studies have aggregated a number of individual policies with potentially conflicting effects. For example, in a regression of land shares on economic determinants of land use, Gardner, Hardie, and Parks (2009) use total government payments as a measure of farm policy. This policy variable includes payments from programs that generally do not have identical impacts on land use, and which change over time. Thus the model captures an average effect of the various policies on land use. The estimated effect cannot be expected to apply generally to a different set of policies or any of the individual policies.

Another potential reason that the existing literature on the market impacts of farm policies has been mixed is the inherent difficulty of structural econometric modeling. Structural models of land use require analysts to specify land owners' or producers' expectations over prices and policies for a range of alternative crops and other relevant land uses, and also to specify risk preferences (Holt 1999). Different specifications of expectations, different treatment of risk, or different approaches to aggregating alternative land uses could lead analysts to different conclusions.

The approach we adopt to examine the role of the planting restriction on crop allocation overcomes some of these challenges. We adopt a simple, reduced-form modeling framework to measure the impact of the planting restriction on land allocation across alternative crops. Our approach exploits a discrete change in farm policy and geographic variation in implementation in order to identify the effects of the planting restriction on allocation of land to alternative crops. In particular, we observe a change in policy in 1990 that adds planting flexibility on base acres but prohibits fruit and vegetable crops. That is, to receive direct payments on base acres, farmers were restricted from planting fruit and vegetable crops on those acres.

The combination of direct payments and the planting restriction simultaneously increased returns to growing program crops, and decreased returns to growing fruit and vegetable crops on base acres (see Young et al. 2007). Thus, we expect that the 1990 Farm Bill resulted in a reduction in fruit and vegetable acreage and an increase in program crop acreage. Moreover, we posit that these effects are likely to be directly correlated with the degree to which the planting restriction is binding. For a given area of land, the larger is the portion of land previously dedicated to program crops (and thus subsequently subject to the planting restriction), the larger is the effect of the planting restriction on acreage allocation across crops.

Based on this discussion we posit a reduced-form econometric model to estimate changes in fruit and vegetable acreage in a county *i* in equation (1):

$$(1) \qquad \Delta A_i^{FV} = \beta_0 + \beta_P A_i^P + \boldsymbol{\beta}_X \mathbf{X}_i^{'} + \varepsilon_i$$

In equation (1) ΔA_i^{FV} is the change in fruit and vegetable acreage in county *i* between 1987 and 1997; A_i^P is area in county *i* allocated to program crops in 1987 (pre-planting restrictions); $\mathbf{X}_i^{'}$ is a vector of other covariates that influence fruit and vegetable acreage in county *i* and includes various agronomic variables; and ε_i is a stochastic error term that captures unobserved factors that influence fruit and vegetable acreage in county *i*.

The change in fruit and vegetable acreage is defined over a period of time that straddles the change in policy, which occurred in 1990. The variable A_i^P measures the impact of land area planted in program crops before implementation of the planting restriction, i.e., the land area that was subsequently subject to the planting restriction. We assume that producers did not know in 1987 that land planted in program crops would subsequently be restricted as a pre-condition for receiving farm payments. In this light, we interpret A_i^P as an exogenous policy treatment. Thus the least squares estimator of B_P may be interpreted as the difference-in-difference (DiD) estimator on the relationship between base acres in 1987 and the change in fruit and vegetables acres between 1987 and 1997, which we interpret as a measure of the impact of the planting restriction.[6]

Identification of the policy effect relies on an assumption that growth rates in fruit and vegetable acreage conditional on $\mathbf{X}_i^{'}$ would have been the same across counties if not for differences in the change in base acres. Under this assumption, the DiD estimator identifies the impact of the planting restriction on fruit and vegetable acreage. Notably, the DiD estimator permits selection bias—the possibility that there is an unobserved factor that is causing both base acreage in the initial period and the change in fruit and vegetable acreage—but requires that such bias is time invariant.

The ability of the DiD estimator to identify the policy effect hinges on our ability to model or otherwise account for factors other than the policy that might influence county-level changes in fruit and vegetable acreage over time. Some of these factors are observable. Total crop area of a county obviously affects the land area dedicated to fruit and vegetable crops, so we include total crop acreage in 1987. Also, agronomic and climatic conditions affect suitability of land for fruit and vegetable production and therefore we include temperature, elevation, and net precipitation as variables in $\mathbf{X}_i^{'}$. Other factors may be unobservable such as market-level economic conditions or regional technological innovations, and we attempt to control for these by including state-level intercept dummies. Other unobservable factors are left in the error term and do not bias estimates of the policy effect as long as they are time-invariant. The key question here is whether there are unobserved factors that cause both 1987 program crop acres and the 10-year change in fruit and vegetable acreage. This might be the case if, for instance, there are factors that cause counties to specialize in fruit and vegetable crops, thus reducing their program crop area in 1987 and leading to larger growth rates in fruit and vegetable production area over time. However, we have not found any evidence that such conditions existed in the U.S. specialty crop market over the time period studied here.

We first estimate the effects of the planting restriction using data from 1987 and 1997 in all counties in the 48 contiguous states. Ravallion (2011) and Heckman, Ichimura, and Todd (1998), among others, recommend using matching techniques to further control for initial heterogeneity in the sample in order to reduce bias in DiD estimators. We follow this idea by selecting a subsample of units (counties) that are similar in every observable way except for the policy. Adopting an *ad hoc* matching technique, we also model the effects using data for two subsamples of counties. First, because the Pilot Program introduced in 2008 brought attention to the role of the planting restriction on land use in selected states in the Great Lakes region, we estimate the effects in this region. Second, because a large share of fruits and vegetables are produced in Sunbelt states, we re-estimate our model using data from the five Sunbelt states that are part of the NFACT coalition (with state departments of agriculture that strongly support the specialty crop sector).

Data

We use data from the U.S. Census of Agriculture describing cropland uses in 1987 and 1997 (USDA-NASS, 2002).[7] We aggregate individual crops into three categories: program crops (13 crops), fruit and vegetable crops subject to the planting restriction (40 crops), and all other crops (49 crops). Soybeans were not added to base acres until 2002, and therefore are not included as a program crop in our analysis. Total crop acreage is calculated as the sum of acres used across the three crop categories (102 crops in total). In the Appendix, Table A1 lists the Census of Agriculture codes and descriptions for the program crops (crops that were included in base acres during the period studied), Table A2 lists the descriptions for crops subject to planting restrictions, and Table A3 lists the descriptions for other crops that are neither program crops nor subject to planting restrictions.

There are 3,143 counties in the United States. We include land use data from all counties except the five counties in Hawaii, the 27 county-equivalents in Alaska, and the 80 counties which did not report any annual crop production in 1987 and 1997. We conduct our analysis on the remaining 3,031 counties. In Tables 1a and 1b we report area in fruit and vegetable crops, area in program crops, and total crop area for each state in 1987 and 1997. We list total acres in each category in each state, and also show the share of fruit and vegetable crops and the share of program crops. At the bottom of each table we calculate the acres and shares for each category for three groups of states: all 48 states, the selected Sunbelt states (the NFACT states), and the Pilot Program states. Table 1a shows that 3% of total cropland was used to produce fruits and vegetables in the 48 contiguous states, 14% of cropland was used to produce fruits and vegetables in the NFACT states, and 1.4% of cropland produced fruits and vegetables in the Pilot Program states in 1987. Table 1b indicates that cropland used for program crops and fruit and vegetable crops decreased overall, but that the shares of cropland used to produce fruits and vegetables changed very little. In some states we see larger changes in fruit and vegetable acreage and in program crop acreage between 1987 and 1997, and although not shown in Table 1a and Table 1b, we see even larger changes in individual counties which are explored further in our econometric model.

Agronomic data are collected from the Rocky Mountain Research Station of USDA Forest Service (Historic Climate Data for 1940 to 2006) for the 48 conterminous states at the county spatial scale based on PRISM (Parameter-elevation Regressions on Independent Slopes Model) climatology (Coulson and Joyce 2010).[8] The dataset contains monthly totals of precipitation, monthly means of daily maximum and minimum air temperature, computed monthly mean of daily potential evapotranspiration, and mean grid elevation. We include elevation, growing-period (the nine months including March through November) averages for temperature, and net precipitation (precipitation less evaporation) as control variables in $\mathbf{X}_i'$ in the regression models.

Results

We report econometric results from nine model specifications that consider different regions and different groups of crops impacted by the planting restriction. We examine the impact of planting restrictions in three regions: all counties in the 48 contiguous United States, all counties in the Pilot Program states, and all counties in the selected Sunbelt states (the NFACT coalition). In all model specifications the dependent variable is a change in county-level acres for a group of restricted crops between 1987 and 1997. For each region considered we also provide results from three model specifications that use dependent variables that focus on different groups of crops: all restricted crops (fruits, vegetables, melons, wild rice, and tree nuts), fruit crops only, and vegetable crops only. The focus of our discussion below is on the key policy variable, the estimated coefficient on program crops acres in 1987. A negative coefficient on this variable would indicate that counties with a greater land area in program crops (i.e., more base acres holding constant the total number of acres) saw a larger reduction in fruit and vegetable acreage from 1987 to 1997, and would suggest that the planting restriction provision did crowd out fruit and vegetable crops.

In Table 2 we report results from estimations using all 3,031 counties reporting crops. The first column presents results when we used the change in area for all fruit and vegetable crops as the dependent variable. Here the estimate on the variable describing program crop acres in 1987 is –0.0199 and it is statistically significant. This coefficient suggests that the average effect of the planting restriction is a reduction in fruit and vegetable acres by nearly 2 acres for every 100 acres of program crops planted in 1987. Given that there were approximately 166 million program crop acres in 1987 (USDA-NASS, 1997), this result suggests that the planting restriction reduced fruit and vegetable area by more than 3 million acres, or approximately 30%

of total fruit and vegetable acres in 1987 (USDA-NASS, 1997). That is, this result suggests that the planting restriction lead to a very large reduction in U.S. fruit and vegetable production; at the same time it lead to only a small percentage increase in acres planted to program crops. The other columns in Table 2 indicate the composition of the policy effect. Of the reduction in total fruit and vegetable acreage, approximately 58% (0.0115/.0199) is taken out of fruit crops (including tree nuts and melons), while the remainder is taken out of vegetable crops (including wild rice).

The results in Table 2 reflect an average policy effect across all counties (conditional on covariates). However, the response might be expected to be heterogeneous, dependent, for example, on the relative importance of program crops in the crop mix, or the availability of non-program acres for fruit and vegetable production. Thus, we estimate the model on sub-regions of the data to tease out heterogeneous effects. In Table 3 we report results for the selected Sunbelt states in the NFACT coalition (California, Arizona, New Mexico, Texas, and Florida). In 1987 these warm-climate states accounted for only 10% of all U.S. crop acreage and 9% of all U.S. program crop area, but 44% of all U.S. fruit and vegetable area (Table 1a). These are among the leading fruit and vegetable producing states, so we might expect the planting restriction to have a greater impact here. Indeed, we find large, negative impact of the planting restriction on fruit and vegetable acreage in the NFACT states; an extra 100 acres of program crop acres in 1987 is associated with approximately an eight acre reduction in fruit and vegetable acreage between 1987 and 1997 in this region. Results from the second and third columns show that the effects are approximately equal for fruit crops and for vegetable crops. Given approximately 17 million base acres in the NFACT states in 1987 (USDA-NASS, 1997), this result implies that the planting restriction resulted in a reduction of 1.3 million acres of fruit and vegetable crops.

Overall, the resulting change in fruit and vegetable acres in the NFACT states is proportional to its share of the aggregate U.S. effect reported in Table 2.

In Table 4 we present results for the Pilot Program states (which include Indiana, Illinois, Iowa, Michigan, Minnesota, Ohio, and Wisconsin). Recall that there was concern in this region that the planting restriction was making it difficult for processors and packers to find sufficient supply of farm product, and lobbied for (and won) the Pilot Program. The Pilot Program allowed the production of fruits and vegetables on a portion of base acres without penalty on a trial basis between 2009 and 2012. In Table 4 we do not find statistical significance on the variable describing program crop acres in 1987, and this indicates that planting restriction did not impact fruit and vegetable acreage in these states over this time period. Although the planting restriction had little impact on fruit and vegetable production in the Great Lakes region between 1987 and 1997, the expansion of base acres to include oilseeds in 2002 may have reduced the area of non-program acres available for fruit and vegetable production in this region after 2002 (Althoff and Gray 2004). As a result, the planting restriction may have become more important in the Pilot Program states after 2002; however, data describing the use of the Pilot Program suggests that its impact was quite modest and that the planting restriction has had a limited impact in this region even after 2002 (Krissoff et al. 2011a; Krissoff et al. 2011b).

Summary and Policy Implications

Restrictions applied to fruit and vegetable crops planted on base acres were introduced in the 1990 Farm Bill and were maintained in the three subsequent Farm Bills. It is widely expected that there will be further discussion about the repeal of the planting restriction in the next Farm Bill. The planting restriction has attracted criticism from a wide variety of stakeholders—including consumer groups, farm policy critics, fruit and vegetable processors, and trade partners. This is an issue that has also attracted the attention of policymakers and agricultural economists. There have been several reports that describe the likely impact of the planting restriction, and there appears to be a consensus that the planting restriction may have affected decisions made by some individual producers yet has had a negligible impact on fruit and vegetable acreage overall.

However, none of the earlier work that examines the role of the planting restriction has adopted an empirical approach with land use data; we contribute to the discussion by collecting data and developing an empirical approach to estimate the effects directly. Using detailed county-level data describing the crop mix before and after the introduction of the planting restriction in 1990, we employ a difference-in-difference econometric framework to measure the impact of the fruit and vegetable planting restriction provision. We find a negative causal relationship between base acres in 1987 and the change in fruit and vegetable acres between 1987 and 1997, suggesting that the policy of direct payments and planting restrictions reduced F&V acreage in the U.S. The corollary result is that removing the direct payments and planting restriction has the capacity to notably increase fruit and vegetable production in the United States (and thereby decrease fruit and vegetable prices). There has been much enthusiasm for the planting restriction from fruit and vegetable growers since its inception, and our findings reinforce reasons for their support of this provision.

In 2005 the WTO ruled that the planting restriction provision effectively results in direct payments that are “minimally trade distorting” and raised the question for whether direct payments should be exempt from WTO obligations (i.e., classified as “green-box” or “amber-box” support). This WTO decision ruling increased pressure for U.S. domestic policy to re-evaluate the role of the planting restriction provision as part of the 2008 Farm Bill discussions, and this led to the development of the Planting Transferability Pilot Program. The Pilot Program relaxed the planting restriction for specific vegetable crops in seven states in the Great Lakes region between 2009 and 2012; the total eligible land area under the Pilot Program was limited to 75,000 acres. Our results that focused on this region found no statistically significant effect of 1987 program crop acres on the change in land area used to produce fruit and vegetables between 1987 and 1997. This finding suggests that the planting restriction was less of a constraint in this region relative to the nation overall. Reports that describe a limited level of grower response to the Pilot Program provide additional evidence that the planting restriction is not a substantial constraint to fruit and vegetable production in this region. Furthermore, the policy variable in our model that focused on selected Sunbelt states (the NFACT coalition) was negative and statistically significant and suggests that the introduction of the planting restriction did crowd out fruit and vegetable acreage in this region.

The implementation of the Pilot Program in the Great Lakes region may have been a misguided policy experiment. We expect that if the Pilot Program was implemented in the Sunbelt states, or was adopted across selected counties nationally, there would have been greater response among agricultural producers. If policymakers were to extrapolate results from the Pilot Program in the Great Lakes region to other U.S. regions, it would most likely understate the impact that the planting restriction has had in U.S. agriculture. Given that the elimination of the planting restriction is an imminent possibility, it is important to carefully consider the impacts of its elimination on acreage used to produce fruits and vegetables and on those markets. It is difficult to predict how producers would respond to the elimination of the planting restriction, but our analysis that studies the effects of introducing the planting restriction suggests that it had a non-trivial impact on land use nationally and notably in selected Sunbelt states.

Footnotes

[1] Program crops are defined as crops for which federal support programs are available to producers, including wheat, corn, barley, grain sorghum, oats, extra-long staple and upland cotton, rice, oilseeds, peanuts, and sugar (USDA-ERS 2012).

[2] Base acreage is defined as farm's crop-specific acreage of wheat, feed grains, upland cotton, rice, oilseeds, or peanuts eligible to participate in commodity programs under the 2002 Farm Act (USDA-ERS 2012).

[3] Specialty crops are defined as fruits, vegetables, tree nuts, dried fruits, nursery crops, and floriculture (USDA-ERS 2012), and are often also referred to as horticulture crops. We use the terms interchangeably here, as well as use the term "fruits and vegetables" to describe the entire group of crops subject to the planting restriction.

[4] Planting restricted crops are wild rice, fruit (including nuts), vegetables (other than lentils, mung beans, and dry peas). Dry peas include Austrian, wrinkled seed, green, yellow, and umatilla. Peas grown for the fresh, canning, or frozen market are not dry peas and are included in the list of restricted crops (Johnson et al. 2006).

[5] Direct payments are defined as annual transfers to producers from the government based on payment rates specified in the 2002 Farm Act and a producer's historical program payment acres and yields (ERS, 2010).

[6] Fruit and vegetable acreage in a county must be non-negative, and therefore cannot be reduced by more than the existing fruit and vegetable acres in 1987. The dependent variable in our model is left-censored but the lower bound varies by county. Using a least squares model will not account for these county-specific lower bounds and, as a result, our estimates may understate the desired reduction in fruit and vegetable acreage for some counties. In this sense, our results may be interpreted as a conservative estimate of the effects of the policy on fruit and vegetable acreage.

[7] Although data in 1982 and 1992 are available, they are not used in the model for two reasons: 1) data from 1982 was from a different source that from 1987, 1992 and 1997, and 2) the 1992 data would only capture very short-term responses to a policy introduced in 1990.

[8] These data were developed from PRISM (Parameter-elevation Regressions on Independent Slopes Model) data at the 2.5 arc minute scale and aggregated to the 5 arc minute grid scale. The county means were computed using a weighted mean of the 5 arc minute grids within the county.

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Table 1a. Areas Dedicated to Fruits and Vegetables, Program Crops, and All Crops, 1987

	Fruits and Vegetables		Program Crops		All Crops
	1000 acres	*% of All Crops*	*1000 acres*	*% of All Crops*	*1000 acres*
AL	51	2	1,015	35	2,940
AZ	265	21	491	40	1,240
AR	23	0	3,533	37	9,610
CA	3,432	34	3,041	30	10,100
CO	193	3	3,669	51	7,252
CT	10	5	29	14	204
DE	68	12	253	44	575
FL	1,117	51	449	21	2,176
GA	288	6	2,715	60	4,496
ID	443	8	2,671	45	5,874
IL	66	0	13,100	53	24,700
IN	32	0	6,700	51	13,200
IA	13	0	14,100	52	27,200
KS	11	0	17,100	70	24,600
KY	7	0	1,679	23	7,191
LA	36	1	2,518	54	4,630
ME	23	4	105	19	553
MD	42	2	881	47	1,889
MA	35	13	27	10	263
MI	689	8	3,715	43	8,643
MN	498	2	11,700	51	22,800
MS	35	1	1,892	37	5,113
MO	34	0	4,733	28	17,200
MT	21	0	8,369	62	13,500
NE	185	1	11,200	55	20,500
NV	2	0	23	2	984
NH	7	4	17	9	177
NJ	79	14	154	27	581
NM	76	6	653	48	1,350
NY	337	6	1,343	23	5,930
NC	108	2	2,346	45	5,258
ND	660	3	14,500	63	23,100
OH	62	1	4,638	41	11,200
OK	102	1	5,698	51	11,100
OR	329	7	1,083	24	4,559
PA	115	2	1,838	30	6,092
RI	3	15	3	13	22
SC	49	2	943	44	2,130
SD	19	0	7,154	39	18,200
TN	25	0	1,425	24	5,954
TX	348	1	14,600	61	23,900
UT	27	1	338	18	1,862
VT	7	1	105	12	882
VA	56	1	946	24	3,915
WA	721	13	3,002	53	5,646
WV	14	1	74	6	1,150
WI	376	3	4,125	33	12,600
WY	29	1	488	16	2,992
48 States	11,170	3	181,181	47	386,035
NFACT States	5,239	14	19,234	50	38,767
Pilot States	1,736	1	58,079	48	120,343

Table 1b. Areas Dedicated to Fruits and Vegetables, Program Crops, and All Crops, 1997

	Fruits and Vegetables		Program Crops		All Crops
	1000 acres	*% of All Crops*	*1000 acres*	*% of All Crops*	*1000 acres*
AL	60	2	1,005	35	2,909
AZ	201	21	396	41	962
AR	29	0	2,894	36	7,972
CA	2,855	31	3,120	34	9,263
CO	215	3	3,481	53	6,605
CT	10	5	31	15	213
DE	81	15	215	39	553
FL	1,030	51	345	17	2,036
GA	198	5	1,805	47	3,820
ID	447	8	2,611	46	5,702
IL	79	0	11,500	51	22,400
IN	34	0	6,222	51	12,100
IA	7	0	12,700	52	24,500
KS	14	0	15,200	70	21,700
KY	9	0	1,552	24	6,359
LA	32	1	1,921	46	4,157
ME	26	5	65	12	533
MD	50	3	841	46	1,817
MA	42	13	35	11	318
MI	841	10	3,597	43	8,359
MN	384	2	10,900	53	20,700
MS	29	1	1,667	35	4,727
MO	28	0	4,227	27	15,800
MT	20	0	8,137	65	12,500
NE	204	1	9,949	54	18,300
NV	2	0	23	2	975
NH	8	4	18	9	190
NJ	112	19	131	22	598
NM	58	5	607	50	1,206
NY	352	6	1,394	22	6,302
NC	129	3	1,878	42	4,436
ND	488	2	13,100	62	21,200
OH	83	1	4,326	40	10,700
OK	63	1	5,190	56	9,312
OR	326	8	1,098	27	4,095
PA	140	2	2,004	32	6,173
RI	4	20	2	8	22
SC	74	4	702	37	1,883
SD	8	0	8,001	48	16,600
TN	27	1	1,432	26	5,428
TX	404	2	12,500	64	19,500
UT	42	2	376	22	1,722
VT	7	1	83	9	951
VA	69	2	909	25	3,627
WA	543	10	2,917	54	5,368
WV	20	2	98	10	992
WI	428	3	4,309	30	14,600
WY	34	1	539	19	2,836
48 States	10,348	3	166,052	47	353,021
NFACT States	4,547	14	16,968	51	32,966
Pilot States	1,856	2	53,553	47	113,359

Table 2. Regression Results, All U.S. Counties (n = 3031 in 48 states)[a]

	Dependent variable is the change between 1987 and 1997 in:					
	Fruit and Vegetable Area		*Fruit Area*		*Vegetable Area*	
Explanatory variables:	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Estimated coefficient	Standard error
1987 Program crop area	-0.0199**	0.0098	-0.0115*	0.0066	-0.0084*	0.0048
1987 Total crop area	0.0239**	0.0108	0.0138*	0.0071	0.0101**	0.0046
Elevation	-0.7585	1.1372	0.7111	0.7424	-1.4697**	0.6174
Net precipitation	-2.5920**	0.9761	-0.4181	0.3963	-2.1739**	0.7465
Temperature	-2.5313	9.8528	5.1397	6.6145	-7.6710	5.5700
R^2	0.12		0.07		0.11	

[a] State dummies and intercept are suppressed in all regressions.

Note: We use a * and ** to denote statistical significance at the 10% and 5% levels respectively. All standard errors are computed using White's sandwich estimator of the covariance matrix.

Table 3. Regression Results, NFACT States (n = 415 in 5 states)[a,b]

	Dependent variable is the change between 1987 and 1997 in:					
	Fruit and Vegetable Area		*Fruit Area*		*Vegetable Area*	
Explanatory variables:	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Estimated coefficient	Standard error
1987 Program crop area	-0.0823**	0.0391	-0.0416	0.0297	-0.0407**	0.0188
1987 Total crop area	0.1052**	0.0371	0.0618**	0.0266	0.0434**	0.0158
Elevation	-1.2757	4.5568	2.7012	3.3115	-3.9769	2.4980
Net precipitation	-2.1050	3.3547	2.1495	2.2086	-4.2545*	2.5419
Temperature	-28.4826	35.8796	3.8132	24.1952	-32.2958	19.6716
R^2	0.27		0.19		0.19	

[a] State dummies and intercept are suppressed in all regressions.

[b] The NFACT states include Arizona, California, Florida, New Mexico, and Texas.

Note: We use a * and ** to denote statistical significance at the 10% and 5% levels respectively. All standard errors are computed using White's sandwich estimator of the covariance matrix.

Table 4. Regression Results, Pilot Program States (n = 415 in 7 states)[a,b]

	Dependent variable is the change between 1987 and 1997 in:					
	Fruit and Vegetable Area		*Fruit Area*		*Vegetable Area*	
	Estimated coefficient	Standard error	Estimated coefficient	Standard error	Estimated coefficient	Standard error
1987 Program crop area	0.010	0.006	0.000	0.000	0.010	0.006
1987 Total crop area	-0.005	0.004	0.000	0.000	-0.005	0.004
Elevation	2.832	2.167	0.414	0.366	2.418	2.121
Net precipitation	2.987**	1.371	-0.220	0.334	3.207**	1.313
Temperature	-18.311**	7.464	-1.780*	0.982	-16.531**	7.345
R^2	0.27		0.10		0.26	

[a] State dummies and intercept are suppressed in all regressions.

[b] Pilot states include Indiana, Illinois, Iowa, Michigan, Minnesota, Ohio, and Wisconsin.

Note: We use a * and ** to denote statistical significance at the 10% and 5% levels respectively. All standard errors are computed using White's sandwich estimator of the covariance matrix.

Figure 1. County-level changes in program crop acreage, 1987 to 1997

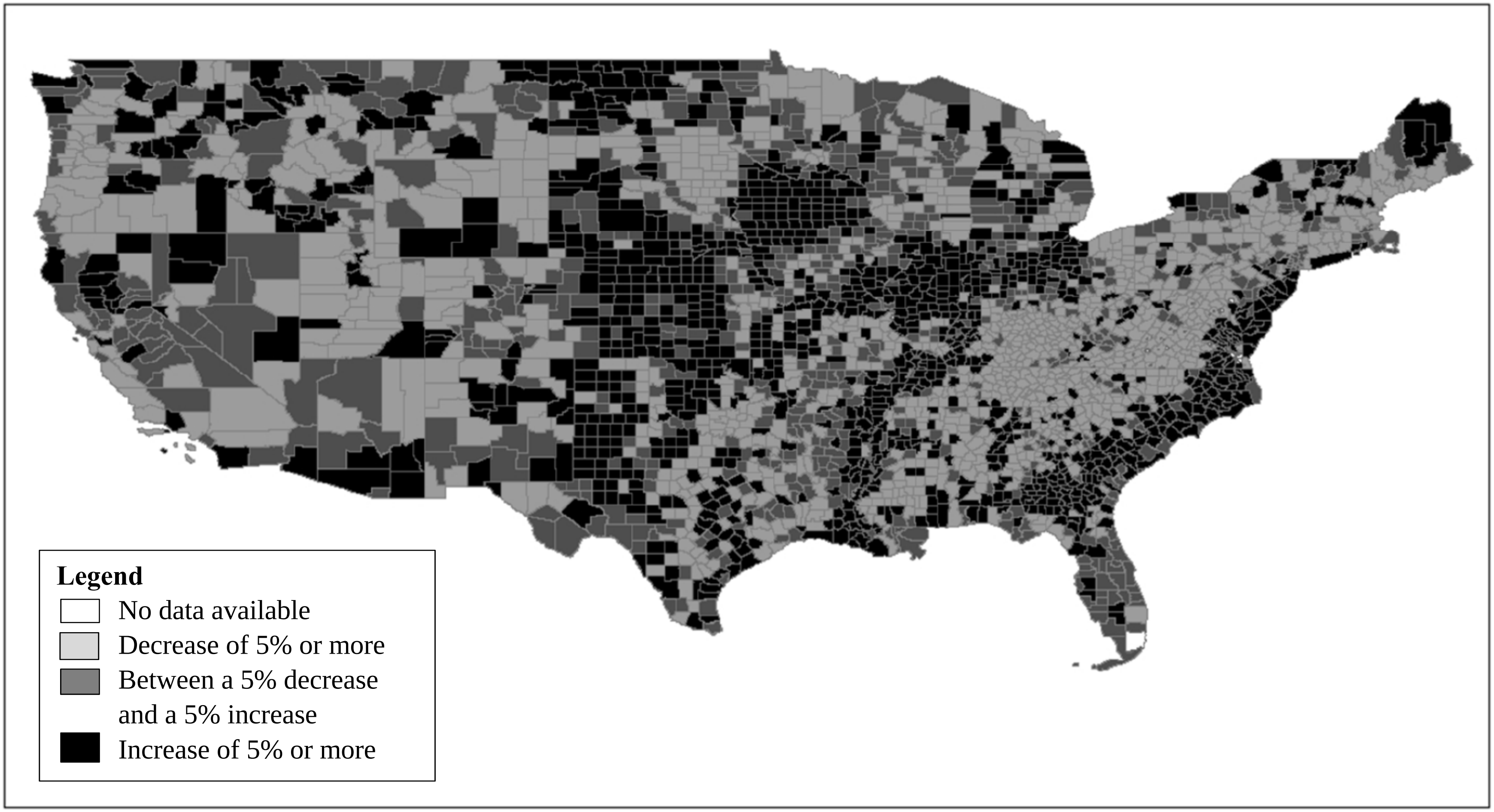
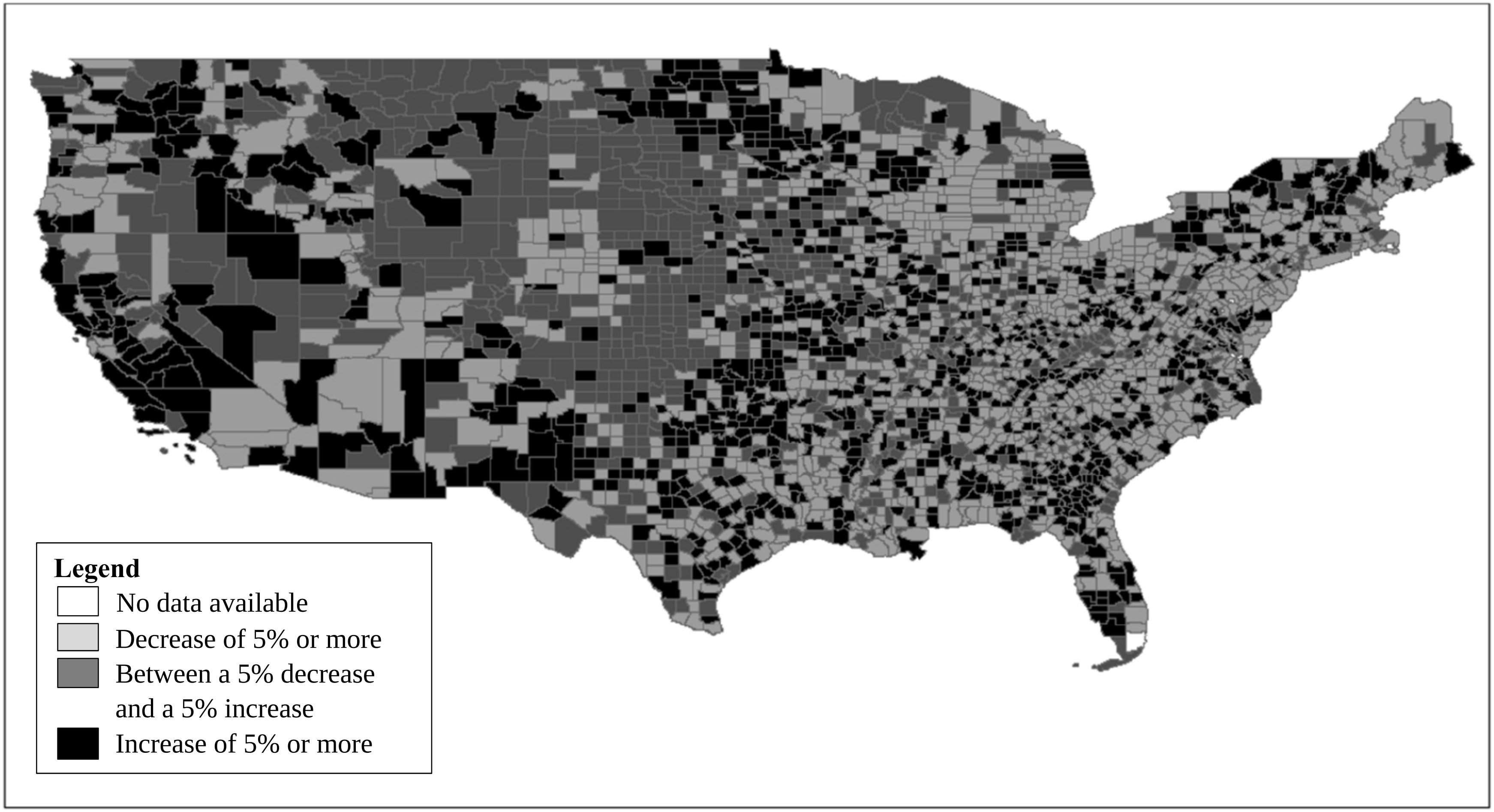


Figure 2. County-level changes in fruit and vegetable (including tree nuts, melons, and wild rice) acreage, 1987 to 1997



Appendix A. Classification of land use based on USDA Census Item Codes.

Table A1: Program Crops*

USDA Census Code	Crop Description
260002	Corn for grain or seed (bushels), harvested (acres)
260007	Sorghum for grain or seed (bushels), harvested (acres)
260012	Wheat for grain, total (see text) (bushels), harvested (acres)
260042	Barley for grain (bushels), harvested (acres)
260082	Oats for grain (bushels), harvested (acres)
260097	Rice (hundredweight), harvested (acres)
270002	Cotton (bales), harvested (acres)
270057	Sugar beets for sugar (tons), harvested (acres)
270067	Sugarcane for sugar (tons), harvested (acres)
270077	Peanuts for nuts (pounds), harvested (acres)
280157	Corn for silage or green chop (tons, green), harvested (acres)
280162	Sorghum cut for dry forage or hay (tons, dry), harvested (acres)
280167	Sorghum for silage or green chop (tons, green), harvested (acres)

* Soybeans and other oilseeds were considered as program crops (i.e., included as part of base acres) beginning in 2002, and therefore are not listed here. They are listed in Table A4 and included as part of “total acres” in our analysis.

Table A2: Crops Subject to Planting Restrictions (fruits, vegetables, tree nuts, and wild rice)

USDA Census Code	Crop Description
290006	Vegetables harvested (see text), harvested (acres)
310011	Apricots, total (acres)
310020	Avocados, total (acres)
310029	Bananas, total (acres)
310038	Cherries, total (see text) (acres)
310047	Sweet cherries, total (acres)
310056	Tart cherries, total (acres)
310065	Cherries, not specified (see text) total (acres)
310074	Coffee (parchment), total (acres)
310083	Dates, total (acres)
310092	Figs, total (acres)
310101	Grapes (see text) (fresh weight), total (acres)
310110	Guavas, total (acres)
310119	Kiwifruit, total (acres)
310128	Mangoes, total (acres)
310137	Nectarines, total (acres)
310146	Olives, total (acres)
310155	Papayas, total (acres)
310164	Passion fruit, total (acres)
310173	Peaches, total (acres)
310182	Pears, total (acres)
310191	Persimmons, total (acres)
310200	Plums and prunes (see text) (fresh weight), total (acres)
310209	Pomegranates, total (acres)
310218	Other non-citrus fruit, total (acres)
310227	All citrus fruit, total (acres)
310317	Almonds (meats) (see text), total (acres)
310326	Filberts and hazelnuts (in shell), total (acres)
310335	Macadamia nuts (husked, unshelled), total (acres)
310344	Pecans (in shell), total (acres)
310353	Pistachios (in shell), total (acres)
310362	English walnuts (in shell), total (acres)
310371	Other nuts (in shell), total (acres)
310380	Other fruits and nuts (see text), total (acres)
320002	Berries (pounds), harvested (acres)
260122	Wild rice (pounds), harvested (acres)
270017	Dry edible beans, excluding dry limas (hundredweight), harvested (acres)
270022	Dry lima beans (hundredweight), harvested (acres)
270042	Potatoes, excluding sweetpotatoes (bushels), harvested (acres)
270047	Sweetpotatoes (bushels), harvested (acres)

Table A3: All other crops including oilseeds* (used to calculate total acres)

USDA Census Code	Crop Description
260067	Emmer and spelt (bushels), harvested (acres)
260087	Popcorn (pounds, shelled), harvested (acres)
260092	Proso millet (bushels), harvested (acres)
260102	Rye for grain (bushels), harvested (acres)
260117	Triticale (bushels), harvested (acres)
270007	Tobacco (pounds), harvested (acres)
270027	Dry edible peas (pounds), harvested (acres)
270032	Dry cowpeas and dry southern peas (bushels), harvested (acres)
270037	Lentils (pounds), harvested (acres)
270052	Sugar beets for seed (pounds), harvested (acres)
270062	Sugarcane for seed (tons), harvested (acres)
270072	Sugarcane not harvested, harvested (acres)
280002	Field seed and grass seed crops, harvested (acres)
280007	Alfalfa seed (pounds), harvested (acres)
280012	Austrian winter peas (pounds), harvested (acres)
280017	Bahia grass seed (pounds), harvested (acres)
280022	Bentgrass seed (pounds), harvested (acres)
280027	Bermuda grass seed (pounds), harvested (acres)
280032	Birdsfoot trefoil seed (pounds), harvested (acres)
280037	Bromegrass seed (pounds), harvested (acres)
280042	Crimson clover seed (pounds), harvested (acres)
280047	Fescue seed (pounds), harvested (acres)
280052	Foxtail millet seed (pounds), harvested (acres)
280057	Kentucky Bluegrass seed (pounds), harvested (acres)
280062	Ladino clover seed (pounds), harvested (acres)
280067	Lespedeza seed (pounds), harvested (acres)
280072	Orchardgrass seed (pounds), harvested (acres)
280077	Red clover seed (pounds), harvested (acres)
280082	Redtop seed (pounds), harvested (acres)
280087	Ryegrass seed (pounds), harvested (acres)
280092	Sudangrass seed (pounds), harvested (acres)
280097	Sweetclover seed (pounds), harvested (acres)
280102	Timothy seed (pounds), harvested (acres)
280107	Vetch seed (pounds), harvested (acres)
280112	Wheatgrass seed (pounds), harvested (acres)
280117	White clover seed (pounds), harvested (acres)
280122	Other seeds (pounds), harvested (acres)
280127	Other hay, grass silage and green chop (tons, dry) harvested (acres)
280132	Alfalfa hay (tons, dry), harvested (acres)
280137	Small grain hay (tons, dry), harvested (acres)
280142	Tame hay other than alfalfa (tons, dry), harvested (acres)
280147	Wild hay (tons, dry), harvested (acres)

Table A3 (continued): All other crops including oilseeds* (used to calculate total acres)

USDA Census Code	Crop Description
280152	Grass silage (tons, green), harvested (acres)
260052*	Canola and other rapeseed (pounds), harvested (acres)
260072*	Flaxseed (bushels), harvested (acres)
260077*	Mustard seed (pounds), harvested (acres)
260107*	Safflower (pounds), harvested (acres)
260112*	Sunflower seed (pounds), harvested (acres)
270012*	Soybeans for beans (bushels), harvested (acres)

* Soybeans and other oilseeds were not included in base acres in 1987 and 1997, and therefore are listed here and simply included as part of “total acres” in the model.

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