# Impact of High Crop Prices on Environmental Quality: A Case of Iowa and the Conservation Reserve Program

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# Abstract

Growing demand for corn due to the expansion of ethanol has increased concerns that environmentally sensitive lands retired from agricultural production into the Conservation Reserve Program (CRP) will be cropped again. Iowa produces more ethanol than any other state in the United States, and it also produces the most corn. Thus, an examination of the impacts of higher crop prices on CRP land in Iowa can give insight into what we might expect nationally in the years ahead if crop prices remain high. We construct CRP land supply curves for various corn prices and then estimate the environmental impacts of cropping CRP land through the Environmental Policy Integrated Climate (EPIC) model. EPIC provides edge-of-field estimates of soil erosion, nutrient loss, and carbon sequestration. We find that incremental impacts increase dramatically as higher corn prices bring into production more and more environmentally fragile land. Maintaining current levels of environmental quality will require substantially higher spending levels. Even allowing for the cost savings that would accrue as CRP land leaves the program, a change in targeting strategies will likely be required to ensure that the most sensitive land does not leave the program.

**Keywords**: agricultural markets, Conservation Reserve Program, environmental quality.

## Introduction

Growing demand for corn due to the expansion of ethanol has increased concerns that higher levels of corn production might cause environmental damage. Higher crop prices could negatively affect soil and water resources as farmers till more acres and remove environmentally sensitive land from conservation programs, including the Conservation Reserve Program (CRP) and the Wetlands Reserve Program. Intensification of production could also lead to larger nutrient and soil losses as farmers attempt to increase their yields. In this paper we focus on the environment benefits that would be lost if land is taken out of the CRP.

The CRP program pays landowners an annual rental payment in exchange for their agreement not to plant their contracted land. Contract duration is between 10 and 15 years. The CRP was authorized in the 1985 farm bill during a period when the United States had excess supplies of wheat and feed grains. Thus, it is not surprising that the program began with an objective of maximizing the amount of land taken out of production. In the early 1990s, enrollment criteria were changed and land began to be accepted into CRP based on the level of offered environmental benefits and cost. Today the program attempts to maximize environmental benefits. Thus, as will be demonstrated, currently enrolled land has lower production potential and would cause greater environmental damage if farmed. This implies that a return of CRP land to crop production would likely lead to lower environmental quality.

Iowa has almost two million acres of CRP land, it produces more ethanol than any other state, and it produces the most corn. Thus, an examination of the impacts of higher crop prices on Iowa land moving out of the CRP and the resulting impacts on soil erosion, nutrient losses, and carbon sequestration will give insight into what we might expect nationally in the years ahead if crop prices remain high. Although this study focuses on soil erosion, nutrient losses, and carbon sequestration, our framework also allows us to make inferences about wildlife and hunting.

## Data Description and Modeling Approach

Figure 1 shows the location of CRP parcels in Iowa by county according to the Farm Service Agency (FSA). Comparing the CRP land to the full soil layer for Iowa, it is apparent that the CRP land is of a lesser quality for agricultural purposes. We focus here on a few indicators to run the comparison: the Corn Suitability Rating, the Highly Erodible Land Code, and slope range. The HEL code refers to land classified by the Soil Conservation Service in Land Capability Class 4, 6, 7, or 8; or land that if used to produce an agricultural commodity would have an excessive annual rate of erosion as determined by the Universal Soil Loss Equation and the wind erosion equation. The three categories are 1 for a highly erodible map unit, 2 for a potentially highly erodible map unit, and 3 for a not highly erodible map unit. The slope range gives the range of incline of the surface of a soil. It is expressed on a percentage scale based on the difference in the number of feet of rise or fall per 100 feet of horizontal distance. Table 1 shows the characteristics of CRP land, all Iowa land, and land planted to either corn or soybeans (the two dominant crops in Iowa) in 2002. As shown, CRP land is, on average, less productive, more erodible, and it has a higher slope than either all of Iowa land or all land planted to corn and soybeans.

Table 1. Average Land Characteristics in Iowa

| | CSR | HEL | Slope Range (%) |
|---|---|---|---|
| CRP Acres | 45.95 | 1.53 | 10.89 |
| All Iowa Land | 61.87 | 2.17 | 7.33 |
| Corn and Soybean Acres | 70.99 | 2.46 | 5.45 |

There are some substantial differences in land characteristics within CRP areas as well. Figure 2 illustrates how land enrolled in CRP in North Central Iowa (the so-called Des Moines Lobe) is of higher productivity than CRP land in the rest of the state as measured by the land’s Corn Suitability Rating (CSR), which is an index from 0 to 100 that measures land’s productivity in corn production. CSR data was obtained from the

ISPAID (Iowa Soil Properties and Interpretations Database) soil data layer (Iowa Cooperative Soil Survey, 2003).

Figure 1. Location of CRP acreage in 2004 (quantiles)

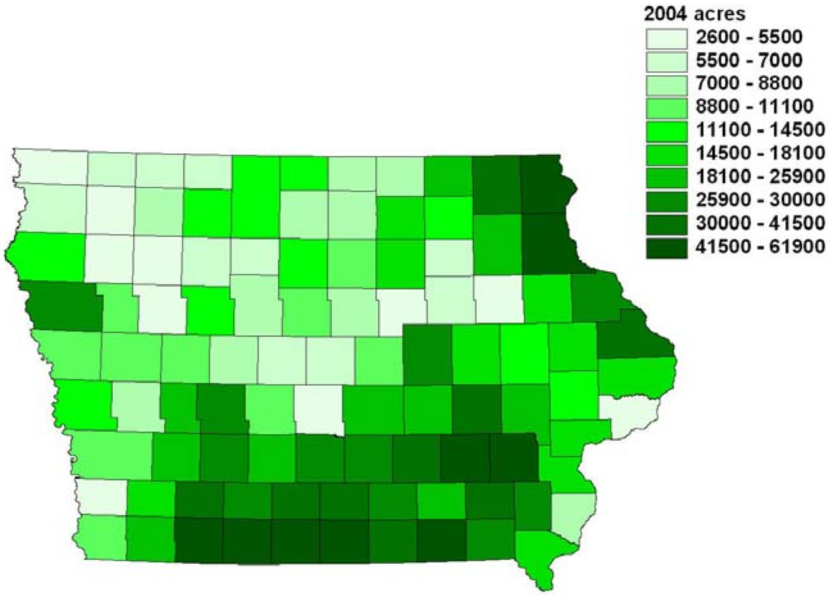
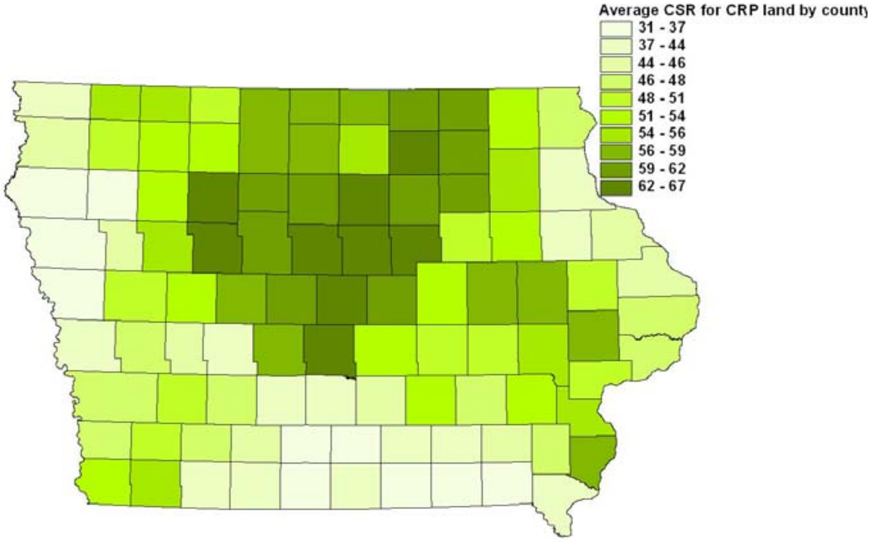


Figure 2. Corn Suitability Rating of CRP land by county (quantiles)



Land in this region is also less erodible (Figure 3), as measured by the proportion of CRP land that is classified as Highly Erodible Land (HEL). Because of this higher productivity, enrolling land into CRP in North Central Iowa is more expensive (Figure 4). Higher erodibility and, correspondingly, lower rental rates are the reasons why enrolled acres are lower in southern and northeastern Iowa.

Figure 3. Percentage Highly Erodible Land in CRP (2002) by county (quantiles)

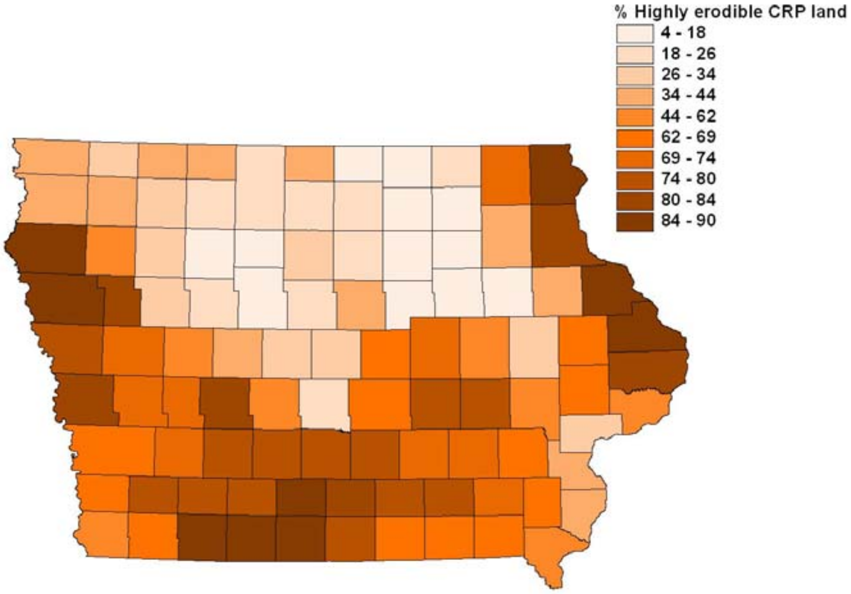
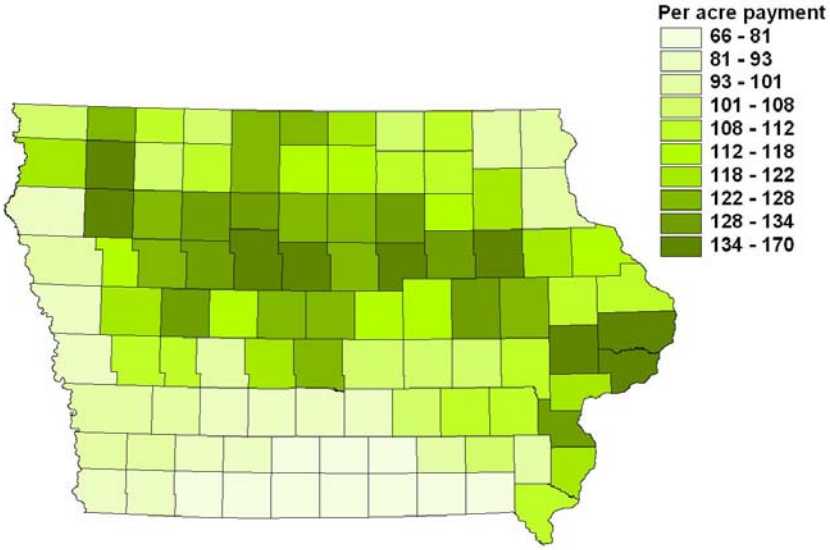


Figure 4. Average per acre rental payment for CRP land in 2004 (quantiles)



We construct CRP supply curves by estimating whether each of the land parcels currently enrolled in CRP would earn more by remaining in the program or by being cropped for various corn and soybean prices. The key factors in this calculation are crop prices, crop yields, and CRP rental rates. Crop yields are obtained through a GIS (geographic information system) exercise, described next. We use FSA Soil Rental Rates (SRR) as an approximation of CRP payments. Because there are several categories of CRP in which land can be enrolled, actual payments do not always match a parcel's SRR. However, using SRR gives us a reasonable approximation. According to the FSA, in 2004, payments for CRP rental rates in Iowa amounted to $152,296,812, and overall CRP payments amounted to $179,349,226 (FSA, 2004a). Using the SRRs, our estimate is that it would cost $181,237,348 to enroll the 2004 CRP acreage in Iowa. Thus, our estimate is quite close to the actual outlay. Moreover, our estimates of the county-level payments are very closely correlated to FSA's reported county-level payments, with a correlation coefficient of 0.9915.

The GIS land use layer we use to identify the location of CRP land (IDNR, 2004) contains errors that hinder the measurement of the amount of land enrolled into CRP in each county. Therefore, we assume that the distribution of CRP land characteristics in a county—specifically productivity—obtained from the GIS layers is representative of the entire county's CRP acreage. FSA (FSA, 2004a, 2004b) provided data on the acres enrolled in CRP by county. We use these data to adjust the estimates obtained from the GIS layer. This allows us to estimate all the characteristics of CRP land on a county-by-county basis. Because of our reliance on the land-use data to identify CRP areas, land that has been planted with trees is excluded from the analysis. However, the great majority of CRP land in Iowa is planted with grasses (FSA, 2004a). Therefore, this assumption does not substantially bias our results.

Figure 5 shows predicted corn yields across Iowa. We obtain predicted yields by constructing a regression equation of corn yield on CSR and adjusting the average yield so as to get realistic current yields. We use a linear equation, without intercept: Corn yield = 2.25 * CSR. We use a similar methodology to predict soybean yields. The equation used for soybeans is Soybean yield = 0.67 * CSR. The yield map for soybean is shown in Figure 6.

Figure 5. Corn yield map

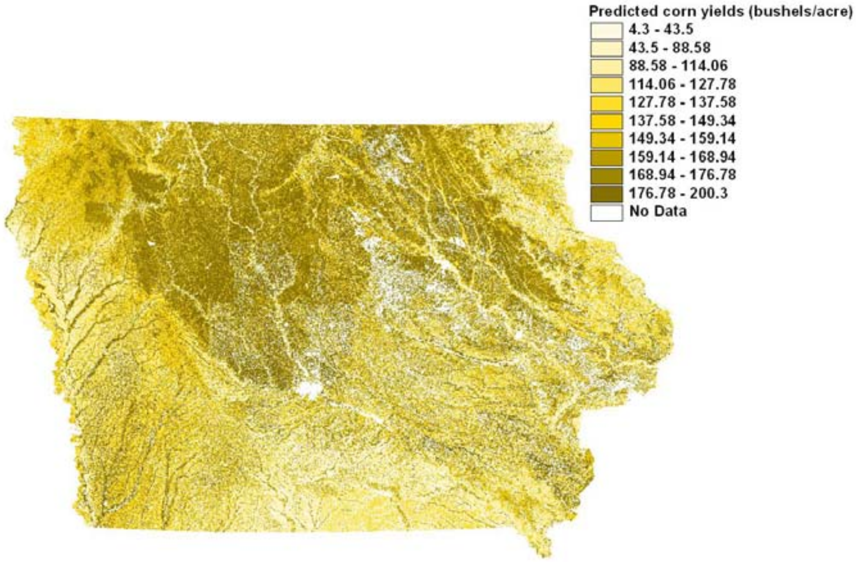
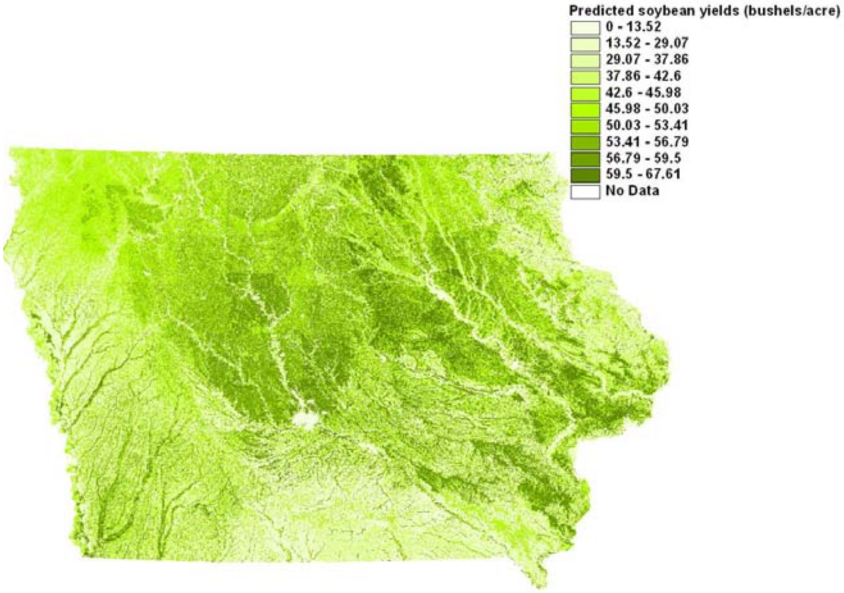


Figure 6. Soybean yield map



For a given level of crop price we then estimate which CRP parcels would be returned to production and which would remain enrolled in CRP. The environmental impacts of growing crops on the land that leaves CRP is estimated through the Environmental Policy Integrated Climate (EPIC) model, originally developed by the U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS). The EPIC model (Williams et al., 1984; Williams, 1990; Williams, 1995) is a field-scale model that is designed to simulate drainage areas that are characterized by homogeneous weather, soil, landscape, crop rotation, and management system parameters. It operates on a continuous basis using a daily time step and can perform long-term simulations of hundreds of years. A wide range of crop rotations, tillage systems, and other management practices can be simulated with EPIC. The most recent versions of EPIC feature improved soil carbon cycling routines (Izaurralde et al., 2001) that are based on routines used in the Century model (Kelley et al., 1997). EPIC provides edge-of-field estimates of soil erosion, nutrient loss, and carbon sequestration. We use the Soil Survey Geographic Database (SSURGO) to run EPIC, because it has all the required soil information to run the model (Soil Survey Staff, 2006).

This approach of estimating supply curves of environmental damage closely follows the approach of Pautsch et al. (2001) and allows us to make county-based estimates of the environmental impacts of acreage returning to crop production for various crop prices.

To determine net returns to crop production, we use 2007 cost-of-production budgets for Iowa (Duffy and Smith, 2007) to obtain the appropriate variable costs. For the low-till corn-soybean rotation, the per-acre costs are \$236.85 for corn and \$137.25 for soybeans. The per-acre costs for continuous corn are \$281.10. To calculate the net supply curves if the land is not highly erodible, the determination of its allocation is given by $Max\{\pi_{CB}, \pi_{CC}, \pi_{CRP}\}$, where $\pi_{CB}$, $\pi_{CC}$, and $\pi_{CRP}$ denotes average returns to a corn-soybean rotation, to continuous corn, and to CRP. If the land is highly erodible, because of conservation compliance requirements, we assume that the choice set is restricted to $Max\{\pi_{CB}, \pi_{CRP}\}$. Thus, the decision about whether to participate in the CRP program is really based on the two-year profit margins. For simplicity, we do not use any discounting and we abstract from risk-aversion considerations. We use a fixed-price wedge between corn and soybeans, which approximates the recent equilibrium between the two markets—$P_c = P_B + 4$—and is consistent with some recent long-term projections (Elobeid et al., 2006). The model could easily accommodate any other type of relationship between the two prices.

## Results

We construct the CRP land supply curves for corn prices ranging from $2 to $5 per bushel. Figure 7 illustrates the statewide curves. At $3 corn, we estimate that almost a million acres would go back into production. Note that not all the acres would go back into continuous corn. We estimate that over 460,000 acres would be HEL land and would therefore be planted in a corn-soybean rotation. Our assessment presumes that profit is the main driver of CRP enrollment decisions. However, there are many reasons why landowners decide to enroll in the CRP program; in practice, profit is not always the driving force behind their choice to enroll. Therefore, our estimates should be considered an upper-bound estimate of the acreage that would go back into production. It is also important to note that this is a long-term equilibrium analysis of the alternative land uses for CRP land. We are abstracting from penalties for early termination and re-enrollment provisions such as the re-enrollment and extension (REX) offer being implemented by FSA.

Figure 7. Acreage out of CRP as a function of corn prices

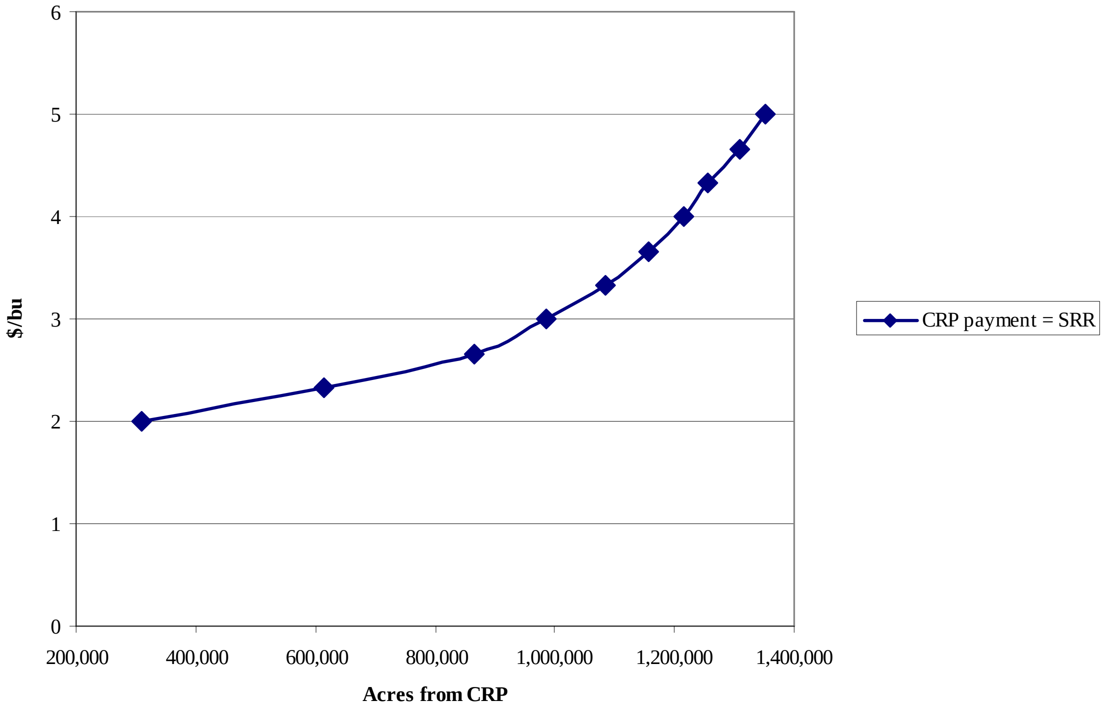
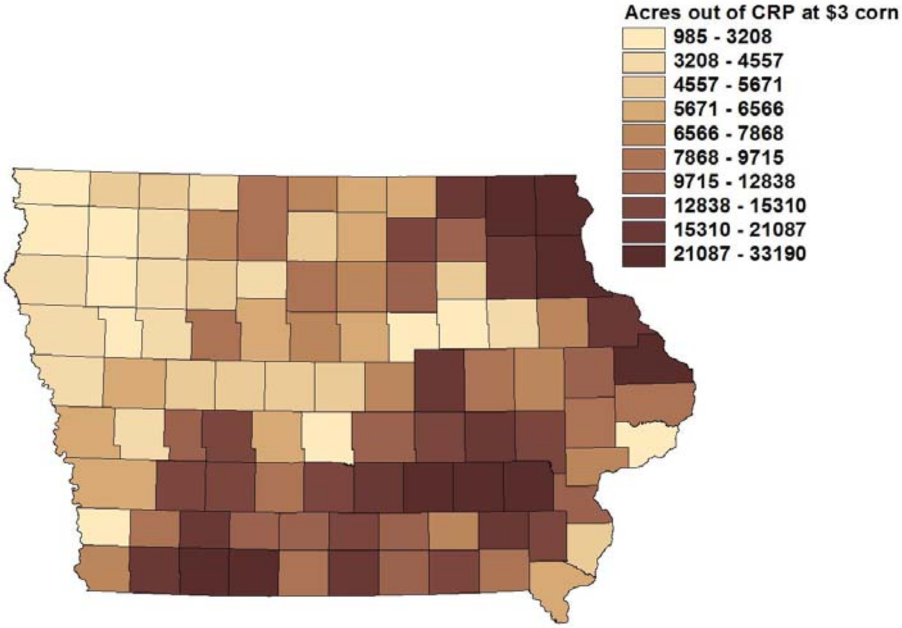


Figure 8 illustrates the geographical location of the acreage that would go back into production at $3 corn. The majority of acres in CRP are in the eastern and southern parts of Iowa, and a large part of the land that would go back into production is located in those areas. However, note that since CRP land in the Des Moines Lobe is quite productive, high corn prices would drastically reduce the amount of land retired from production in that area.

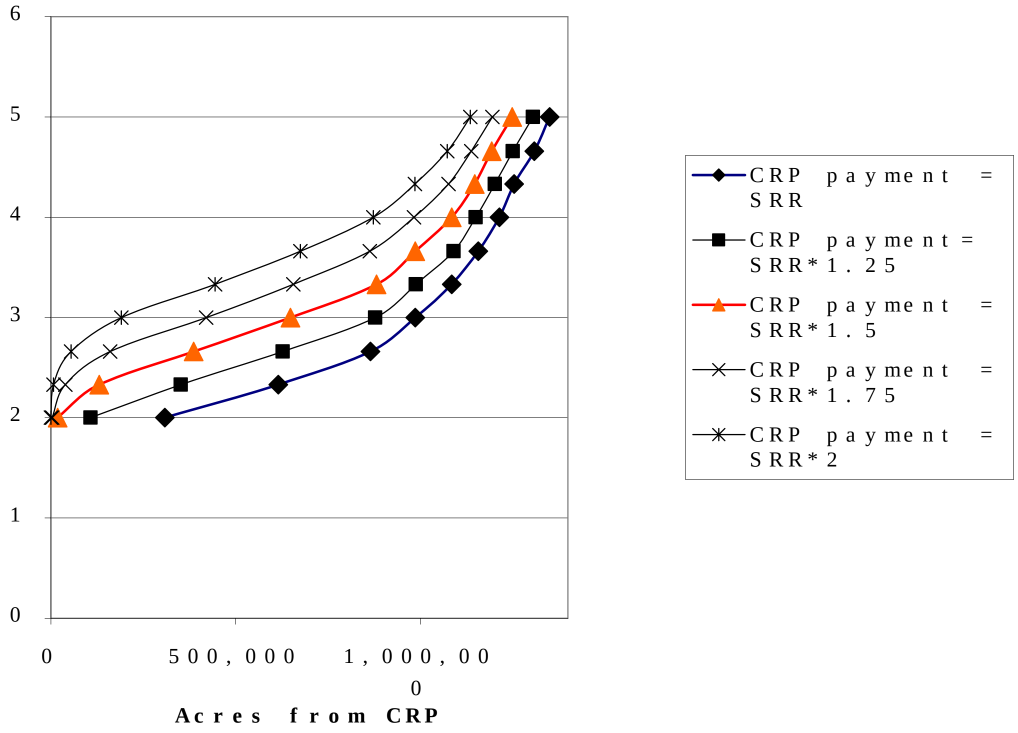
Figure 8. Distribution of acreage out of CRP at $3 corn



To estimate how the CRP program may respond to higher corn prices to maintain enrollment, we increase the SRRs by 25%, 50%, 75%, and 100% to estimate the CRP land supply curves with higher CRP payments. We then calculate program costs for all these scenarios. Figure 9 illustrates how higher CRP payments would limit the return of land into production. At a corn price of $3 per bushel, we estimate that it would cost almost $314 million to limit the return of CRP acreage into production to less than 200,000 acres. For higher corn prices, even doubling the payments becomes a relatively ineffective policy. For example, we estimate that for corn prices of $3.66/bushel, doubling the rental rate paid to farmers would result in program costs of slightly less than

$200 million, a sum comparable to recent historical costs for Iowa, but would only result in the enrollment of around 675,000 acres. The tables in the Appendix detail the program outlays and corresponding acreage.

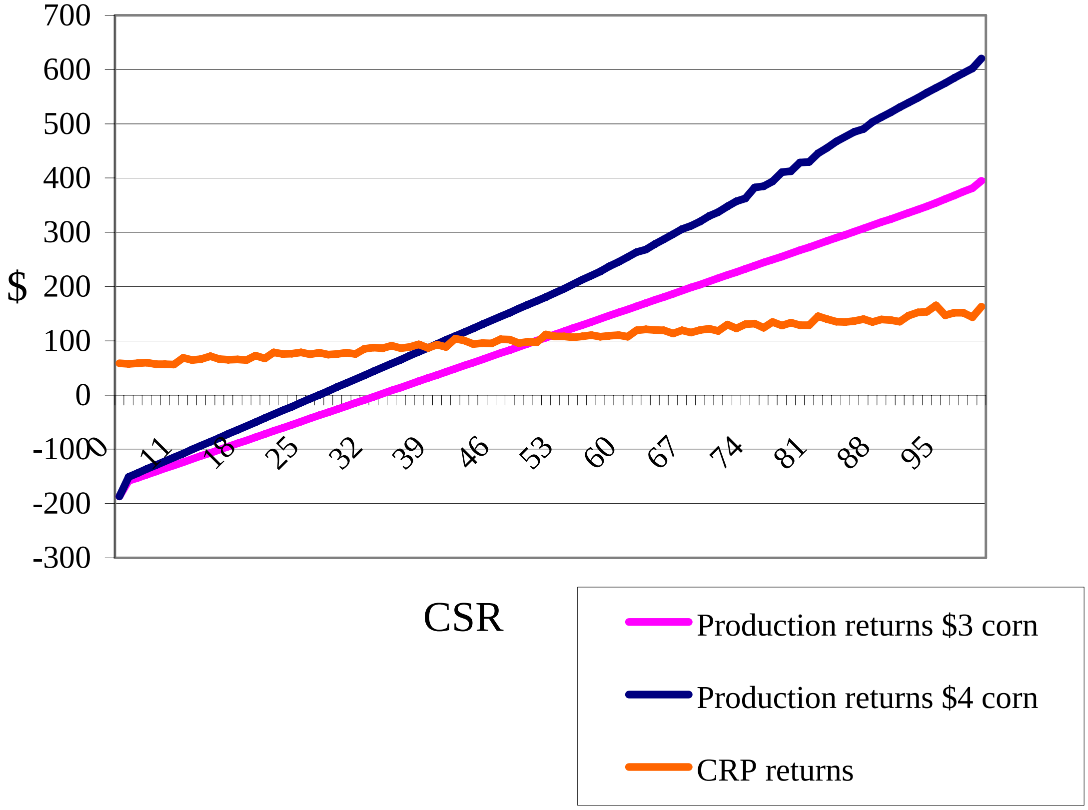
Figure 9. Acreage out of CRP as a function of corn prices and CRP payments



It is important to note that a driving force behind the current and projected spatial distribution of CRP land is the relationship between SRRs and the productivity of the land. As Figure 10 shows, CRP payments are quite inelastic with respect to the CSR index. This implies that highly productive land tends to be under-enrolled because of higher returns from production. As corn prices rise, Figure 10 illustrates the pivoting of the returns to production. At $3 corn, CRP payments are higher than returns from production for land with CSR of less than 50 or so. At $4 corn, land with a CSR index as low as 39 can gain higher returns if put back into production.

To estimate the environmental impact of cropping land previously set aside from production, we use the EPIC model to estimate 30-year averages for soil erosion, nitrogen and phosphorous loss, and carbon sequestration. To replicate the management differences between crop rotations, we assume a fertilizer rate application of 120 lbs/ac for nitrogen in corn planted after soybeans and a rate of 120 lbs/ac for corn planted after corn. Moreover, we assume a phosphorous rate of 60 lbs/ac for corn and 40 lbs/ac for soybeans. Fertilizer applications are assumed to occur in the spring.

Figure 10. Returns by land use and CSR



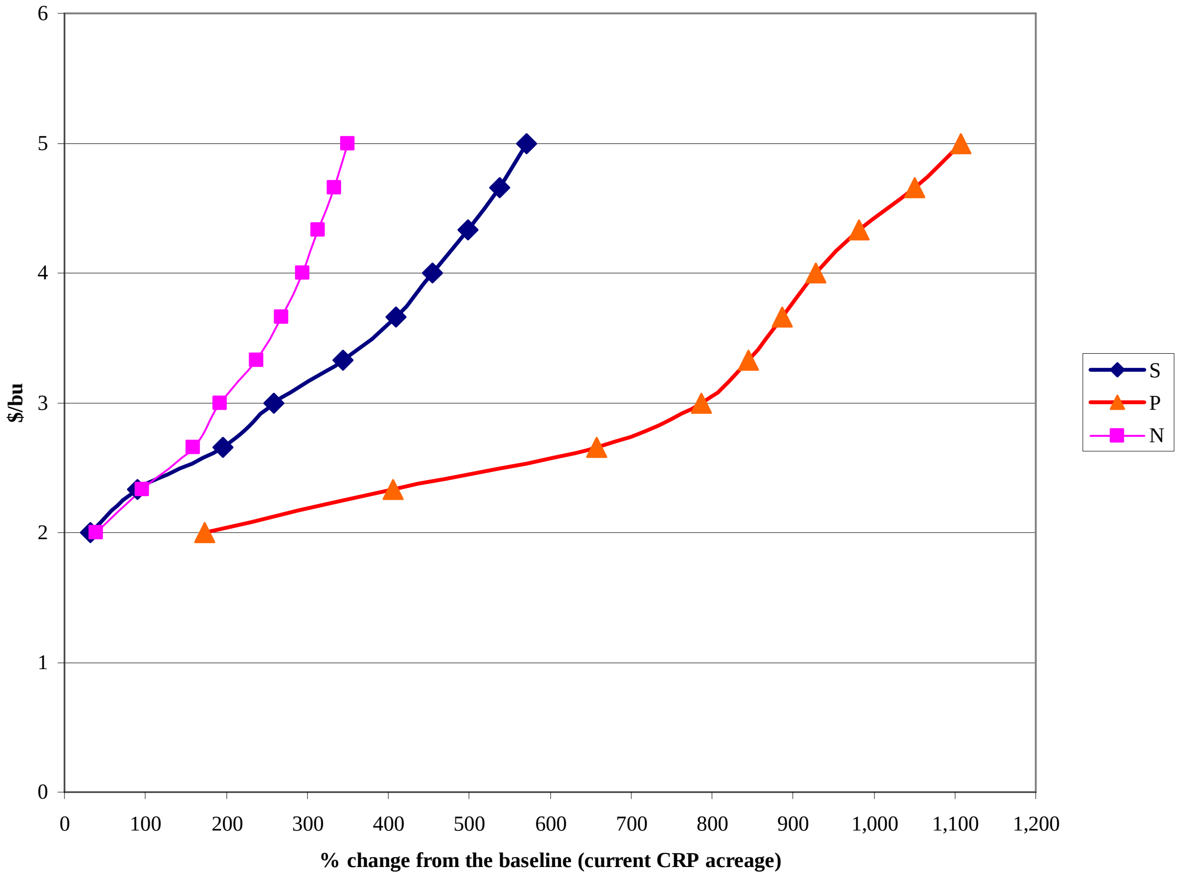
The soil information necessary to run EPIC was not available for around 43,000 acres. Therefore, our results have to be considered somewhat of an underestimate, though almost 98% of the CRP area is included in the analysis.

Our results show that the environmental impacts increase drastically as higher corn prices bring into production more and more environmentally fragile land. For example, sediment losses increase from less than 1 million tons for the almost 2 million acres in CRP to almost 5 million tons at $5 corn, when over 1.35 million acres would go back into production. We estimate that if all CRP land in Iowa were put back into a continuous corn rotation, the sediment losses would exceed 9 million tons.

Nitrogen losses follow a similar pattern. Losses increase from around 11,000 tons at the baseline, with all current CRP acreage out of production, to over 50,000 tons at $5 corn. If all CRP land in Iowa were put back into cropping, the nitrogen losses would exceed 75,000 tons.

Figure 11 shows the percent changes in sediment, nitrogen, and phosphorous losses based on corn prices. The percent changes are calculated from the erosion and nutrient levels when all parcels are kept out of production.

Figure 11. Percent changes in sediment, nitrogen, and phosphorous losses



At $3 corn, there is over a 250% increase in sediment losses from the baseline, almost an 800% increase in phosphorous losses, and over a 190% increase in nitrogen losses. Changes in carbon losses in percentage terms are much smaller, ranging from a 1% decrease for $2 corn to a 6% decrease for $5 corn. Result tables with the absolute values, changes, and percent changes are reported in the Appendix. Note that as prices increase, there is progressively less and less acreage put into production, as illustrated by the steepening of the curves in Figure 9. However, environmental damages per acre tend to become progressively higher as corn prices increase and bring additional, more environmentally sensitive land into production.

Table 2 shows the marginal impact of additional acres put into production. Marginal impacts increase rather steeply, reflecting the increasing environmental sensitivity of the land brought back into production. The increases are not smoothly monotonic, however, because for each increase in corn price there is a different percentage of HEL and non-HEL land back into production. Since HEL land is more environmentally fragile, the fact that a different proportion of the additional acres is HEL will affect the results. In particular, the percentage of additional land brought into production that is HEL decreases a bit at $4 and $4.66, which corresponds to the decreases in the marginal environmental damage. This happens because the correlation between the CSR and productivity and erodibility as represented by the HEL index is quite high, but it is not perfect.

Table 2. Marginal environmental impacts of land back in production, tons/acre/year

| | **Corn Prices** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **$2** | **$2.33** | **$2.66** | **$3** | **$3.33** | **$3.66** | **$4** | **$4.33** | **$4.66** | **$5** |
| Sediment tons /acre/year | 0.93 | 1.74 | 3.78 | 4.73 | 7.77 | 8.20 | 7.08 | 9.84 | 6.55 | 7.04 |
| Nitrogen pounds /acre/year | 34.63 | 51.50 | 67.71 | 77.09 | 124.31 | 117.89 | 124.17 | 125.67 | 103.92 | 108.79 |
| Phosphorous pounds /acre/year | 11.05 | 15.02 | 19.83 | 21.05 | 11.65 | 11.57 | 13.99 | 26.63 | 25.24 | 26.47 |
| Carbon tons /acre/year | -4.46 | -6.93 | -9.26 | -10.39 | -11.81 | -11.67 | -13.35 | -15.49 | -12.03 | -12.27 |

To put our estimates in context, using the same methodology, the national 2006 Conservation Effects Assessment Project (CEAP) report estimated an average soil loss of

2 tons per acre per year in the Upper Midwest for cropland (Potter et al., 2006). As for nitrogen and phosphorous, the estimates of their total losses were 39.2 and 2.8 pounds per acre per year, respectively, in the Upper Midwest for cropland.

It is also interesting to note that if all the CRP land were returned to production, the environmental damages would be much higher than we estimate with corn prices as high as $5 per bushel, as we noted earlier for sediment and nitrogen losses. In the case of carbon sequestration, losses would increase from over 11 million tons at $5 corn and 1,350,000 acres back in production to 18 million tons for the almost two million acres currently in CRP. This suggests that—no matter how high the corn prices—some of the land in CRP is too marginal to be considered for crop production.

## Conclusions

The results of our work carry implications for large parts of the United States, particularly in the Corn Belt. The results indicate that the land returning to production will be spatially distributed according to the quality of the land in CRP in the area, which is itself likely a function of overall land productivity. These results suggest that conservation policy could be substantially impacted by the increase in commodity prices. Maintaining current levels of environmental quality will require either substantial budget increases or a focused targeting approach to increase the cost/benefit ratios of land retired from production. In particular, high corn prices may accelerate the trend that started with the 2002 farm bill in which CRP has shifted from the idling of whole fields for conservation purposes toward implementing "high-priority 'buffer' practices (e.g., filter strips, grassed waterways) that support working lands by reducing the environmental implications of ongoing agricultural production (USDA, 2006, p. 24)." To preserve whole fields in CRP, higher payments will have to be considered. Since these will keep only part of the land out of production, it is not certain that more money will have to be devoted to conservation programs. For example, at $4 per bushel corn, doubling soil rental rates would keep over a million acres in the program, as opposed to less than 700,000 acres with current payment levels, and the program costs would be lower than they are now by over $26 million.

In any case, some areas could see considerable acreage reductions, thereby affecting wildlife populations. In particular, several recent studies indicate that CRP land has positive impacts on game birds and that their populations could be severely affected (Nielson et al., 2006; Schroeder and Vander Haegen, 2006; and Riffell and Burger, 2006). Our framework allows us to superimpose the location of CRP acres going back into production with the composition and distribution of wild birds in the state as identified by the Iowa Breeding Bird Atlas (BBA). Figures 12 and 13 illustrate the case of the wild turkey and ring-necked pheasant, respectively. They show that the impacts of CRP return into production could be substantial, particularly for species with a heterogeneous spatial distribution, such as the wild turkey. Our modeling framework can provide important information on some of the other potential impacts of returning CRP land to production.

Figure 12. BBA distribution of wild turkeys and acreage out of CRP at $3 corn

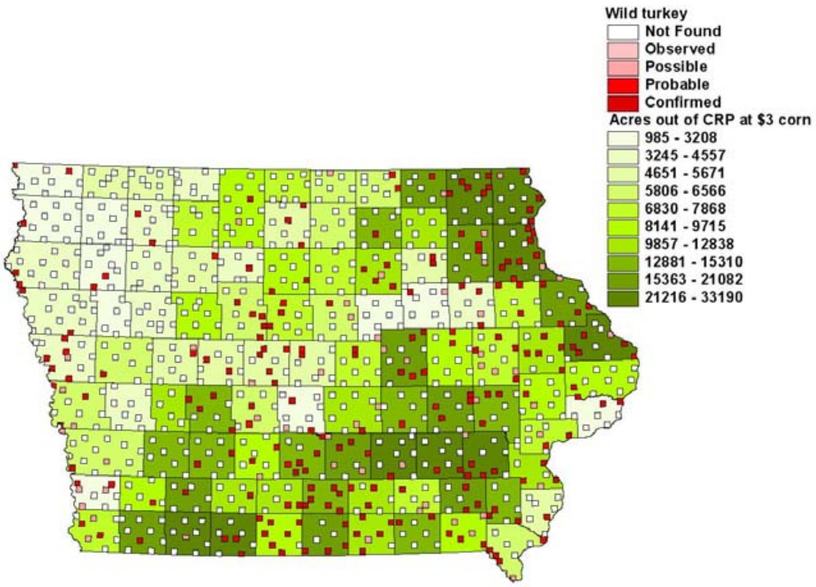
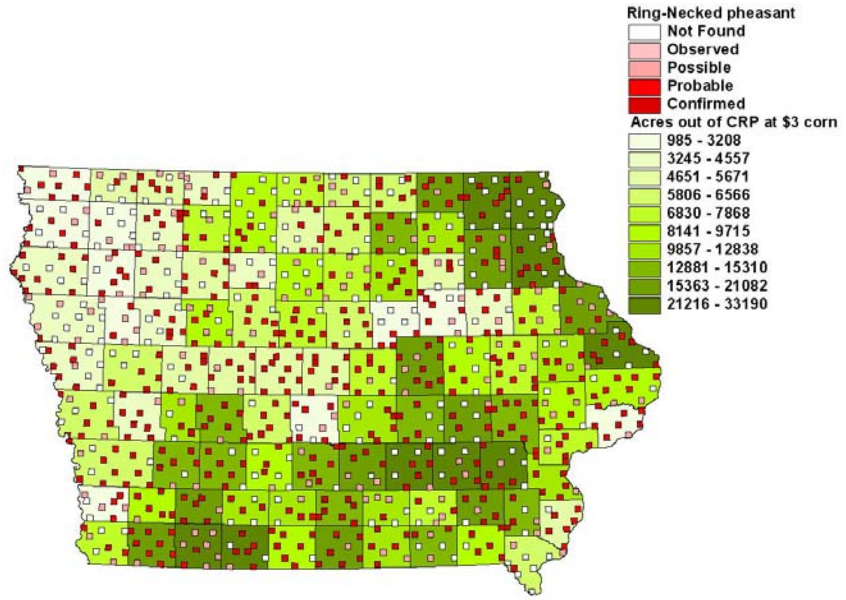


Figure 13. BBA distribution of ring-necked pheasant and acreage out of CRP at $3 corn



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## Appendix: Acreage, Program Costs, and EPIC Results

### Acreage

| | Acres into production | | | | |
|---|---|---|---|---|---|
| Corn price | SRR | SRR*1.25 | SRR*1.5 | SRR*1.75 | SRR*2 |
| $2.00 | 308,970 | 107,100 | 18,527 | 3,225 | 21 |
| $2.33 | 615,349 | 351,636 | 130,698 | 39,192 | 7,045 |
| $2.66 | 865,207 | 627,667 | 386,483 | 160,439 | 54,655 |
| $3.00 | 986,860 | 877,998 | 648,286 | 420,233 | 190,627 |
| $3.33 | 1,085,624 | 988,547 | 882,001 | 656,653 | 444,876 |
| $3.66 | 1,157,408 | 1,090,870 | 986,330 | 863,496 | 675,429 |
| $4.00 | 1,214,708 | 1,150,597 | 1,085,515 | 982,836 | 872,968 |
| $4.33 | 1,254,748 | 1,202,770 | 1,148,028 | 1,076,988 | 985,612 |
| $4.66 | 1,308,554 | 1,251,179 | 1,194,102 | 1,138,069 | 1,072,774 |
| $5.00 | 1,350,989 | 1,305,399 | 1,248,906 | 1,195,291 | 1,135,181 |
| | | | | | |
| baseline | 1,894,472 | | | | |

### Program costs

| | Program costs | | | | |
|---|---|---|---|---|---|
| Corn price | SRR | SRR*1.25 | SRR*1.5 | SRR*1.75 | SRR*2 |
| $2.00 | $140,799,404 | $209,534,605 | $268,760,077 | $316,747,773 | $362,656,741 |
| $2.33 | $104,833,352 | $170,951,948 | $247,010,514 | $309,579,121 | $361,201,930 |
| $2.66 | $77,417,923 | $129,710,292 | $199,577,830 | $282,036,842 | $350,181,788 |
| $3.00 | $65,284,527 | $95,654,097 | $152,631,449 | $226,293,675 | $314,964,328 |
| $3.33 | $55,636,374 | $81,797,516 | $114,574,050 | $177,009,575 | $252,788,594 |
| $3.66 | $49,189,016 | $69,432,231 | $98,588,728 | $137,672,599 | $198,802,987 |
| $4.00 | $44,356,110 | $62,402,198 | $84,119,366 | $115,815,879 | $155,231,358 |
| $4.33 | $41,320,512 | $56,836,369 | $75,290,086 | $99,702,582 | $131,893,065 |
| $4.66 | $37,429,433 | $52,072,595 | $69,429,130 | $89,629,335 | $114,877,550 |
| $5.00 | $34,280,968 | $47,151,422 | $62,804,154 | $80,803,877 | $103,034,809 |
| | | | | | |
| baseline | $181,330,473 | | | | |

**EPIC results**

| Absolute amounts in '000 tons | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Baseline | $2 | $2.33 | $2.66 | $3 | $3.33 | $3.66 | $4 | $4.33 | $4.66 | $5 | All area cropped |
| S | 902 | 1,188 | 1,720 | 2,664 | 3,239 | 4,007 | 4,595 | 5,001 | 5,395 | 5,748 | 6,047 | 11,097 |
| N | 14 | 19 | 27 | 35 | 40 | 46 | 50 | 54 | 57 | 59 | 62 | 91 |
| P | 1 | 3 | 5 | 7 | 9 | 9 | 10 | 10 | 11 | 11 | 12 | 19 |
| **C** | 206,878 | 205,500 | 203,377 | 201,063 | 199,799 | 198,633 | 197,795 | 197,030 | 196,410 | 195,763 | 195,242 | 188,036 |
| Changes from the baseline in '000 tons | | | | | | | | | | | | |
| | Baseline | $2 | $2.33 | $2.66 | $3 | $3.33 | $3.66 | $4 | $4.33 | $4.66 | $5 | All area cropped |
| S | | 286 | 818 | 1,762 | 2,337 | 3,105 | 3,693 | 4,099 | 4,493 | 4,846 | 5,145 | 10,195 |
| N | | 5 | 13 | 22 | 26 | 33 | 37 | 40 | 43 | 46 | 48 | 77 |
| P | | 2 | 4 | 6 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 18 |
| **C** | | -1,377 | -3,501 | -5,815 | -7,078 | -8,245 | -9,083 | -9,847 | -10,468 | -11,115 | -11,635 | -18,841 |
| % Changes from the baseline | | | | | | | | | | | | |
| | | $2 | $2.33 | $2.66 | $3 | $3.33 | $3.66 | $4 | $4.33 | $4.66 | $5 | All area cropped |
| S | | 32 | 91 | 195 | 259 | 344 | 410 | 455 | 498 | 537 | 570 | 1,131 |
| N | | 39 | 97 | 159 | 193 | 238 | 269 | 295 | 313 | 333 | 350 | 566 |
| P | | 173 | 406 | 657 | 787 | 845 | 887 | 928 | 982 | 1,051 | 1,108 | 1,844 |
| C | | -1 | -2 | -3 | -3 | -4 | -4 | -5 | -5 | -5 | -6 | -9 |