Appendix A—Land-Use Data

To fully investigate the dynamics of land-use change, we use data on **gross** land-use change, obtained from the National Resources Inventory (NRI). The NRI is an area-based survey conducted by USDA's Natural Resources Conservation Service (NRCS), in cooperation with Iowa State University. NRI provides information on land use, land characteristics, and conservation practices for about 800,000 points of nonfederal land across all U.S. counties except for Alaska. Because most of the same points were sampled at 5-year intervals, the NRI allows us to investigate gross land-use changes over time. Since the 1997 survey, the NRI has changed its procedures to sample fewer points annually. Based on the new annual sample, NRCS provides annual estimates of national land use and summary information on selected land-use transitions.[1]

[1]Point-level data are publicly available for the 5-year NRI surveys, enabling the analysis of three land-use transitions for each sample point (1982-87, 1987-92, 1992-97). At the time of this study, point-level data were not publicly available for the annual surveys started in 2001.

Because NRI is a survey rather than a full enumeration of all land, estimates of land-use change are subject to a small amount of error. For estimates of land use and land-use change at the regional and national level, these errors are quite small and are not reported in tables to avoid clutter. In some cases, however, data presented in the form of maps is aggregated to the 8-digit Hydrological Unit Code (HUC). In these cases, only estimates that are statistically different from zero with 90 percent confidence are displayed.

The NRI places land uses into one of 58 categories, with special emphasis on classifying various categories of cropland. The NRI aggregates these 58 specific land uses into 12 broad land-use categories. We focus on changes between four categories: cultivated crops; uncultivated crops; CRP; and grazing, forest, and other rural land.

Cultivated cropland primarily includes the cropland uses that require more intensive management and have the potential to yield higher values (although summer fallow and set-aside acres are also included). In contrast, uncultivated cropland primarily includes hay with no rotation, a lower value and lower intensity use of cropland. Grazing, forest, and other rural lands include pasture, range, forestland, and other farm lands such as farmsteads.

Appendix table A-1

Land-use classifications in this report based on the National Resources Inventory (NRI)

Classification in this report	NRI broad use categories	NRI specific land-use categories
Cultivated cropland	Cultivated cropland	• Row crops • Close crops • Hay with close/row rotation • Pasture with close/row rotation • Double-cropped horticulture • Set-asides, summer fallow, and aquaculture
Uncultivated cropland	Uncultivated cropland	• Single-cropped horticulture • Hay with no rotation
Conservation Reserve Program (CRP)	Conservation Reserve Program (CRP)	Conservation Reserve Program (CRP)
Grazing, forest, and other rural land	• Pasture • Rangeland • Forestland • Other rural land	• Pasture • Rangeland • Forests grazed and ungrazed • Other farm & rural land
Developed land	• Urban/built-up • Rural transportation	• Urban/small built-up • Urban/10 acres or larger • Rural transportation
Water and Federal land	• Small water areas • Census water areas • Federal land	• Small & large streams • Small & large water bodies • Federally owned land

Appendix B—EPIC-Based Nutrient Loss Indicators

This appendix describes how indicators for nitrogen and phosphorus loss to water were simulated using the Environmental Policy Integrated Climate Model (EPIC) for different crop production activities, as well as pastured land or land planted to trees. EPIC is a crop biophysical simulation model that is used to estimate the impact of management practices on crop yields, soil quality, and pollution discharged at the field level (Mitchell et al., 1998). It uses information on soils, weather, and management practices—including specific fertilizer rates—and produces information on crop yields, erosion, and chemical losses—including nitrogen losses—to the environment. Cropping and management practices used in the EPIC management files were set consistent with agronomic practices for highly erodible (HEL) and non-highly erodible (non-HEL) land in 45 farm production regions (see app. fig. B-1).

Cropping Enterprises

The National Resources Inventory (NRI) and Agricultural Resource Management Surveys (ARMS) were used to identify 62 crop rotations commonly used throughout the United States and the tillage practices commonly associated with them. This totaled 623 systems, which include rotations of up to four crops differentiated by up to five tillage practices. Rotations were defined based on the number of crops contained in the cropping history. NRI records were divided into regions by overlaying the 26 Land Resource Regions onto the 10 Farm Production regions (fig. app. B-1). Records were then differentiated by HEL or non-HEL. Acreage for each rotation was then recorded. Tillage practices associated with the rotations and the acreage devoted to them were derived from the CPS. Crop rotations as identified through the NRI were used to group the CPS records.

Running EPIC simulations for the predominant systems (and the physical impacts of these systems—yields and environmental effects) required obtaining all the management information needed to mimic the complete production cycle of any crop in a rotation. This included information on all field operations from pre-planting to post-harvesting (i.e., what occurred, when it occurred, with what type of equipment, and how frequently) and input levels (i.e., seeding rates, fertilization and liming rates, pesticide applications, etc.) for each crop within a production activity sorted by rotation, tillage practice, and region.

Fertilizer regimes for each crop in a rotation-tillage system were derived from the fertilizer information contained in ARMS. The means for total quantity of nitrogen (N), phosphate (P), and potash (K) were used to determine how many pounds per acre of N, P, and K to apply to each system. Likewise, liming information was used to determine lime applications. Also, the most frequently occurring month(s) were used to set fertilization date(s).

ARMS data were also used to determine how many field or tillage operations (other than planting, fertilizing, or spraying) occurred for a crop (again, by farm production region, specific to each crop within a rotation-tillage system). The mean number of machinery operations reported in

ARMS for that crop (rounding up or down to an integer, according to convention) was used. Here too, ARMS data determined the most frequently occurring time(s) of field (tillage) operations.

In matching values to NRI observations according to land use, the estimated EPIC values for land in single-hay rotations were used for uncultivated cropland, while values for land in all other rotations (including mixed-hay rotations) were assigned to cultivated cropland. Values for pasture land were used for both pasture and rangeland while values for land in trees were used for forests. Idle cropland and forest values were used for CRP land depending on whether grass/legumes or trees/wildlife cover were reported in the NRI.

EPIC Model Runs

We generate an array of environmental indicators associated with each crop production activity, as well as pastured land or land planted to trees, by running EPIC in two steps. The first step conditions the soil, while the next is used to calculate average rate of discharge. Each step was run to generate separate environmental values for HEL and non-HEL.

The first or conditioning step allows EPIC to rectify any inconsistencies in the soil profile imported from STATSGO data set.[1] It involves running EPIC out for 5 years while keeping its soil erosion module turned off. This step makes the soils profile at the next step consistent with a field that has been subjected to the management practices being simulated. This is important because any particular soil profile used does not necessarily come from a field where the system being simulated has been used.

[1]See *http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/metadata/index.html*.

In the next step, environmental indicators are calibrated by running EPIC out for 60 years, this time with soil erosion turned on. Total discharges for each indicator are tabulated and divided by the length of the simulation to obtain the annual rate of discharge. Running the systems for 60 years does two things: it eliminates the dependence of the discharge from the sequence of weather for any particular period and it provides a consistent base for making comparisons between systems. By eliminating the dependence on weather, we do not have to coordinate weather patterns among the various weather sites. Therefore, all systems are run through two full weather cycles. At the same time, each management regime is run through at least five full management cycles.

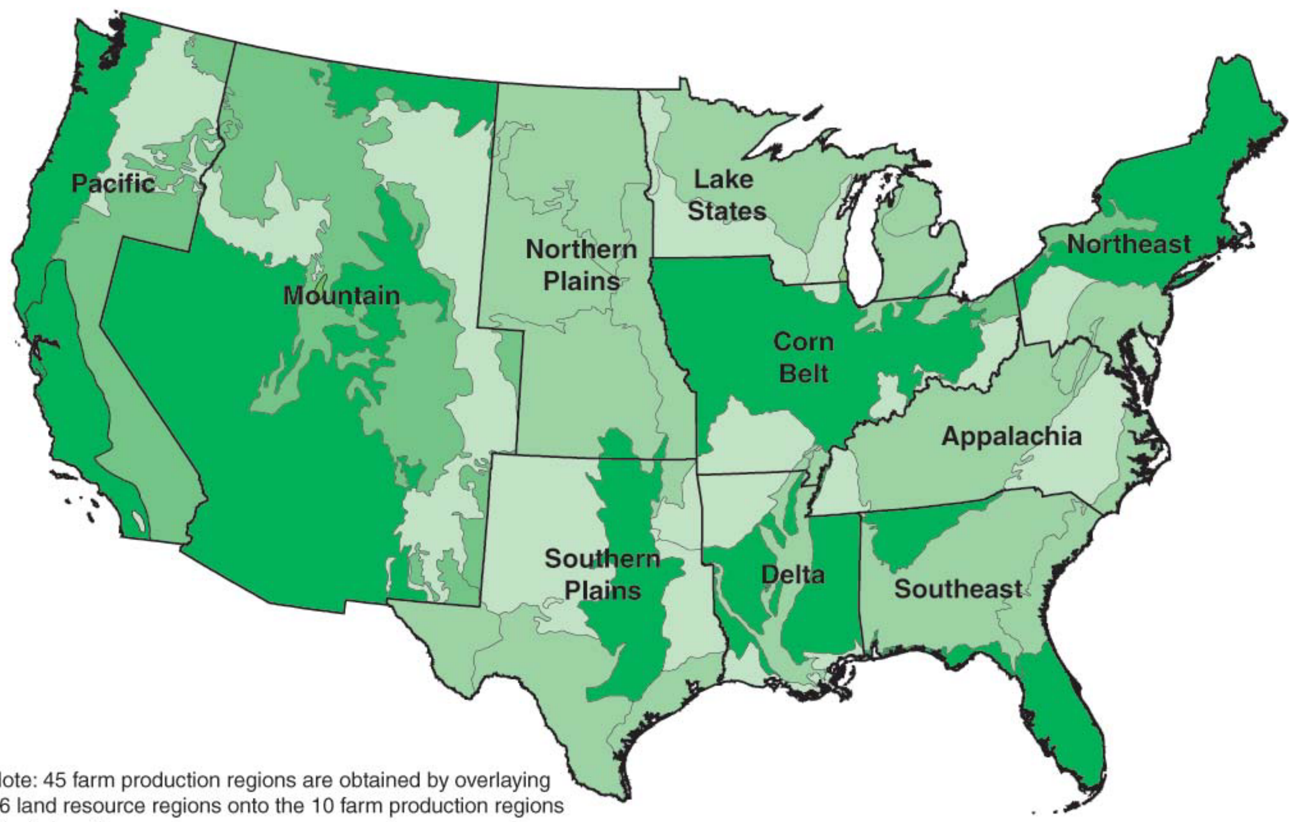
Selected Indicators

We categorize the potential impacts of changes in agricultural production on nutrients lost to the environment using several indicators. The indicators we examine are: nitrogen runoff, nitrogen leaching, nitrogen loss to estuaries, and phosphorus loss to water. Excess nitrogen balance is first constructed using data on chemical fertilizer use, manure fertilizer, and nitrogen fixed by legumes. From this, the nitrogen harvested in crop yield is subtracted, which leaves excess nitrogen left on the field vulnerable to leaching or runoff. Nitrogen runoff is the amount of nitrogen in subsurface flow, in solution, and attached to sediment that is estimated to arrive in surrounding streams, rivers, and lakes. USGS forecasts of nitrogen delivery from agricultural sources are used to calibrate nitrogen runoff and the amount of this runoff reaching estuaries (Smith et al., 1997).

Phosphorus loss to water is an indicator that uses EPIC estimates of phosphorus losses to the field edge (in leaching, sediment, and solution and calibrates them to baseline USGS forecasts of phosphorus delivery from agricultural sources (Smith et al., 1997).

Appendix figure B-1

Farm production regions used in environmental simulations



Note: 45 farm production regions are obtained by overlaying 26 land resource regions onto the 10 farm production regions labeled on the map.

Source: USDA/ERS.

Appendix C—Imperiled Species Counts

Counts of "imperiled" species are derived from the conservation status rankings in NatureServe's Natural Heritage data set as of 2000, though data for different States may reflect different levels of updating. NatureServe is a nonprofit network of biological inventories, known as natural heritage programs or conservation data centers, in all 50 U.S. States as well as other countries. The Natural Heritage data set includes conservation status assessments of species from all three taxa (animals, invertebrates, and plants) and their classes. Data on invertebrates is probably the most incomplete of the three as heritage programs tend to assign low priority to collecting species data for this group (NatureServe, 2005).

For each species (or "element") in the Natural Heritage data set, NatureServe assigns a ranking of its risk of extinction.[1] While NatureServe has a wide variety of ranking measures, we use their highest level ranking, their so-called "G" ranking, which rates the element's risk of extinction on a rangewide or "global" basis. For our analysis, we consider "imperiled species" as those classified by NatureServe as either "critically imperiled" or "imperiled" at the national level, receiving a Global Conservation Status (G) rank of 1 or 2, respectively.[2]

Standard ranking criteria and definitions are used to ensure that a particular rank has the same meaning regardless of the species or geographic region considered. Ranking is a qualitative process based on the following factors: total number and condition of element occurrences, population size, range extent and area of occupancy, short- and long-term trends in the foregoing factors, threats, environmental specificity, and fragility. According to NatureServe, "The ranker's overall knowledge of the element allows him or her to weigh each factor in relation to the others and to consider all pertinent information for a particular element" (NatureServe, 2005).[3]

The set of species identified by the Natural Heritage network as imperiled or vulnerable provides a more accurate indication of biodiversity hot spots than the federally maintained endangered species list, according to Ehrenfeld et al. (1997). The list of species under the Endangered Species Act includes only species that are formally designated as endangered or threatened as a result of legal proceedings, rather than all species considered by most biologists to be at risk of extinction (Stein et al., 2000). Additionally, the NatureServe data avoid the problems of raw population occurrence data, which overemphasize areas that have been particularly well inventoried. This is overcome by calculating the number of different species within a geographical unit. Counts of imperiled species also help to overcome inconsistencies in inventory intensity.

NatureServe data are available at a national level and in a Geographic Information System (GIS) format. However, these data are often collected with limited *a priori* justification, which limits their usefulness because of variable sampling efforts, inconsistent sampling protocols, small sample sizes, inclusion of opportunistic observations, and a tendency to report unusual observations. In addition, species included in data sets often vary among States (Niemuth, 2004).

[1]An "element" is defined as a unit of natural biological diversity, representing species, ecological communities, or other nontaxonomic biological entities, such as migratory species aggregation areas. These elements refer to the species records by county and by watershed only. No ecological communities or other significant areas such as migratory stopover points are included in the data sets provided.

[2]An element known or assumed to exist within a jurisdiction is designated by a whole number from 1 to 5, denoting: 1 = critically imperiled; 2 = imperiled; 3 = vulnerable to extirpation or extinction; 4 = apparently secure; and 5 = demonstrably widespread, abundant, and secure (NatureServe, 2005).

[3]See *http://www.natureserve.org/explorer/ranking.htm* for more information.

Appendix D—Estimating Land-Use Changes from Crop Insurance Subsidies

This appendix describes the econometric model used to estimate changes in cultivated cropland area resulting from the large increase in crop insurance premium subsidies during the mid-1990s. Following discrete choice studies on land-use change (e.g., Schatzki, 2003; Lubowski et al., 2003; Irwin and Bockstael, 2002; Claassen and Tegene, 1999), the model builds on traditional rent theory to estimate the likelihood that a parcel of land in a particular land use in 1992 remained in the same use or had moved to a different one by 1997. The land-use impact of the increase in crop insurance subsidies is estimated by exploiting variation in the expected profits from crop cultivation due to the large change in premium subsidies from 1992 to 1997. By examining changes in land use in relation to changes in subsidies, the effect of the subsidies can be identified, controlling for other determinants of land-use change. A critical assumption is that the policy change is largely exogenous and uncorrelated with other, unobserved land-use determinants not included in the model.

The likelihood that land transitions from four initial land-use categories (cultivated crops, uncultivated crops or pasture, range, forest) to any of six broad land-use options (cultivated crops, uncultivated crops or pasture, CRP, range, forest, and urban) is estimated using observation-specific data on land use and land characteristics from the National Resources Inventory (NRI) and county-level estimates of net returns to the different land-use alternatives.[1] One key explanatory variable is the change in expected profitability of crop cultivation in a county resulting from the change in premium subsidies from 1992 to 1997. Estimated 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 5 years. The difference in 1997 land-use predictions with and without the change in crop insurance returns provides an estimate for the impact of the 1992-97 subsidy increase at the level of each NRI observation.

[1]Uncultivated crops and pasture account for the majority of changes to and from cultivated crops. These categories are combined as our estimates of net returns from these activities are based on similar factors (hay and forage prices and yields). We do not model land starting in urban uses, as these lands are unlikely to transition from development to agricultural land uses. We also do not examine transitions of land exiting CRP, as lands eligible to leave the program represent a small fraction of the land base and depend on government as well as landowner choices. These issues are explored in Sullivan et al. (2004).

Conditional Logit Model

We hypothesize that a producer (or other land-use decisionmaker) will choose to convert a parcel of land from one land use to another based on the profitability (rents) of the alternative land uses (see chapter 3). If land-use patterns are initially in equilibrium, then only changes in the relative levels of profits—and not the profit levels themselves—should drive land-use transitions. Although our focus is on land-use changes over time (1992-97), we include 1992 profit levels (as well as the 1992-97 changes in these levels) in our analysis because the levels will matter if land markets were in disequilibrium initially. 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 producers to convert from one land use to another.

Producers presumably compare net returns to alternative uses on particular land parcels. Although we do not observe profits of alternative land uses for each NRI observation, we do observe 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 point-level indicators of land quality (Land Capability Class), erodibility, average slope gradient, and flooding frequency.

Land parcels near one another may have unobserved characteristics that are correlated across space. If such characteristics influence land-use decisions or if local land-use choices are interdependent, error terms will be correlated across space, leading to inconsistent and inefficient estimates in a logit model due to induced heteroskedasticity (McMillen, 1992). We deal with spatial autocorrelation in two ways. First, and most importantly, we randomly select only a single point from each sampling cluster of NRI observations because errors within these points located near one another are most likely to be strongly correlated.[2] Second, we use a polynomial spatial trend surface to control for spatial heterogeneity. 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 (Anselin, 1988).[3]

The producer's profit function may be thought of as including both observed and unobserved components. Using a general random utility expression, the one-period expected net profit (utility) to the producer on parcel *i* from switching 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 *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).[4]

We estimated separate models for 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/pasture, CRP, range, forest, and urban).[5] Each model is based on the same specification. After

[2]The NRI has a stratified sampling design. Data on urban and water areas are collected for about 300,000 primary sampling areas varying from 40 to 640 acres in size. More detailed data on land characteristics and use are collected at two to three sample points randomly selected within each of these areas (Nusser and Goebel, 1997).

[3]The spatial trend surface has an advantage over the spatially autocorrelated error approach for two reasons: First, it may control for omitted factors associated with space, even if they are associated with other covariates, whereas the spatial error model must assume these are not correlated (i.e., a spatial trend may reduce bias in the estimated coefficients, not just the standard errors). Second, it is much easier to estimate. A limited dependent variable model with spatial autocorrelation could be estimated using simulation methods. However, this is very computationally expensive. Remaining spatial autocorrelation, if present, would bias our standard errors, but not our estimates.

[4]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. The more general choice model used here has terms varying over both choices and individuals and is sometimes called "McFadden's choice model" or a "mixed model" (Long and Freese 2001).

[5]While we estimated models for four starting uses, the discussion in chapter 5 focuses on the results based on land starting in either cultivated crops or in uncultivated crops and pasture. We focus on these results since transitions from uncultivated crops/pasture accounted for the majority of transitions to cultivated cropland and because there were too few observations of land-use changes to compute confidence intervals (for the estimates) for land starting in either forests or range. Transitions from uncultivated crops/pasture to cultivated cropland accounted for 77 percent of all land-use transitions from other uses to cultivated cropland between 1992 and 1997.

examining several functional forms for *f (X)* we chose a linear model that considers all possible two-way interactions between a parcel-level indicator of land quality, based on the Land Capability Class (LCC),[6] and estimated 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 - 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 producer'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, 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. We would thus expect greater enrollment on lower quality lands.

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 profit variables (and changes in profits) for each land-use alternative generally significant and positively associated with a greater likelihood of moving to each respective use.[8] The change in insurance returns is positively related, all else equal, to the probability of moving to cultivated crops from 1992 to 1997.

Results from counterfactual simulations in which insurance net returns are set to zero are reported in chapter 5. In these 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 use to each of the six land-use alternatives. These amounts are used as weights in determining mean land characteristics of acres affected by the increase in crop insurance subsidies relative to cultivated cropland overall. Standard errors for the predictions were estimated by bootstrap.[9] We resampled an equal number of NRI point/clusters from our main sample (with replacement) and obtained a new set of estimates and predictions. We repeated this exercise 500 times for each of the model equations.

[6]The Land Capability Class is a summary measure of the suitability of the land for crop production, based on a ranking of 12 different soil characteristics that are critical for crop production. The overall LCC score consists of the lowest ranking given to any of these 12 soil features based on the principle that this factor will be limiting for crop production (USDA, 1973). Higher LCC ratings indicate poorer soils for crop production. To ensure sufficient observations in each LCC category, we combine the eight categories into three: LCC 1-2; LCC 3-4; LCC 5-8.

[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).

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

[9]This procedure enabled the construction of confidence intervals for the estimates based on points starting in either cultivated cropland or uncultivated cropland/pasture in 1992. There were too few observations to achieve convergence in the bootstrapping runs for the models based on points starting in either forest or range in 1992, so we were unable to compute standard errors for the results from these models. The discussion in chapter 5 focuses on the results for which standard errors could be estimated.

Data

The likelihood that a land unit moves from one land use to another is estimated based on repeated observations of non-Federal land use from the National Resources Inventory (NRI). The NRI is a panel survey of land use and land characteristics on non-Federal lands conducted at 5-year intervals from 1982 to 1997 over the 48 contiguous United States (see chapter 2). Data include approximately 844,000 "points," each representing a land area given by a sampling weight that is inversely proportional to the sampling intensity (Nusser and Goebel, 1997). Our analysis is based on a subset of points drawn from the 657,781 observations that consist 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. We randomly sample from these points so as to include only one point in each of our 1982 land-use categories from each of the NRI's primary sampling clusters. This reduces our sample to 83,807 points (23,637 observations in cultivated crops, 25,148 in pasture, 23,723 in forest, and 11,299 in range). This procedure eliminates parcels located near one another in order to purge our sample of potential spatial dependence.

Summary statistics are provided for each of our county- and parcel-specific variables (appendix tables D-1 and D-2). 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. 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 (see Heimlich and Anderson, 2001).[10]

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 regime change that decoupled these commodity payments in 1996. The 1996 Federal Agriculture Improvement and Reform (FAIR) Act removed most conditions on plantings and conditioned payments on prior planting histories as opposed to current planting decisions. As a result, payments received in 1997 proxy for program participation prior to 1996.[11]

Our key explanatory variable is the 1992-97 change in expected net returns to crop insurance due to the increase in Federal crop insurance premium subsidies. The construction of this variable is described below. 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 is a revealed preference measure that should reflect initial differences across the country in the relative returns from insurance participation. This also controls for the amount of initial participation, which determines the potential for an increase in participation over 1992-97.

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

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

[11]The 1996 FAIR Act also introduced loan deficiency payments (LDPs) and marketing loan gains (MLGs) for grain crops, which had previously only been available for cotton and rice. Our results were not affected by the inclusion of county-average changes in expected LDPs as a separate explanatory variable.

coordinates for the centroid of each NRI polygon.[12] We include these coordinates (interacted with an alternative-specific constant) singly and in all second and third-order interactions.[13]

County-Level Estimates of Profits (Net Returns)

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 USDA's National Agricultural Statistics Service (NASS). Producers are assumed to form expectations of future land-use returns based on current prices and the average of yields over the previous 5 years. Data on cash costs as a share of revenue at the State and regional level are from the Census of Agriculture and the Economic Research Service (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 farm 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 (USDA/NASS, 1997). Payments under the Conservation Reserve and Wetlands Reserve programs are excluded, as the payments measure is intended to only reflect government payments associated with crop production only, rather than cropland retirement.

Pasture Net Returns. Annual net returns per acre for pasture are estimated using pasture yields from the SOILS-5 data set 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 net returns per acre for rangeland are computed with forage yields from SOILS-5 and State-level grazing rates per head 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 et al. (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,

[12]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.

[13]Denoting the location coordinates as x and y, we include $x, y, xx, yy, xy, xxx, yyy, xxy$, and xyy as explanatory variables.

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) microdata from the Census Bureau.

Crop Insurance Returns. For the period of years under study, 1992-97, 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. Return 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; $r_i - s_i$ is the (total) crop insurance premium, s_i is the premium subsidy (the premium paid by producers is ri) and E is the expectations operator. Also, catastrophic coverage (APH insurance with a 50-percent yield guarantee and 100-percent premium subsidy) was introduced in 1995. In 1995, producers participating in farm commodity programs were required to purchase at least catastrophic coverage (producers where charged a small processing fee, per crop), but the requirement was dropped for the 1996 and subsequent seasons.

Crop insurance program data for APH contracts, available from USDA's Risk Management Agency, include total indemnities, total premiums, and the subsidy by crop and county. To estimate expected returns, expected indemnity is estimated as the average indemnity over the previous 10 years, by crop and county for eight major crops. A single expected return to crop insurance is estimated for each county as the acre-weighted average of crop-specific expected returns.

Estimates of expected returns were made with and without catastrophic coverage. Because our objective was to estimate the impact of the subsidy increases on expected returns to crop insurance, however, the addition of catastrophic coverage confused the situation. While the introduction of catastrophic coverage significantly increased both liability and enrolled acreage, the low yield guarantee, which made indemnities rare, resulted in a sharp reduction in indemnities per dollar of liability and per unit of land with a crop insurance product. The issues are particularly important given that catastrophic coverage was required for the large share of crop producers who participate in commodity programs. Even when the requirement was removed, renewal was automatic and many producers may have simply allowed the contracts to continue rather than making a conscious decision to continue catastrophic coverage. Thus, we believe that the expected return to buy-up coverage (coverage of 65 percent or higher) best reflects the change in expected returns to crop insurance due to the subsidy increase for those producers who were actually engaged in the crop insurance program.

Appendix table D-1
Summary statistics: County-level variables

County-level variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
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	73.9
Urban net returns in 1992 ($/acre/year)	657,781	2,224	2,892	183	36,944
Urban influence code in 1990	657,781	1.40	0.89	1.0	5.0
Total government payments in 1997 ($/acre/year)	657,781	8.4	5.9	0	47.3
% of eligible crop acres insured in 1992	657,781	0.4	2.6	0	92
Change in insurance net returns, 1992-97 ($/acre/year)	657,781	1.8	4.3	-37.1	40.2
Change in crop net returns, 1992-97 ($/acre/year)	657,781	15.1	62.9	-819.1	939
Change in pasture net returns, 1992-97 ($/acre/year)	657,781	2.2	5.4	-8.2	52
Change in forest net returns, 1992-97 ($/acre/year)	657,781	0.2	2.4	-8.6	12.3
Change in range net returns, 1992-97 ($/acre/year)	657,781	36.2	65.5	-175.2	575.5
Change in urban net returns, 1992-97 ($/acre/year)	657,781	14.1	891	-1,610	10,769

Source: Various sources described in Appendix D.

Appendix table D—2

Summary statistics: Observation-specific variables

NRI point-level variable	No. of observations	Mean	Standard deviation	Minimum	Maximum
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	.04	0	1
Land in urban use in 1997 (yes=1, no=0)	657,781	.01	.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	.04	0.18	0	1
Slope % greater than 15[1] (yes=1, no=0)	657,781	.01	0.11	0	1
Land irrigated (yes=1, no=0)	657,781	.05	0.22	0	1
Acreage weight (NRI xfact in acres)	657,781	1,980	2,368	100	192,200

[1] 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, forest, or range uses in 1992; and in cultivated crops, uncultivated crops, pasture, forest, range, CRP, or urban uses in 1997.

Appendix E—Estimating Erosion From Policy-Driven Changes in Land Use

This appendix describes the procedures used to estimate environmental impacts in terms of rainfall and wind erosion from the changes in land use induced by: (1) the change in crop insurance subsidies from 1992 to 1997 and (2) the Conservation Reserve Program as of 1997.

Change in Crop Insurance Subsidies. To estimate the impacts from the 1992-97 change in subsidies, we compare erosion under the 1997 land uses with and without the change in crop insurance subsidies, as predicted by the econometric model. Data on rainfall and wind erosion are derived from the NRI. For each NRI point observed in a particular 1997 land use (e.g., crops), the actual 1997 erosion data from NRI are used to calculate 1997 tons/acre of erosion on the fraction of land at that point predicted by the model to be in that particular use in 1997. For the acreage at that point predicted by the model to be in each different use (e.g., pasture), we impute wind (WEQ) and rainfall (USLE) erosion values based on the average 1997 erosion values for similar points in that land use in the same Crop Reporting District (CRD). NRI erosion estimates are only available for land in cultivated crops, uncultivated crops, pasture, and CRP. Erosion on other land uses is assumed to be zero. Given that most changes between the 1997 baseline and no-subsidy-increase scenarios occur at the margin of cultivated cropland with uncultivated crops, pasture, and CRP, these data should account for the majority of the erosion differences due to the simulated changes in land use.

To impute wind and rainfall erosion, points are matched based on erodibility index (EI) quantiles for wind and water, respectively; land capability class (LCC); and 1992 land use. If perfect matches are not available in a particular CRD, we progressively loosen the requirements for similarity—first in terms of erodibility, then LCC, then geographic scale, and then land use—until values are imputed for all points.

Conservation Reserve Program. For the 1997 baseline, given by the observed 1997 pattern of CRP and land use in the NRI, erosion is estimated with 1997 WEQ and USLE erosion values from the NRI. For the counterfactual no-CRP scenario, lands not in CRP are assumed to remain in their observed 1997 use. This assumes that lands not enrolling in CRP did not change use in response to the program (no "slippage"). Lands in CRP in 1997 are assumed to convert to other land uses (or remain in the same use) in the same proportion as similar lands in the same geographic area over 1982-97. We impute 1997 land use—and associated 1997 rainfall and wind erosion—by matching each CRP point to similar points in a CRD based on erodibility, LCC, and pre-CRP land use (1982) through the iterative procedure described above.