Extent, Location, and Characteristics of Land Cropped Due to Insurance Subsidies

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Abstract

We examine changes in land use caused by the large increase in crop insurance premium subsidies under the Federal Crop Insurance and Reform Act (FCIRA) of 1994. We use a conditional logit model to estimate changes in six major land uses from 1992 and 1997 as a function of the change in expected return to crop insurance. Our data on individual land parcels across the entire coterminous United States enable identification of the extent, location, and physical characteristics of the land brought into and retained in production as a result of the crop insurance policies. Results indicate the additional crop insurance premium subsidies increased cultivated cropland area on the order of 1.9 million acres (0.6%), consistent with the lower range of previous estimates of crop insurance acreage effects. The estimated lands in production due to the subsidy increases are of lower quality than cropland overall in term of both Land Capability Classification and proneness to flooding, as well as more environmentally sensitive in terms of erodibility and proportion in wetlands (G220, Q150, Q180, Q240, R140).

Key words: crop insurance; crop insurance subsidies; Federal Crop Insurance and Reform Act (FCIRA); land use; land-use change; National Resources Inventory (NRI).

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Introduction

Subsidized crop insurance has long been thought to encourage crop production on economically marginal land. A number of researchers have drawn connections between the amount of land in crop production and crop insurance (Goodwin, Vandeveer, and Deal 2004; Goodwin and Smith 2003; Keeton *et al*. 1999; Wu 1999; Young *et al*. 1999; Griffin 1996). All have noted the potential for additional environmental damage due to expanded crop production, particularly if marginal land is also environmentally sensitive. In a 1999 letter to Congress, twenty-seven conservation and taxpayer groups also opposed additional crop insurance subsidies on the grounds that these, "…would create strong incentives to crop millions of acres of environmentally sensitive flood or drought-prone pastureland and wildlife habitat" (Environmental Defense 1999).[1] The contention is that crop insurance tends to increase cultivation on lands where growing crops is particularly risky, and that these are also where crops are particularly damaging to the environment.

In this paper, we exploit exogenous variation in insurance adoption caused by a rapid increase in insurance subsidies to estimate the effect of crop insurance on land use. This approach allows us to isolate the impact of crop insurance policies and control for unobserved factors that affect cropping decisions. The use of parcel-level data on land use also facilitates identification of the locations and physical and environmental characteristics of land brought into production and retained in production as a result of crop insurance policies.

Our approach contrasts with an existing literature on land-use effects from crop insurance that has chiefly relied on county-level data and has not identified the environmental characteristics of lands affected by the crop insurance policies. Previous studies, including one of the few farm-level analyses (Wu 1999), focus on particular subsets of crops and relatively small geographic regions of the country, limiting an assessment of the overall impacts of

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[1] See http://www.environmentaldefense.org/documents/1366_crop%20insurance%20letter2.htm.

subsidized crop insurance.   Most research consists of cross-sectional analyses, which may be biased due to unobserved heterogeneity that drives both insurance adoption and land-use decisions.   Other studies have used simulation models that rely on assumptions about farmers' costs and risk aversion (e.g., Young, Vandeveer, and Schnepf 2001).

We estimate impacts of crop insurance subsidies using data on observed changes in land use on individual land parcels before and after a major increase in crop insurance subsidies. Between 1994 and 2000, crop insurance premium subsidies were increased significantly.   The Federal Crop Insurance and Reform Act (FCIRA) of 1994 increased premium subsidies for all crop insurance products, while adding a catastrophic coverage option with 100 percent premium subsidy and new revenue insurance options.   Further premium subsidy increases were enacted in 1999-2000.   Average annual program costs roughly doubled to $1.5 billion between 1990-94 and 1995-99, then doubled again to $3.1 billion after the Agricultural Risk Protection Act of 2000 (Glauber and Collins 2002).   Most existing empirical research on crop insurance and land in crop production uses data that pre-date even the 1994 crop insurance subsidy increases.[2]   Yet these subsidy changes create a natural experiment in which to measure producer insurance purchase and subsequent land-use decisions against an exogenous change in subsidies.

Our land-use data are derived from the 1992 and 1997 Natural Resources Inventory (NRI).   The NRI is a panel survey of land use and land characteristics on non-Federal lands conducted at five-year intervals from 1982 to 1997 over the 48 contiguous United States.   The data include approximately 844,000 points, each representing a land area given by a sampling weight inversely proportional to the sampling intensity (Nusser and Goebel 1997).   The NRI collects data on the same points over time, which makes it possible to estimate both land-use change and the characteristics of parcels undergoing change.   These data enable measurement of the extent, location, and environmental characteristics of land-use change due to crop insurance

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[2] An exception is the recent study by Goodwin, Vandeveer, and Deal (2004), which includes an analysis of wheat and barley production in the Northern Great Plains over 1997-98.

subsidies, compared to the previous literature that has examined net acreage changes at national, state, or county levels.

The Federal Crop Insurance Program

Beginning in the 1995 crop season, the Federal Crop Insurance Reform Act of 1994 (FCIRA) modified the federal crop insurance program by authorizing the USDA to offer essentially "free" catastrophic coverage to producers who grow an insurable crop.[3] Catastrophic coverage insures production losses falling below 50% of expected yield, indemnified at 55% of the expected market price of the insured crop.   The FCIRA allows farmers to purchase additional coverage that provides a higher yield or revenue protection, with the premium on this "buy-up" coverage subsidized by the government. For buy-up coverage, producers paid only a portion of the actuarial premium plus a small administrative fee. The share of the total premium paid by the government varies by coverage level. In 1997, the typical premium subsidy share was 42% on the 65% buy-up coverage.

The FCIRA had a large effect on the number of acres insured and the level of coverage (as measured by premiums paid). Figure 1 shows total subsidies, total premiums, and total acres enrolled in the crop insurance program from 1990 to 1998. The figure presents separate plots for all crops and for the three largest individual crops (in acreage): corn, soybeans, and wheat. In 1997, these three crops made up 78.9% of the acreage insured, 55.5% of the subsidies, 51.7% of the total premiums paid, and 53.8% of cultivated cropland (excluding hay). The figure illustrates the marked increase in crop insurance coverage following implementation of the FCIRA and suggests that the bulk of this increase stemmed directly from the increase in subsidies. There were large increases in premiums for most crops between 1992 and 1997. For barley, potatoes, and dry beans, premiums per acre harvested increased by about one-third; for wheat and

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[3] The premium on this level of coverage is fully subsidized by the government but farmers must pay a $50 per crop per county administrative fee.

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sorghum, premiums increased by about one-half; and cotton, corn, and soybean premiums increased by almost two-thirds.

Premium rates in the crop insurance program are set according to reported yield histories. Premiums (prior to subsidization) are nominally set at actuarially fair rates. Because premiums are subsidized, participation in the program is thus nominally profitable for all farmers. In fact, many argue that some premiums are set below actuarially fair rates for some farmers and above actuarially fair rates for other farmers (e.g., Serra, Goodwin, and Featherstone 2003; Just, Calvin, and Quiggen 1999; Coble *et al.* 1996; Vandeveer and Lohman 1994; Goodwin 1993). This occurs because yields are highly variable, which makes it difficult to determine actuarially fair premiums from often limited yield histories. Imprecise premium rates lead to the well known problem of adverse selection: farmers with premiums set too low are more likely to enroll as compared to farmers with premiums set too high. If farmers do not have a yield history, premiums are set according to transitional "T" yields, until yield histories have been established. T yields usually equal 60% of the county-average yield and may be lower or higher than farmers' expected yield, which may also lead to adverse selection.

Significant and persistent losses in the crop insurance program suggest that premiums are, in fact, below actuarially fair rates for a substantial number of producers (Glauber 2004). Just, Calvin, and Quiggen (1999) suggest that the risk reduction motive for crop insurance participation is small for most producers and that most crop insurance participants enjoy an increase in average returns over time because of errors in crop insurance premium rates and subsidies. Over the past decade, significant increases in premium subsidies have likely expanded the group of producers who enjoy positive expected (average) returns to crop insurance. Depending on the level of coverage purchased, premium subsidies can be as high as 67 percent, up from a maximum of 30 percent prior to 1994.[4] Further increases in crop insurance

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[4] Not including Catastrophic (CAT) coverage, which is offered at a 100 percent premium subsidy.

participation rates have been associated with the increased subsidies (Dismukes and Vandeveer 2001).

We estimate the change in land use between 1992 and 1997 as a function of the subsidy-induced change in expected return to crop insurance. Over this period, crop insurance was dominated by actual production history (APH) contracts, although revenue insurance products were introduced in selected counties in 1996 and purchase of these products has grown rapidly in the years since. For our empirical analysis, insurance return is computed as a weighted county-level average across eight major crops (corn, wheat, soybeans, cotton, sorghum, barley, oats, and rice) of the (expected) APH crop insurance indemnity minus the total crop insurance premium, net of the premium subsidy. Specifically, returns and expected returns to APH crop insurance can be written as:

$$R_{ni} = I_i - r_i + s_i$$
$$E(R_{ni}) = E(I_i) - r_i + s_i$$

where R_{ni} is the *change* in crop revenue due to insurance program participation; I_i is the crop insurance indemnity; r_i is the (total) crop insurance premium, s_i is the premium subsidy (the premium paid by producers is $r_i - s_i$) and E is the expectation operator. We estimate the expected indemnity as the average of indemnity payments over the previous 10 years, by county. Expected insurance returns for each of the eight crops are weighted based on the 1992 county acreage of each particular crop.

Our estimate of the change in expected return to crop insurance is based on buy-up coverage only. Catastrophic coverage (APH insurance with a 50% yield guarantee and 100% premium subsidy) was introduced in 1995. Producers participating in farm commodity programs in 1995 were required to purchase at least catastrophic coverage for a small, per crop, processing fee. This requirement was dropped for the 1996 and subsequent seasons, but re-enrollment was automatic unless producers notified agents of their intent to discontinue catastrophic coverage.

Because catastrophic coverage was required for commodity program participants in 1995, its purchase does not necessarily represent an expansion of crop insurance demand due to the subsidy change. In 1996, automatic re-enrollment may have caught some producers unaware

resulting in larger purchases than would have otherwise been the cases. Indeed, purchase of catastrophic coverage declined throughout the late 1990s, suggesting that many producers would not have purchased catastrophic coverage except for the commodity program requirement. Moreover, the data suggest that net return to catastrophic coverage is less than that of buy-up coverage, even with the 100 percent premium subsidy, approaching zero in many cases. Factoring in catastrophic coverage may actually reduce the average return to crop insurance. Thus, the change in expected return to buy-up coverage (coverage of 65% or higher) is likely to better reflect the change in expected return to crop insurance due to the subsidy increase for those producers who made a positive decision to purchase crop insurance based on the expectation of an economic return.

Modeling Land-Use Change

Land use is driven by profitability that varies over time and space. Crop insurance subsidies increase the expected returns and reduce the risk of crop production and thereby provide farmers with an incentive to increase land in cultivated crops. To estimate this effect, we consider a model of land use change that incorporates both observed and unobserved factors affecting the profitability of alternative uses.

The landowner's profit function may be thought of as including both observed and unobserved components. Using a general random utility expression, the expected net return (utility) to the landowner on parcel i from converting from use j to k at time t can be specified as:

$$U_{ijkt} = f(X) + \varepsilon_{ijkt}$$

where ε_{ijkt} is a random error term. Assuming that the error terms ε_{ijkt} are independent and identically distributed with the type I extreme value distribution yields the probability that parcel i transitions from use to j to use k between t and $t+1$ can be written as:

$$\text{Prob}(U_{ijkt} > U_{ijlt}) = P_{ijkt} = \frac{\exp(U_{ijkt})}{\sum_{l=1}^{J} \exp(U_{ijlt})}$$

This is the general formulation of a conditional logit model (McFadden 1974).[5]

We assume landowners base their expectation of future net returns based on the current and historical net returns to each particular use. If land-use patterns are initially in equilibrium, then only the changes in the relative levels of profits, and not the levels of profits themselves, should drive observed land-use transitions between two periods. Although our focus is on land-use changes over time (1992-1997), we include 1992 profit levels (as well as the 1992-1997 changes in these levels) in our analysis because the levels will matter if land markets were in fact in disequilibrium in the initial period. Because our measures of profits are not normalized to any one use, we also include profit levels because they indicate the relative profits among alternative uses. Relative profits will matter for land-use changes if hurdles in relative rents must be crossed to induce landowners to convert from one land use to another. To control for net returns to crop insurance in the initial period (1992), we include the county-level share of insurance program participation for the eight major crops considered. Insurance participation reflects initial cross-sectional differences in the relative returns from insurance participation.

Although the profits of alternative land uses for each NRI observation are not observed, we have information on certain parcel-level attributes and condition our estimates on these attributes as well as on interactions between the attributes and county-level profits and profit changes. We include these interactions because lands with different attributes may be more or less likely to convert from one use to another, especially because our measures of relative profits are based on relatively coarse county-level data. In this way, we model some within-county variation in land-use profits from the different activities. The parcel-level attributes, plus an intercept that varies by land-use transition, also proxy for the costs of converting land from its current use to each of the six land-use alternatives. These attributes include observation-specific indicators of land quality (Land Capability Class), erodibility, average slope gradient, and

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[5] The term "conditional" logit or "discrete choice" logit (Greene 1998) is sometimes used for a logit model in which the independent variables vary only over the choices, in contrast to a "multinomial" logit, in which explanatory variables vary only over the individuals but not over the choices. We use "conditional" logit for the more general model used here, which has terms varying over both choices and individuals, as it is structurally analogous to the conditional logit once individual characteristics are interacted with choice-specific dummy variables.

flooding frequency. Further descriptions of the model variables are provided in the following section.

We also include a polynomial trend surface unique to each land-use alternative to control for unobserved factors correlated with location. This approach includes a measure of geographic location as an explanatory variable and is a common approach in spatial statistics (Venables and Ripley 1994). This approach differs from an approach common in the literature on spatial econometrics, which uses a spatially-autorcorrelated error structure (*e.g.* Anselin 1988). Such spatial-autocorrelation models are difficult to implement with limited dependent variables, especially in studies (like ours) with more than a few hundred observations.[6]

We estimate separate models for each of the four starting land-uses *j* (cultivated crops, uncultivated crops/pasture, forests, and range) that allow for six land-use alternatives *k* (cultivated crops, uncultivated crops or pasture, CRP, range, forest, and urban). Each model is based on the same specification. After examining several functional forms for $f(X)$, we chose a linear model that considers all possible two-way interactions between the parcel-level indicator of land quality (LCC) and the estimates of county-level levels and changes in levels of land-use profits. Two-way interactions between LCC and the other parcel-level measures are also included, and other explanatory variables (described below) are included without interactions.[7] Dropping the time subscripts, we specify the component of utility that is unique to each alternative *k* (and initial land use *j*) as:

$$f(X) = U_{ijk} - \varepsilon_{ijk} = \alpha_{jk}^0 + \alpha_{jk}^s LCC_{jk}^q + \beta_{jk}^s LCC_{jk}^q R_{jk}^c + \theta_{jk}^s LCC_{jk}^q x_{jk}^s + \alpha_{jk}^s x_{jk}^s + \beta_{jk}^c x_{jk}^c,$$

where α_{jkt}^0 is an alternative-specific intercept, α, β and θ are parameters, R_{jk}^C are net returns (and changes) to use *k* in county *c*, LCC_{it}^q is a dummy variable indicating whether parcel *i* is of quality *q* at time *t*, and x_{jk}^s and x_{jk}^c denote other explanatory variables measured at the parcel-

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[6] A limited dependent variable model with spatial autocorrelation could be estimated using simulation methods. However, this is very computationally expensive. Unlike the spatial-autocorrelation model, a polynomial surface is easier to estimate, does not assume unobserved factors are uncorrelated with observable factors, and does not impose spatial correlations that are inversely associated with sampling density.

[7] The choice of these additional parcel and county-level variables was determined through a process in which terms were dropped and added successively in order to minimize the Akaike (1974) information criterion (AIC).

specific and county-level, respectively.

CRP participation depends on a different set of decisions than other land-use choices, because enrollment depends on both the landowner's bid, which includes a proposed rental rate, and the government's choice of whether to accept the bid, which depends on the environmental characteristics of a parcel as well as the cost. Because the program targets cropland retirement, CRP rental rates are highly correlated with the profitability of cropping in a given locality. We account for the effect of crop net returns on the incentive to remain in cropland. Incentives to enroll in CRP are specified as a function of LCC, the other parcel-level variables, and a spatial trend surface unique to this alternative. Lower land quality as measured by LCC has always been strongly associated with program eligibility so we would expect greater enrollment on lower quality lands.

The econometric model described above estimates the probability that an NRI parcel transitions from its current use to any of six major land-use alternatives (cultivated crops, uncultivated crops and pasture, CRP, range, forest, and urban) between 1992 and 1997. To identify the magnitude of these effects, parameters from the model are used to simulate 1997 land use under a hypothetical case in which there was no change in crop insurance subsidies over the previous five years. The difference between land use under this scenario and land use in reality — which reflects the effects of the actual 1992-97 change in insurance returns — provides an estimate of the land-use effects of the 1994 change in crop insurance premium subsidies.[8]

In the simulations, land-use change probabilities are estimated for each NRI observation in the sample based on the estimated parameters. These probabilities are multiplied by the acreage weight for each observation to estimate the amount of land transitioning from each initial

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[8] In our analysis, we do not compare land use under the counterfactual scenario of no crop insurance subsidy increase to the observed patterns of land use reported in the 1997 NRI. Rather, we compare the counterfactual scenario to land use under a simulated "factual" baseline predicted from our estimated parameters fitted with the actually observed values for the change in insurance returns and all other variables. In this way, we produce estimates of the land-use impacts of the change in crop insurance returns that are internally consistent within the framework of the econometric model.

use to each of the six land-use alternatives. These amounts are also used as weights in determining mean land characteristics of acres affected by the crop insurance subsidy increases

Data

The likelihood that a land unit transitions from one land use to another is estimated based on repeated observations of non-federal land use from the National Resources Inventory (NRI). Our analysis is based on a subset of 657,781 observations from the NRI that consists of lands that were in cultivated crops; uncultivated crops and pasture; forest; or range in 1992 and any of our six alternative uses in 1997. The land base in our analysis comprises about 1.3 billion acres, representing about 69% of non-federal land in the contiguous United States.

Crop insurance program data are available from the Risk Management Agency (RMA), USDA. The data include total indemnities, total premiums, and the subsidy by crop, insurance product, and county. We constructed the land-use profit variables (and changes in these variables) using county-level data derived from a number of sources to approximate revenues less variable costs for each the six land-use activities (see Appendix). In addition to our measure of net returns from urban development, we include the 1990 "urban influence" code for the centroid of each county. This variable is a distance-weighted measure of access to population centers based on the 1990 Census and is included as an additional proxy for urban development pressures, given the coarse nature of our urban profit estimates (Heimlich and Anderson 2001).[9] In addition to crop net returns derived from the market, government payments for 1997 are included as a proxy for prior participation in government commodity programs and the effect of the major policy change that "decoupled" these commodity payments in 1996. The 1996 Federal Agriculture Improvement and Reform Act (FAIR) removed most conditions on plantings and conditioned payments on prior planting histories as opposed to

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[9] Interaction terms between the urban influence code and the urban net returns (and changes) are also included.

current planting decisions. As a result, payments received in 1997 are an indication of program participation prior to 1996 and the resulting "base acres" assigned under the 1996 Act.

Summary statistics are provided for each of our county and parcel-specific variables (tables 1 and 2). To control for unobserved factors correlated with location, we estimate models with a spatial polynomial surface trend. To estimate this trend, we assign to each point a measure of location, proxied by longitude and latitude coordinates for the centroid of each NRI polygon.[10] We include these coordinates (interacted with an alternative-specific constant) singly and in all second and third-order interactions.[11]

Results

The included variables explain a significant share of the variation in land-use changes, with pseudo R^2 measures ranging from 0.71 to 0.86. The estimated parameters are consistent with economic intuition, with the profits variables (and changes in profits) for each land-use alternative generally significant and positively associated with a greater likelihood of transitioning to each respective use.[12]

The change in crop insurance returns, all else equal, is positively related to the likelihood that land transitioned to cultivated cropland from another use as well as the likelihood that land that was cultivated in 1992 remained cultivated in 1997. The counterfactual analysis (with the change in insurance net returns assumed zero) indicates that the change in crop insurance premium subsidies in the mid 1990s increased total cultivated cropland area in 1997 by roughly 1.9 million acres or 0.64 percent, with the bulk of this land (1.5 million acres) coming at the expense of uncultivated crops, pasture, and range (table 3).

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[10] NRI polygons are land areas defined by the intersections of all counties and 9-digit watershed classifications. To protect the confidentiality of landowners sampled by the NRI, more specific location indicators are not publicly available.

[11] Denoting the location coordinates as *x* and *y*, we include *x, y, xx, yy, xy, xxx, yyy, xxy,* and *xyy* as explanatory variables. For the equations for the CRP and range choices, only a second-order surface could be estimated due to the smaller number of observations.

[12] For brevity, given the large number of variables and equations, individual parameter estimates are not reported but are available from the authors upon request.

The added croplands due to the higher insurance subsidies are located largely in the Prairie Gateway region (roughly the Southern and Central Plains) up through Northeast Wyoming, Western Nebraska, and South Dakota. Additional clusters are in the Mississippi Portal, along the Eastern Seaboard, and to a lesser extent in the Central Valley of California. The Heartland (Missouri, Iowa, Illinois, Indiana, Ohio) has virtually no estimated lands in production due to the change in crop insurance subsidies. This pattern can perhaps be explained by variation in the actuarial performance of the crop insurance program. In particular, the actuarial performance of the federal crop insurance program has historically been better for corn and soybeans in the Midwest, and poorer for cotton in the Southern Plains (Young, Vandeveer, and Schnepf 2001). As one would expect, we see lands shifting into crop cultivation as a result of crop insurance in areas where crop insurance is a better deal for farmers (e.g. the actuarial performance is worse), and few shifts in areas where the actuarial performance has been better.

Discussion

Most researchers who have studied the impact of crop insurance on land use have found that land-use effects are small, on the order of 1-2 million acres (Goodwin, Vandeveer, and Deal 2004; Young, Vandeveer, and Schnepf 2001). One study — an unpublished manuscript by Keeton, Skees, and Long (2000) — argues that the increase in crop insurance subsidies during the mid-1990s led to the introduction of 15 million new cropland acres (50 million if land in CRP is included) or about 5 percent of cultivated cropland.

Our estimates are not directly comparable to previous studies. Compared to other studies, we use data from a more recent time period and focus only on the impacts of the 1992-97 changes in the crop insurance subsidies, rather the overall impacts of the crop insurance program as a whole. Nevertheless, our estimates likely capture a significant share of the program's overall impact given that crop insurance participation and total premiums more than doubled over the 1992-97 period. During these years, insured acreage increased from 83 to 182 million acres while total premiums increased from 0.7 to $1.8 billion (Glauber and Collins

2002). If the program's impact on acreage is assumed to be proportional to the total premium levels, our estimated effect of the 1992-97 subsidy change would capture about 57% of the overall effect of the total crop insurance program, which would thus be 3.3 million acres (1.1% of total cultivated cropland). This estimate is larger than other estimates, based on a policy simulation model, that insurance subsidies in 2000 increased total planted cropland area by about 1 million acres or 0.6% (Young, Vandeveer, and Schnepf 2001). However, our estimated effect of the 1992-97 subsidy change is in the range of the most recent empirical estimates that a 30% increase in premium subsidies (more than twice the 1992-97 change) would increase acreage of major crops from 0.2 to 1.1% (Goodwin, Vandeveer, and Deal 2004).[13]

In general, the analysis indicates that crop insurance effects are largest for low quality and some environmentally sensitive land. When compared with national average for overall cultivated cropland, our estimate of land retained in cultivated crops due to subsidy increases includes disproportionately large shares of low quality (high LCC) land and highly erodible land (table 4).[14] For example, an estimated 36 percent of acres retained in crops due to insurance subsidies were highly erodible versus 25 percent of cropland overall.

Our findings also lend some support to claims that lands brought into production due to crop insurance subsidies are more likely to lie in floodplains and, in the case of wetlands, on environmentally sensitive ecosystems than croplands overall. Our estimates indicate that the additional croplands due to the crop insurance subsidy increases have a higher incidence of frequent flooding as well as a greater share of wetland acreage than the average cultivated cropland nationally (tables 4). Total wetlands cropped as a result of the 1992-97 crop insurance subsidy increase are estimated at 86 thousand acres, roughly 1.6 percent of the 5.4 million acres of wetlands under crop cultivation. From a different perspective, these 86 thousand acres are about half of the 163 million acre net loss in non-federal wetland area between 1992 and 1997

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[13] Premium subsidies for the 65% coverage level were set at 30%, 42% and 59%, respectively, under the major crop insurance acts of 1980, 1994, and 2000 (Goodwin, Vandeveer, and Deal 2004). Linearly scaling their estimates upwards to reflect a 42% change suggests cropland increases from 0.3 to 1.5% compared to 0.6% from our analysis.
[14] Given the relatively small numbers of land parcels affected by the change in crop insurance subsidies, local comparisons are not statistically significant and are not reported.

(USDA-NRCS 2000). Ending crop production on these acres and restoring them to better wetland condition *could* make a difference in the overall loss of wetland function. Of course, realizing these gains may require more than just discontinuing crop production on these wetland areas.

Conclusion

We investigated the acreage response to the 1994 crop insurance premium increases by estimating the change in crop acreage between 1992 and 1997 as a function of this exogenous change in expected return to crop insurance. A conditional logit model including six land major uses (crops, pasture, CRP, range, forest, and urban) is estimated for the entire coterminous U.S. Using the estimated parameters, we perform a counter-factual analysis to estimate land use in the absence of the crop insurance subsidy increase. Results from counter-factual simulations indicate that the increase in crop insurance premium subsidies increased cultivated cropland area on the order of 1.9 million acres (0.6%), consistent with the lower range of previous estimates of crop insurance acreage effects. The estimated additional lands in production due to the change in insurance subsidies are of lower quality than cropland overall in term of both Land Capability Classification and proneness to flooding, as well as more environmentally sensitive in terms of erodibility and proportion designated as wetlands.

Given this evidence that crop insurance encourages crop production on land that is both economically and environmentally marginal, crop insurance subsidies may be working at cross purposes to agri-environmental programs such as the CRP, as other researchers have suggested (e.g. Goodwin and Smith 2003). That is true to the extent that land which has been retained in cultivated crops due to the crop insurance subsidy increase is also targeted for CRP enrollment. In the case of highly erodible land, acres estimated to be retained in crop production due to crop insurance and acres enrolled in CRP are both, on average, more erodible than overall cropland (table 4). That is not true of wetland or land subject to frequent flooding. While land estimated to be retained in crops due to the insurance subsidy increase is more likely than overall cropland

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to contain these land types, CRP is less likely to enroll these lands (table 4). Moreover, the spatial distribution of CRP enrollments is somewhat different from that of the estimated additional croplands resulting from the 1992-97 increase in crop insurance premium subsidies (figure 2). The lands in production due to the change in subsidies (the red dots) are clustered in certain regions and not uniformly spread through the areas of CRP (the green dots).

These results suggest that increasing crop insurance subsidies may be working at cross-purposes to CRP in terms of encouraging crop production on erodible lands. By encouraging production in wetland areas, increasing subsidies may also be undermining broader program goals in terms of wildlife habitat protection. Nevertheless, the overall estimate of cropland area affected by the change in crop insurance subsidies in the mid 1990s is relatively small relative to the cropland base and the 34 million acres in CRP. As a result, the aggregate environmental impacts attributable to the increase in insurance subsidies are probably modest, though local effects may be significant.

We have no information on how the environmental costs of crop insurance subsidies compare to the insurance benefits at either national or local levels. Nevertheless, our results could help identify the areas where the tradeoffs might be greatest. Conservation efforts could perhaps yield greater benefits if they were specially targeted to those areas where insurance policies are having the greatest impact. While our study focused on the change in insurance subsidies between 1992 and 1997, premium subsidies were increased further in 1999 and 2000. To the extent that the marginal effects of crop insurance subsidies are non-linear, these latest subsidies might have greater or smaller effects per dollar than those identified in our analysis. When micro-data from the NRI's annual surveys for 2001-2005 become available, future research could apply a similar methodology to examine the impact of this latest round of crop insurance subsidy increases.

Figure 1. Insurance Coverage of all Crops and Largest Individual crops in Years Before and After the Federal Crop Insurance and Reform Act (FCIRA) of 1994
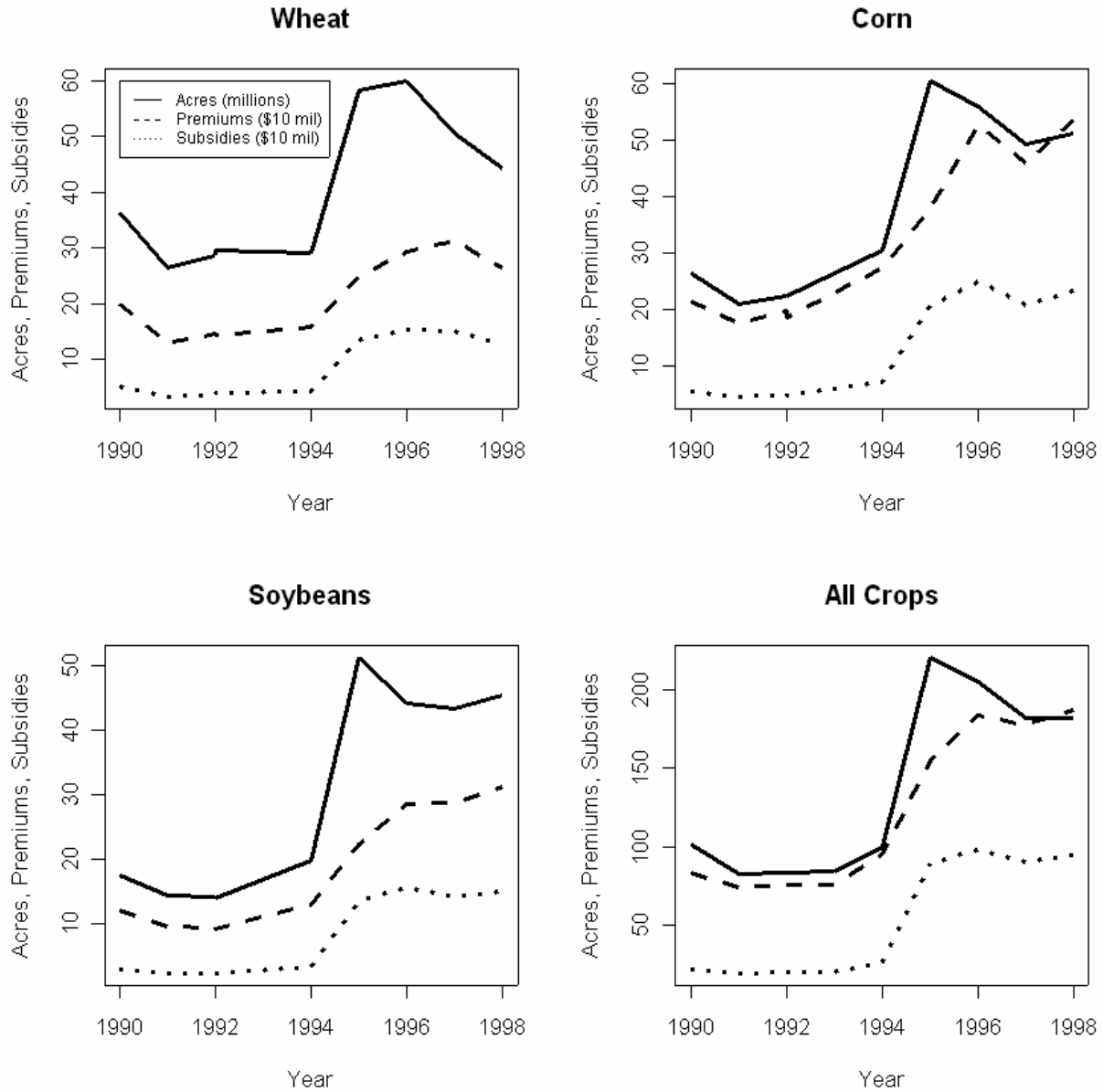
Source: Risk Management Agency (RMA).

Table 1. Summary Statistics: County-Level Variables

County-Level Variable	No. of Obs.	Mean	Std. Dev.	Min.	Max.
Crop net returns in 1992 ($/acre/year)	657,781	16.9	51.1	-829.2	294.3
Pasture net returns in 1992 ($/acre/year)	657,781	-3.0	76.3	-599.8	200.3
Forest net returns in 1992 ($/acre/year)	657,781	6.9	9.8	-1.2	92.6
Range net returns in 1992 ($/acre/year)	657,781	9.0	10.3	0.0	73.9
Urban net returns in 1992 ($/acre/year)	657,781	2,224	2892	183	3,6944
Urban influence code in 1990	657,781	1.40	0.89	1	5
Total government payments in 1997 ($/acre/year)	657,781	8.4	5.9	0.0	47.3
% of eligible crop acres insured in 1992	657,781	0.4	2.6	0.0	92.0
Change in Insurance net returns, 1992-1997 ($/acre/year)	657,781	1.8	4.3	-37.1	40.2
Change in crop net returns, 1992-1997 ($/acre/year)	657,781	15.1	62.9	-819.1	939.0
Change in pasture net returns, 1992-1997 ($/acre/year)	657,781	2.2	5.4	-8.2	52.0
Change in forest net returns, 1992-1997 ($/acre/year)	657,781	0.2	2.4	-8.6	12.3
Change in range net returns, 1992-1997 ($/acre/year)	657,781	36.2	65.5	-175.2	575.5
Change in urban net returns, 1992-1997 ($/acre/year)	657,781	14.1	891	-1610	10769

Source: Various sources described in the Appendix.

Table 2. Summary Statistics: Observation-Specific Variables

NRI Point-Level Variable	No. of Obs.	Mean	Std. Dev.	Min.	Max.
Land in cultivated crops in 1992 (yes=1, no=0)	657,781	0.25	0.44	0	1
Land in uncultivated crops/ pasture in 1992 (yes=1, no=0)	657,781	0.13	0.34	0	1
Land in forests in 1992 (yes=1, no=0)	657,781	0.31	0.46	0	1
Land in range in 1992 (yes=1, no=0)	657,781	0.31	0.46	0	1
Land in cultivated crops in 1997 (yes=1, no=0)	657,781	0.25	0.43	0	1
Land in uncultivated crops/ pasture in 1997 (yes=1, no=0)	657,781	0.13	0.33	0	1
Land in forests in 1997 (yes=1, no=0)	657,781	0.31	0.46	0	1
Land in range in 1997 (yes=1, no=0)	657,781	0.31	0.46	0	1
Land in CRP in 1997 (yes=1, no=0)	657,781	0.00	0.04	0	1
Land in urban use in 1997 (yes=1, no=0)	657,781	0.01	0.09	0	1
Land Capability Class 1-2 (yes=1, no=0)	657,781	0.23	0.42	0	1
Land Capability Class 3-4 (yes=1, no=0)	657,781	0.33	0.47	0	1
Land Capability Class 5-8 (yes=1, no=0)	657,781	0.43	0.49	0	1
Highly erodible land (yes=1, no=0)	657,781	0.44	0.49	0	1
Land prone to frequent flooding (yes=1, no=0)	657,781	0.04	0.18	0	1
Slope % greater than 15 [a] (yes=1, no=0)	657,781	0.01	0.11	0	1
Land irrigated (yes=1, no=0)	657,781	0.05	0.22	0	1
Acreage weight (NRI xfact in acres)	657,781	1,980	2,368	100	192,200

[a] Lands with slope percentages greater than 15 are considered as having "strong" to "very steep" slopes.
Source: 1997 National Resources Inventory. Observations were included if they were in cultivated crops, uncultivated crops, pasture, forests, or range uses in 1992 and in cultivated crops, uncultivated crops, pasture, forests, range, CRP or urban uses in 1997.

Table 3. Estimated of 1994 Crop Insurance Subsidy Change on 1997 Land Use

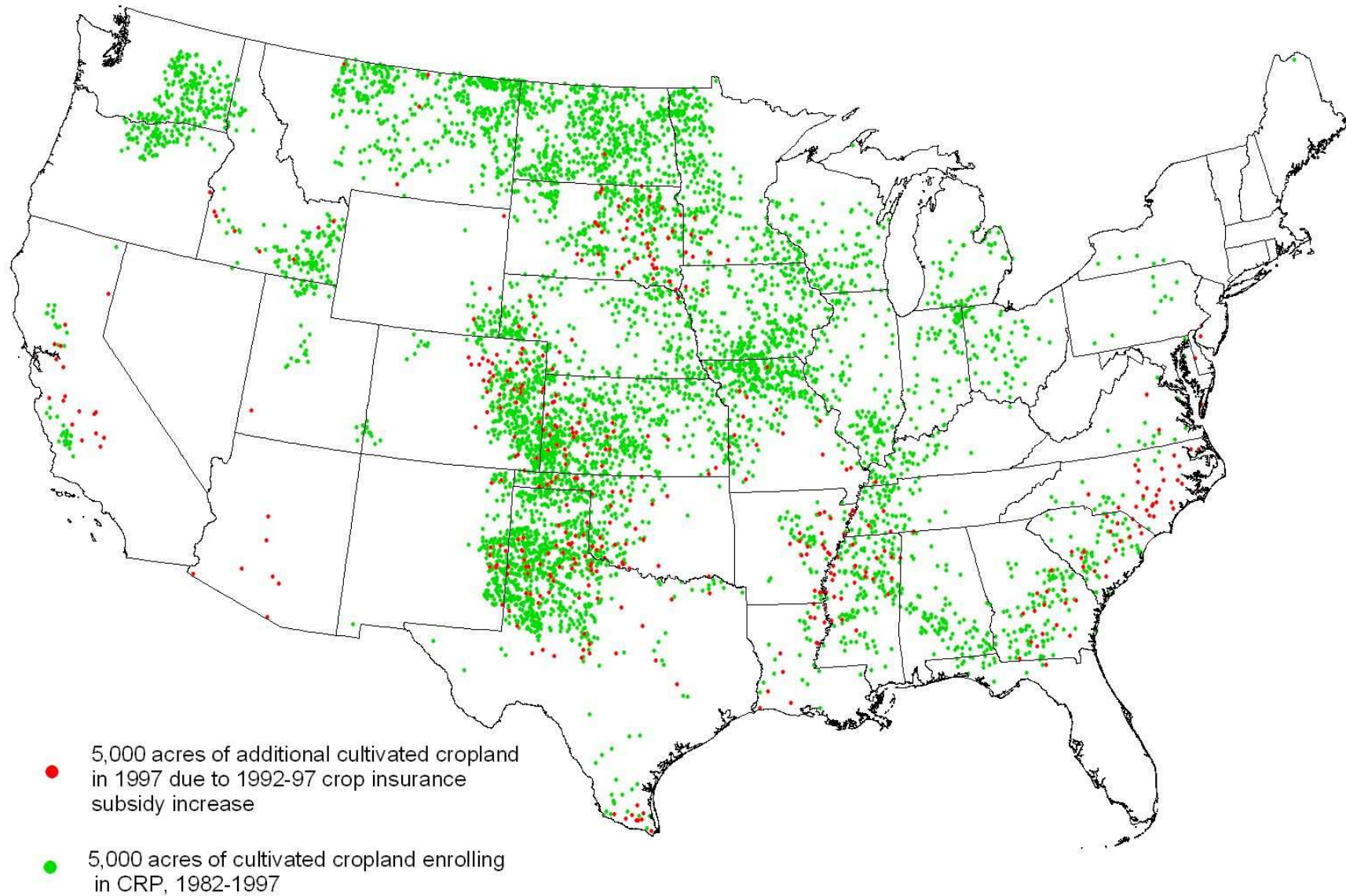| Land Use	Actual Policy *1992-97 Subsidy Increase* (1,000 acres)	Counterfactual *No Subsidy Increase* (1,000 acres)	Estimated Impact of Policy (1,000 acres)	Estimated Impact of Policy (%)
	A	B	A-B	100*(A-B)/A
Cultivated Crops	300,639	298,725	1,914	0.64%
Uncultivated Crops and Pasture	181,257	181,473	-1,216	-0.67%
Forest	391,534	391,581	-47	-0.01%
Urban	69,672	69,967	-294	-0.42%
CRP	35,721	35,696	-24	-0.07%
Range	400,294	400,627	-333	-0.08%

Source: 1997 National Resources Inventory and estimates from this study.

Table 4. Land Characteristics at Crop-Insurance Policy Margin, Relative to CRP and Other Croplands

Land Characteristic	Predicted Land in Cultivation in 1997 due to Crop Insurance Subsidy Change	All Cultivated Cropland in 1997	CRP Land in 1997
% LCC 1-2	43%	56%	23%
% LCC 3-4	41%	40%	65%
% LCC 5-8	16%	4%	12%
% Highly Erodible	36%	25%	56%
% Wetland- Cowardin	4.5%	2.5%	1.8%
% Frequently Flooded	2.7%	1.8%	0.9%

Source: 1997 National Resources Inventory and estimates from this study

Figure 2. Location of CRP Enrollments and of Additional Cropland Estimated Due to Crop Insurance Subsidy Increases

● 5,000 acres of additional cultivated cropland in 1997 due to 1992-97 crop insurance subsidy increase

● 5,000 acres of cultivated cropland enrolling in CRP, 1982-1997

Source: 1997 National Resources Inventory and estimates from this study.

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Appendix: County-Level Land-Use Profits

Crop Net Returns: Data on prices, yields, costs, and acres are used to compute a weighted county-level average of the net returns per acre for 21 major crops. State-level marketing-year-average prices and county-level yields are from the National Agricultural Statistics Service (NASS). Landowners are assumed to form expectations of future land-use returns based on current prices and the average of yields over the previous five years. Data on cash costs as a share of revenue at the state and regional level, respectively, are from the Census of Agriculture and the Economic Research Service's (ERS). County acreage from NASS and the Census of Agriculture provided weights for averaging across individual crops.

Government Payments: County-level estimates of total federal program payments per acre are from the Census of Agriculture and include receipts from deficiency payments, support price payments, indemnity programs, disaster payments, and payments for soil and water conservation projects. Conservation Reserve and Wetlands Reserve program payments are excluded.

Pasture Net Returns: Annual net returns per acre for pasture are estimated using pasture yields from the SOILS-5 database linked to the NRI, state prices for "other hay" from NASS, and per acre costs for hay and other field crops from the Census of Agriculture.

Range Net Returns: Annual rangeland net returns per acre are computed with forage yields from SOILS-5 and state-level per head grazing rates for private lands from ERS.

Forest Net Returns: We use a 5 percent interest rate to annualize the estimated net present value of a weighted average of sawtimber revenues from different forest types based on prices, yields, costs, and acres. State-level stumpage prices were gathered from state and federal agencies and private data services. Regional merchantable timber yield estimates for different forest types were obtained from Richard Birdsey of the U.S. Forest Service. Regional replanting and annual management costs were derived from Moulton and Richards (1990) and Dubois, McNabb and Straka (1999). The Faustmann formula was used to compute the optimal rotation age, assuming forests start newly planted at year zero. County acreage and timber output data from the Forest Inventory and Analysis (FIA) and Timber Product Output (TPO) surveys of the U.S. Forest Service provided weights for averaging across individual forest types and species, respectively.

Urban Net Returns: Annual urban net returns per acre are estimated as the median value of a recently-developed parcel, less the value of structures, annualized at a 5 percent interest rate. Median county-level prices for single family homes were constructed from the decennial Census of Population and Housing Public Use Microdata Samples and the Office of Federal Housing Enterprise Oversight (OFHEO) House Price Index. Regional data on lot sizes and the value of land relative to structures for single-family homes were from the Characteristics of New Housing Reports (C-25 series) and the Survey of Construction (SOC) micro data from the Census Bureau.

Further descriptions of these data are provided in Lubowski (2002) and are available upon request.