World Development Vol. 34, No. 1, pp. 130–148, 2006

Printed in Great Britain
0305-750X/$ - see front matter
www.elsevier.com/locate/worlddev
doi:10.1016/j.worlddev.2005.08.002

Grain for Green versus Grain: Conflict between Food Security and Conservation Set-Aside in China

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Summary. — This paper examines the conflict that may exist between conservation and food security. In China, policymakers and scholars are debating whether or not conservation set-aside programs threaten food security. To address the debate, we describe China's conservation set-aside program known as Grain for Green and compare it with similar programs outside of China. We then use data that we collected to measure the production and price impacts of the program on China's grain economy since 1999. Our simulations find that Grain for Green has only a small effect on China's grain production and almost no effect on prices or food imports.

Key words — food security, conservation set-aside program, Grain for Green, China, Asia

1. INTRODUCTION

Do environmental set-aside programs threaten food security? This is the question that is at the center of a debate among policymakers and scholars in China. While the leaders in most developing countries are concerned about degradation of natural resources as a result of efforts to enhance food security (e.g., Mink, 1993; Scherr & Yadav, 1996), the leaders in China are concerned about the opposite. In fact, China's leaders are blaming its conservation set-aside program, popularly titled Grain for Green, as one of the main causes for the recent surge in grain prices and rising food imports (Ministry of Land and Resources, 2004). By setting aside more than seven million hectares, Grain for Green, the developing world's largest cultivated land set-aside program, was designed to curtail soil erosion in China's major river basins. The main goal of leaders was to reduce the rising incidence of floods that were thought to be caused by the increased siltation build-up in the country's river system (Zuo, 2002). But, while at one time Grain for Green was the cornerstone of China's battle against floods and the possible consequences that poor water conservancy was having on the country's agricultural production and rural economy, it is now being blamed as the source of the unprecedented fall in China's domestic grain production. In fact, the belief in China that land conservation is contributing in a major way to the deterioration of its food security is so strong that the leadership severely curtailed the progress of the program in 2004.

Surprisingly, despite the importance of such an idea, to our knowledge there is very little work that is currently trying to quantify the impact of Grain for Green on China's grain economy. Because of the magnitude of the decision that is being considered inside China, it is important to understand how Grain for Green has affected the country's grain production. While a recent study by Feng, Yang, Zhang, Zhang, and Li (2005) simulated the impact of Grain for Green on China's grain supply, it does not take account of the changes in farmer production behavior on the remaining cultivated land, including responses to price changes, and also does not examine by crop effects.

* Final revision accepted: August 29, 2005.

The importance of the issue transcends the current debate in China. There are currently many developing countries that are launching and that are being pushed into land conservation programs. Given the level of poverty that exists in many developing countries as well as the role that food plays in their political economy, it is important to study relationship between environmental programs and food security.

In this paper, our overall goal is to carefully measure the production impacts of the implementation of China's Grain for Green program since the pilot program began in 1999 in order to help illuminate some of the basic questions that are being debated in China. While the prominence of food security in China's national politics and its approach to land set-aside are unique, we believe that there are also lessons for other developing countries. To meet the goal, we first introduce China's Grain for Green program and attempt to put it into context by reviewing the literature on the implementation of conservation set-aside programs in other countries. In particular, we are interested in understanding how similar programs in other countries have affected crop prices and productivity. Next, we create a framework for studying the impact of Grain for Green in China using CAPSIM, a policy simulation model of China's food economy. In carrying out the analysis, we rely on data that have been collected by ourselves during a number of periods of fieldwork since 2000. Finally, we examine the results of the analysis and attempt to draw lessons for China and other developing countries.

2. CHINA'S GRAIN FOR GREEN PROGRAM

The Grain for Green program (also known as Sloped Land Conversion Program) was implemented in 1999 by China's government as a cropland set-aside program to increase forest cover and prevent soil erosion on sloped cropland. [1] When available in the community, farmers set aside all or part of certain types of land and plant seedlings to grow trees. In return, the government compensates the participants with in-kind grain allocations, cash payments, and free seedlings. In PPP terms, the average first year compensation amounts to a payment that is more than 15 times the average per hectare rental payment under the Conservation Retirement Program (CRP) in the United States (Uchida, Xu, & Rozelle, 2005).

Grain for Green is one of the world's largest conservation projects, covering vast tracts of China. Starting with a pilot program, officials expanded the program to 20 provinces by the end of 2001 (Zuo, 2002). During the initial period of the program (1999–2001) farmers converted 1.2 million hectares of cropland into forest and pasture land (Xu & Cao, 2002—Table 1, rows 1–3). During 2001–03, the pace of conversion accelerated (rows 4 and 5). By 2003, the program had converted in accumulated terms 7.19 million hectares of cropland and farmers had afforested 4.92 million hectares of barren land (row 6). By the end of the program in 2,010, leaders (at least originally) planned to set aside nearly 15 million hectares of cropland, affecting 40–60 million rural households.

Since the main objective of China's program is to restore the country's forests and grasslands to prevent soil erosion, program designers have made the steepness of the slope one of the main criteria on which plots are selected for inclusion into the Grain for Green program. The steepness criterion means that the program in Southwest China targets land with 25 degrees of slope or more for participation. In Northwest China, the program targets land with 15 degrees of slope or more. China's site selection criterion is much simpler than those used by other cropland set-aside programs, such as the CRP. Uchida *et al*. (2005) show that although there are some targeting problems, to a remarkable degree, program officials are setting aside cultivated land that is mostly steep.

Table 1. *Total area of converted cropland and area of afforested barren land in the Grain for Green program in China, 1999–2003 (million hectares)*

Year	Converted cropland (all crops)	Afforestation on barren land	Total
1999	0.38	0.15	0.53
2000	0.40	0.07	0.47
2001	0.42	0.47	0.89
2002	2.65	0.56	3.21
2003	3.33	3.67	7.00
Total	7.19	4.92	12.1

Data source: SFA.

(a) *Impact of Grain for Green on villages and farm household incomes*

While there is some concern about the implementation in the long run, at least up until now the Grain for Green program has had a positive effect on the welfare of most farmers in the program areas. Evaluations of the Grain for Green program (e.g., Uchida *et al.*, 2005; Uchida, Xu, Xu, & Rozelle, 2004; Xu, Katsigris, & White, 2002; Zuo, 2002) have mostly found that the welfare of the participating farmers improved in most areas. Case studies in Xu *et al.* (2002) reveal that net income per capita increased, after the program in most regions. For example, in Tianquan County, Sichuan Province, the average net income per capita for the participating households increased by 72%, from 1,027 yuan to 1,765 yuan. Based on a survey commissioned by the State Forestry Administration (SFA), Uchida *et al.* (2004) showed that participating households enjoyed a faster increase in assets such as livestock.

Although it is perhaps not surprising that total income did not fall since farmers received compensatory payments from the government, contrary to some prior expectations, even agricultural income did not decrease in some regions (Uchida *et al.*, 2004, 2005; Xu *et al.*, 2002). In fact, in some localities agricultural income increased due to more intensive agricultural production on non-program plots. This result is primarily because farmers have intensified agricultural production on the remaining land by using better seed stock, switching from single to multi-cropping or increasing livestock production.

3. GRAIN FOR GREEN AND TRENDS IN CROP PRODUCTION

Despite the mostly positive effects of Grain for Green on farm households in participating regions, a controversy has arisen about the effect of the program on the much broader grain economy. Responding to rapidly rising domestic grain prices that began in October 2003, the Ministry of Land Resources and several researchers hypothesized that one of the main reasons that grain production had fallen in recent years and why grain prices had risen during the recent months was the country's Grain for Green program (Chinesenewsnet, 2004; Ministry of Land and Resources, 2004). Moreover, if the plans to expand the program are carried out, it is implied that the problem should be expected to get worse in the future. Others, however, argue that setting aside the marginal land in the Grain for Green program likely has little, if any, effect (Feng *et al.*, 2005). Not only is the direct production effect small because output was already so low, but farmers who are in the program only set aside part of their land and other agricultural activities and are able to increase productivity on their remaining household productive assets.

So, which team in this debate is correct? What has triggered the idea that Grain for Green is causing China's grain prices to rise? To answer these questions, in this section, we look at the trends of national grain sown area and production, compare them to Grain for Green trends, initially using naïve assumptions about how a reduction in sown area from the program might affect national output, and then try to motivate why the naïve assumptions are not correct. In some sense, this section examines the direct effect of Grain for Green using a set of unrealistic assumptions that do not account for quality differences between Grain for Green and non-Grain for Green areas and also do not allow for farmers to respond economically. We also examine the experience of other countries. Following this descriptive-based analysis, in the next section we relax these assumptions and use a multivariate simulation model to try to undertake a critical analysis of the impact of Grain for Green using a more realistic set of assumptions.

(a) *National sown area and production trends*

Sown area trends since the early 1990s demonstrate the concern of those that might try to blame Grain for Green for the rising prices in recent months. During 1991–99 (and, in fact, since the mid-1980s) China's sown area remained fairly static. In fact, during the 1990s, grain sown area never deviated by more than two million hectares in any given year; grain sown area in 1999 was one million hectares higher than in 1991.

After 1999, however, there is a sharp change. During 1999–2003, grain sown area fell monotonically. By 2003, sown area dropped to 99 million hectares, a drop of 12% when compared to 1999. In fact, in 2003 the area sown by grain by China's farmers fell below the 100 million hectare level for the first time since 1950. Production trends parallel those of sown area and reinforced the concerns (right or wrong) about the effect of Grain for Green. After trending up during the 1990s, grain production fell steeply as China's farmers produced only 430 million metric tons in 2003, a level of 15% lower than in 1999.

Given these trends, it is easy to understand why it would be easy to blame Grain for Green for the fall in China's grain sown area and production: the reduction in cultivated area driven by program implementation started in 1999, the same year grain sown area began to fall. In 1999 as national grain sown area began to fall, the reduction of sown area due to the program also began to fall. As China's grain sown area continued to fall through 2001, 2002, and 2003, the area reduction due to Grain for Green accelerated, reaching an aggregate level of more than seven million hectares. Hence, it is true that there is a co-movement of national grain sown area and the reductions due to the program. When comparing the two series, however, it is apparent that Grain for Green cannot be fully responsible for falling sown area, since overall sown area falls by 14 million hectares, twice as much as the amount of land removed from production due to Grain for Green.

(b) *Grain for Green and yield effects*

While it is unclear, the exact assumptions of those who have blamed Grain for Green for China's grain shortfalls and rising prices (there is never an analysis underlying their assertions), under the most naïve of assumption one could draw a conclusion that about half of the drop in production was due to Grain for Green. To get such a high level of impact, however, it must be assumed that the yields on the set-aside land are the same as the average land in China's grain economy. If so, then under these extreme assumptions, of the 78 million ton total reduction in output, the Grain for Green program would be responsible for about 30–40 million tons.

Those familiar with China's Grain for Green program, however, would have to take exception to such extreme assumptions and could do so in several ways. First, and most fundamentally, it should be remembered that Grain for Green officials have exerted a lot of effort to target steeply sloped land in poor, remote, and mountainous regions (Uchida *et al.*, 2005). As such, the productivity of retired land almost certainly should be expected to have much lower yields than the areas in which land was not retired. When examining our data from a national survey of Grain for Green, we find that on a crop for crop basis, yields are, in fact, much lower for plots that were retired than those that were not (Table 2, columns 8 and 9). For example, wheat producers across China achieved yields of 3.95 tons per hectare in 1999. In contrast, wheat producers achieved yields of only 1.08 tons per hectare on their Grain for Green plots during the year prior to when the plot was converted into forests. In other words, the yields on the Grain for Green plot were only about 30% of those on the non-Grain for Green plots. Similarly, maize and other grain farmers in the Grain for Green program only had yields on their program plots that reached about 50% of non-program plots. These observations are consistent with Feng *et al.* (2005) who found that the yields are significantly lower for sloped cultivated land in seven regions in China.

Differences are also found when comparing the productivity potential of the environment within which Grain for Green programs were executed with other regions of the country. To examine this we use a detailed GIS database constructed by our coauthor and his colleagues as described in Deng, Huang, Rozelle, and Uchida (forthcoming). Using information on factors that will determine the agronomic and climatic potential of a region's agriculture (such as, rainfall, sunlight, number of frost free days, elevation, soil, and water resources), we are able to create an Eco-Environment Index for all of China's counties (Figure 1, Panel A). According to the index, across all of China's 2000 counties, 1.81% of China's farmers grow crops on land with an index as low as four, while 0.53% of China's farmers cultivate crops on land with an index that reaches 9. When we divide counties into those that are key Grain for Green counties (Panel B) and those counties that did not have any Grain for Green activity (Panel C), it is clear that the productivity potential of Grain for Green counties is below that of non-participating counties.

Results from individual surveys and case studies also support the fact that Grain for Green officials encouraged the retirement of plots with lower yields. For example, in one study there is evidence that although the total area under cultivation dropped after the program began, the total production on remaining cropland did not fall, at least not proportionally (Xu *et al.*, 2002). When households set aside a part of their land, in many cases they actually increased production on the rest of

Table 2. *Annual percentage decreases of sown area and annual increases in yields due to Grain for Green in China, 1999–2003*

	Total sown area in 1999 (1,000 hectares)	Sown area converted (1,000 hectares)					Share by crop (%)	Actual yield in 1999 (ton/hectare)	Yield in converted land (ton/hectare)	Annual decrease of sown area (%)	Annual increase of average yield (%)
		2000	2001	2002	2003	Total					
Total converted sown area (1,000 hectares)		573	405	1,506	2,938	5,422	100				
Wheat	28,855	258	182	678	1,322	2,440	45	3.95	1.08	2.05	1.64
Maize	25,904	86	61	226	441	813	15	4.94	1.73	0.78	0.52
Sweet potato	6,000	7	5	20	38	70	1.3	4.20	2.69	0.29	0.11
Potato	4,100	7	5	18	35	65	1.2	2.74	2.48	0.39	0.09
Other grains	9,056	58	41	154	300	553	10.2	1.86	0.75	1.49	0.96
Soybean	7,962	10	7	26	50	92	1.7	1.79	0.69	0.29	0.18
Oil crop	13,906	41	29	107	209	385	7.1	1.87	0.56	0.68	0.50
Sum of above	95,783	467	330	1,227	2,395	4,419	82				

Data sources: All area data in the above table are sown area. Sown area in 1999 (column 1) are from CNSB, 2000. Rest of the figures is either from our data or is estimated from our data.

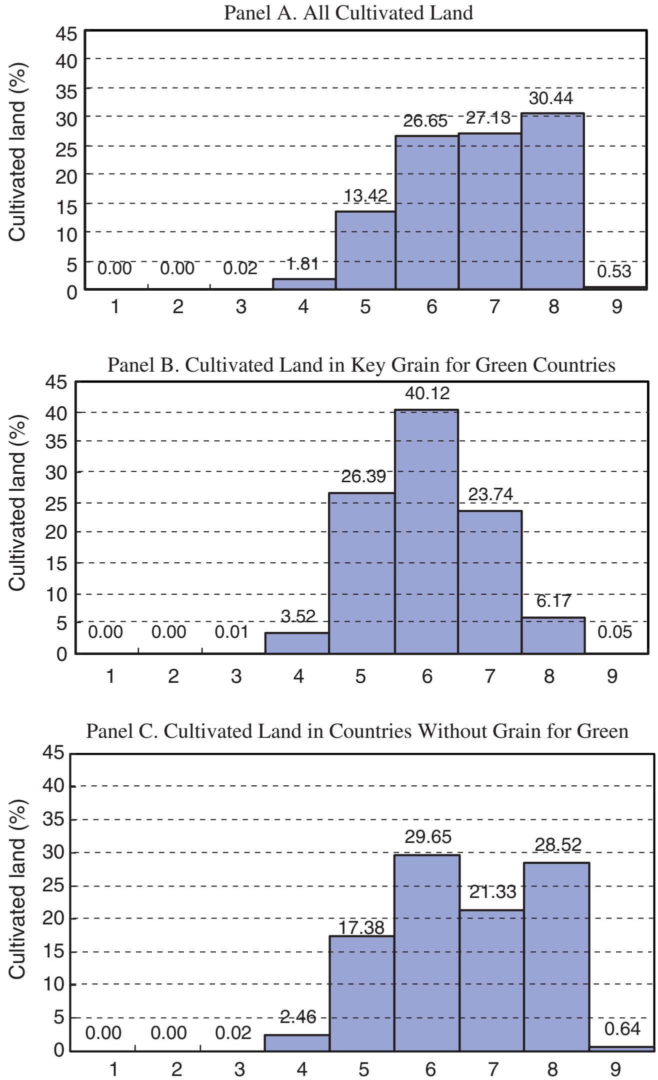

Figure 1. *Distribution of the cultivated land by the level of eco-environment index in participating and non-participating counties in China, 2000. Panel A: All cultivated land; Panel B: Cultivated land in key grain for green counties; and Panel C: Cultivated land in counties without grain for green. Data source: Authors' Data. Note: The level of the eco-environment index of a county is measured as an index that account for agro-climatic variables (sunlight, temperature, annual mean precipitation), geophysical variables (e.g., elevation, slope), and soil variables (texture, pH value, nutrients) that affect its agronomic productivity potential.*

their sown area, offsetting in part or in full the fall in output from the set-aside. Specifically, in the case of Delong County in Ningxia Hui Autonomous Region, the aggregate sown area dropped after the program from 477 mu to 364 mu, but total production increased from 80 tons to 105 tons.

In addition, when one looks at the changing composition of income, it appears as if there is not a large decrease in agriculture income, which would not occur if farmers retired high quality land. The income impact analysis in Uchida *et al.* (2005) illustrates that average household real net income from grain did not decrease by a large amount after participating in Grain for Green. In Ningxia, the average real net income per capita from grain decreased from 1999 to 2000 by 25%, from 374 yuan to 281 yuan. In Guizhou, it decreased by 11%, from 206 yuan to 183 yuan. The decline in income from grain production is not large considering the fact that the sample households in Ningxia and Guizhou converted 62% and 72% of their land, respectively.

Hence, the effect of Grain for Green is less evident when we use the lower yields (from Table 2) in estimating the direct loss from setting aside land. In Table 3, we examine on a province by province basis the amount of area in China's Grain for Green program and multiply the area by the estimated yields on the retired plots. When we aggregate the numbers to the national level and examine them on a year by year basis, we see that when taking the productivity differences of program and non-program plots into consideration, the accumulated reduction in production from Grain for Green is only 7.5 million tons which is only 9.6% of the total reduction (7.5/78). From this, we can see that as soon as we take

Table 3. *National sown area in grain, Grain for Green area in grain, and estimated losses in grain production due to Grain for Green program*

Province	Total sown area in grain, 2000 (million hectares)	Total GFG area in 2003 (million hectares)	Estimated GFG area in grain, 2003 (million hectares)
Beijing	0.41	0.02	0.02
Tianjin	0.43	0.00	0.00
Hebei	7.24	0.38	0.32
Shanxi	3.24	0.38	0.31
Neimeng	4.95	0.64	0.52
Liaoning	3.06	0.19	0.15
Jilin	3.51	0.19	0.16
Heilongjiang	8.10	0.21	0.17
Shanghai	0.34	0.00	0.00
Jiangsu	5.83	0.00	0.00
Zhejiang	2.75	0.00	0.00
Anhui	5.93	0.20	0.16
Fujian	2.01	0.00	0.00
Jiangxi	3.55	0.14	0.12
Shandong	8.10	0.00	0.00
Henan	9.03	0.21	0.17
Hubei	4.67	0.26	0.21
Hunan	5.14	0.39	0.32
Guangdong	3.37	0.00	0.00
Guangxi	3.73	0.18	0.15
Sichuan	7.30	0.78	0.64
Guizhou	3.14	0.34	0.28
Yunnan	4.04	0.28	0.23
Shannxi	4.03	0.82	0.67
Gansu	2.91	0.50	0.41
Qinghai	0.34	0.17	0.14
Ningxia	0.84	0.18	0.15
Taiwan	0.00	0.00	0.00
Hainan	0.57	0.04	0.03
Xinjiang	1.54	0.17	0.14
Xizang	0.20	0.01	0.01
Chongqing	2.88	0.31	0.26
Bingtuan	0.00	0.09	0.07
Total	113.16	7.19	5.90

Data source: Total sown area obtained from China Statistical Yearbook 2000. Grain for Green area obtained from the SFA. Grain for Green area in grain is estimated as 82% of the total area converted, which includes wheat, maize, tuber, other grain, soybean, and oil crops.

into account the lower productivity of Grain for Green plots, while it could still affect grain prices, there clearly are other forces that also are affecting grain production and prices.

Therefore, from an analysis of the descriptive statistics we come to the conclusion that although it is plausible that there are price effects of Grain for Green, we also know that there must be other factors. Moreover, we also can see that despite the fact that half of the reduction in national sown area during 1999–2003 is associated with Grain for Green, the lower productivity of the retired plots means that at most the direct estimate of the loss of production from Grain for Green is only about 9.6% of the total fall in production.

4. SUPPLY AND PRICE EFFECTS IN OTHER COUNTRIES

In the previous section, based on the descriptive analysis, there is reason to believe that a small, but still significant share of production fell due to Grain for Green. In fact, these may still be too high. Lessons from the literature on the price effects of conservation set-aside programs in other countries caution that the descriptive-based estimates may be too large. In this section, we examine the experience of other countries. Lessons from these countries can help us refine our estimates of the overall production effects.

(a) *OECD land set-aside programs*

Major set-aside programs in developed countries typically have the main objective of either supply control or environmental conservation or (in most cases) a combination of both (OECD, 1997). Short-term set-asides of up to five years are mainly aimed at supply control, whereas long-term set-asides of 10 years or more chiefly are aimed at providing environmental services. Examples of short-term set-aside programs include the one-year and five-year set-aside programs in the European Union as well as the US Acreage Reduction Program. Long-term set-aside programs include US Conservation Reserve Program (CRP), Canada's Permanent Cover Program and the set-aside option of the agro-environmental regulation, and the forestry schemes in the European Union. Japan's rice paddy field diversion programs include both short-term and permanent conversion schemes.

Regardless of the differences in the purpose and the mechanism, the set-aside programs in OECD countries have mostly succeeded in taking substantial areas of land out of production (OECD, 1997). In Canada, for example, around 520,000 hectares of cropland have been placed under a permanent cover, mostly in the provinces of Alberta and Saskatchewan. In the European Union, around 7.2 million hectares were diverted under the short-term set-aside schemes in 1995, and around 930,000 hectares under the long-term forestry scheme. Japanese farmers set aside 660,000 hectares of paddy fields from rice production in 1995, and Swiss farmers placed 57,000 hectares of land into set-aside programs in 1994. In the United States, by far the most ambitious user of its CRP program, 13.6 million hectares were enrolled in CRP by 2000, which is nearly 10% of the total cropland of the United States (USDA, 2000).

(b) *Environmental regeneration through food-for-work programs in India and Ethiopia*

While there are no real conservation set-aside programs in other developing countries, there are some programs that are similar to those of China's Grain for Green. In these programs, officials set up food-for-work programs that are directed toward resource conservation projects. In general, the common threads that run through these programs are the method of payment and the target investment. Food-for-work programs pay the poor in grains or other food items for providing labor to create community assets through labor-intensive work (Ravallion, 1991). Although these are used in many countries, in only a relative few are projects specifically targeted at environmental rehabilitation. In India, for example, food-for-work programs have a long history, primarily to provide wage employment and ensure food security in drought-affected areas. In recent years, officials have shown a preference to fund soil and water conservation projects (Deshingkar, Johnson, & Farrington, 2005). More recently, the government has started a massive reforestation program called the Greening India Program, which proposes to reforest 43 million hectares in 10 years and it is planned to be combined with a food-for-work program (Balooni, 2002). There are also similar programs that are being tried in Ethiopia (Humphrey, 1999).

(c) *Price effects of CRP in the United States*

When using the production and price impacts of these programs to help understand what is happening in China, two observations are worth pointing out. First, many of the OECD programs, in particular the short-term ones, are specifically aiming to control supply and increase crop prices. Therefore, it should be no surprise that in addition to affecting cropping area, crop production also has been reduced and prices have risen (at least in a relative sense). Despite the explicit intent of some programs to affect prices, it is not always easy to measure the impact. In most countries, there are almost always a number of other agricultural support policies that are being implemented in parallel to the set-aside programs (such as direct subsidies on crop prices) that confound the impact on prices. As a result, the price effect of the set-aside programs will generally be difficult to isolate from impacts of other policies. In fact, about the only nation where considerable analytical work has been done to quantify the effect of set-aside programs is in the United States (which we summarize below).

In fact, like China, policymakers and economists in the United States are concerned about how CRP affects agricultural commodity prices. Taking cropland out of production will result in less agricultural production and thus higher agricultural commodity prices. If commodity prices rise proportionately more than production falls, farm income from crop production should increase. There can also be secondary general equilibrium effects, however, that dampen the direct program effects—although not all models capture all of the effects.

The model that shows the largest effects of the program on prices was created by USDA. Based on a maximum 36.4 million acre program (slightly larger than the current program) and by using a partial equilibrium model, USDA estimated that wheat, corn, and soybean prices would rise by 12–15% compared with prices in the absence of CRP (USDA, 1997, 2000). While the price increase is a gain to farmers, it is a cost to commodity users (i.e., livestock producers and consumers). The USDA estimated that the price increase would raise farmer income by 7.60 billion dollars but increase domestic commodity expenditure by 4.90 billion dollars. The estimates based on the USDA model are the largest because they do not account for secondary, indirect effects.

The results of other studies, however, show that estimated price increases differ significantly depending on the structure of the model used for the simulations. For example, Boyd, Konyar, and Uri (1992) used a general equilibrium model and estimated that after retiring 33.9 million acres through the CRP, the price of the output of program crops would rise by less than 1%. This result contrasts sharply with those of the USDA study. We believe that their estimate is much lower primarily because the Boyd team uses a general equilibrium model; the model allows non-program agricultural sectors to respond to the price increases of program crops by switching to the program crops, thereby increasing the output of program crops, and dampening their price increase. The point of the above analysis is that in addition to estimating the direct price effects of a program, economists also need to be concerned about indirect effects. [2]

(d) *Implications for China*

In summary, then, the estimated price effects of the US CRP are all generally small, but vary: from less than 1% to 15%. So which one should be believed and which one is relevant for the case of China? First, if we believe the magnitude of the price response that was calculated by the USDA (the highest of the estimates), then we would have to say that China's price could have moved somewhat due to Grain for Green. [3] However, it also should be recognized that China's program through the end of 2003 was less than one-third the size of the program in the United States. Therefore, at the most, if China was subject to the same pressures as those in the United States (according to the USDA program), at most, the price of grain would have only risen due to the program by 5%. Hence, at most, this is the highest estimate and would represent less than a 2% increase per year.

Moreover, it should also be remembered that the USDA study with the highest estimates were estimated based on a partial equilibrium framework. It is almost certain that there are general equilibrium effects and indirect effects that will have offset some of this direct effect and according to some cases, such countervailing effects (or price dampening effects) could be significant. If this were the case, given the size of China's program, we should expect to find only a marginal positive or even no measurable effect on China's grain prices. In the case of China, we can expect the response of reconversion of other non-program land into cropping (such as was seen in the United States). During 1986–2000 China recorded a 1.9% net increase in cultivated land (Deng *et al.*, forthcoming); although the quality of the newly created cultivated land is lower than existing cultivated land, we expect that China still has the capacity to respond to price increases by changing other land uses into cultivated land. In addition, we can expect that the intensification effect of the household's remaining land is more significant than in the United States. Hence, based on the experience in the United States, it may be reasonable to assume that the real effect of Grain for Green on China's grain prices is less than the high responses predicted by modeling efforts in the United States. If so, this would mean that prices may have risen by at most 1–2% during the program period or less than 1% per year. In the next section we provide a case study of the impact of the Grain for Green program on China's grain prices.

5. GRAIN FOR GREEN, PRICES AND FOOD SECURITY—MODELING THE FULL EFFECTS

In order to evaluate the impact of the Grain for Green program on China's grain production and the rest of agriculture, a quantitative method has been developed based on CCAP's Agricultural Policy Simulation and Projection Model (CAPSiM). CAPSiM was developed out of a need to have a framework for analyzing policies affecting agricultural production, consumption, price, and trade at the national level. [4] CAPSiM is a partial equilibrium model in the sense that it looks only at the agricultural sector and does not include factor markets. The model, however, endogenously determines prices for the agricultural commodities within the model. [5] It is the first and most comprehensive model for examining the effects of policies on China's food demand, supply, and trade. Most of the elasticities used in the CAPSiM were estimated econometrically by ourselves using state-of-the-art econometrics and with assumptions that make our estimated parameters consistent with theory. Both demand and supply elasticities change over time as income elasticities depend on the income level and cross-price elasticities of demand (or supply) depend on the food budget shares (or crop area shares). [6] The commodities include 12 crops and 7 animal products. The crops included are rice, wheat, maize, sweet potato, potato, other coarse grains, soybean, cotton, all edible oils, sugar crops, vegetables, and fruits. Farmers cultivate the 12 crops on more than 90% of China's total sown area. The animal products include pork, beef, mutton, poultry, eggs, milk, and fish. In this paper, we focus mostly on the grain crops.

In order to parameterize our model, we use two main sets of data. First, to get the Grain for Green area reductions over time and by province, we rely on a set of data provided to use directly by SFA. These data are from the records of each set of county and province program offices and are the records on which payments are made to farm households.

In addition, we also use a special set of primary household data on which we base a number of parameters of our model, including the breakdown of the area reductions by crop and the yields of set-aside plots. The survey, which we conducted ourselves, also was commissioned by SFA as part of their effort to evaluate the country's Grain for Green program after the third year of implementation. The household survey employed a careful sampling strategy designed to collect data on a random sample of households in the program area. Initially, the three provinces that had been participating in the Grain for Green program from 2000 were selected. Two counties in each province and three townships in each county (a total of 18 townships) were randomly selected. In each of the 18 randomly selected townships, two participating villages were selected. Within each village, 10 households were randomly selected from each village. In the sample there is at least one household participating in the program in every village. In 2 out of 36 villages, all of the households in our sample were participating households.

The household survey asked respondents about a number of variables from both before and after the time the program began. Enumerators collected information on the household's production activities on a plot-by-plot basis. The household reported plot-specific production data for 2002, the year prior to the survey, and 1999, the year prior to launching of the program. It is on this part of the survey form that we collected information on the crop mix that was affected by the program. [7] According to our data, 45% of total retired plots were

Table 4. *Documenting the estimation of the amount of cultivated land converted during a given year that affects production during that year*

	Crop land converted from January 1 to December 31 (1,000 hectares)	Converted crop land affecting production during current year (1,000 hectares)	
		Total	Crops analyzed
1999	381		
2000	405	584	476
2001	420	412	336
2002	2,647	1,533	1,250
2003	3,338	2,992	2,439
2000–03	7,191	5,522	4,501

Notes: The area data in the table are cultivated land area and that in column 1 are from the State Land Administration. The numbers that we use in our analysis differ, however, because in each year the converted land occurred from January to December. Therefore, not all land converted in each year has an effect on current crop sown area and production. Consequently, we make a simplifying assumption and estimated the amount of converted crop land that affects production in the current year as land that affects production in year t as: (total converted crop land in year $t-1$) $\times$ 0.5 + (total converted crop land in year t) $\times$ 0.5. Because CAPSIM only models China's major crops, in the final analysis we account for only about 82% (or 4,501/5,522) of the area.

sown to wheat, 15% to maize, 10.2% to other grains and the rest of the area to other crops, such as potato, sweet potato, soybeans, and oil crops (Table 2, column 7). The plot by plot data were also used to generate estimates of the yields on the plots that ultimately were retired (column 9) which are compared to the actual yields of China's crops (column 8), which come from the China National Statistical Bureau's annual publications (NSBC, 2004).

(a) *Scenario development*

Given the above discussions, the changes from Grain for Green can be divided into two parts. First, there is the direct reduction in sown area. In order to simulate the setting aside of program land two adjustments need to be made to the year by year national statistics on program area. First, we need to account for the fact that if SFA reports an area reduction during a given calendar year, only a part of the area reduction that was executed during the first part of the year will affect grain production during the year. In order to adjust the reported program area for the timing program implementation during the year, we make the simplifying assumption that half of the changes are made in the early part of the year (and will affect the current year's production) and half are made at the end of the year (and will affect only the following year's production). In making these adjustments, the year by year total area reductions fall and the total area set aside during the 1999–2003 time period fall from 7.191 million hectares to 5.522 million hectares (Table 4).

Using the aggregate adjusted set-aside numbers for each year, we then need to use the estimates of the cropping patterns of the program areas to disaggregate our data into by crop estimates of crop retirements. We do so by multiplying the crop shares in Table 2 (column 7) by the set-aside areas. Under such assumption, our estimates for the annual sown area set aside for wheat, maize, other grains, and other crops are in Table 2 (columns 2–5).

The next step is to convert the absolute amount of reductions for each crop (measured in hectares) into an annual percentage fall in sown area. This is done, for example, by comparing the amount of the total sown area for each crop (column 6) that was set aside during the program years to China's total grain sown area in 1999 (Table 2, column 1) and annualizing the reductions (column 10). In the case of wheat, for example, we estimate that program officials retired 2.44 million hectares out of China's total wheat crop in 1999 of 28.855 million hectares. This means that during 1999–2003, there was a 2.05% annual reduction in wheat area. The annual rates of decline of sown area for the other crops range from 0.29% (for soybean and sweet potato) to 1.49% (other grains).

The final step involves generating an estimate of the positive yield effect that occurs from the systematic retirement of low-yielding cultivated land. This step basically was accomplished by asking the question: without any general equilibrium effects, what would have been the yields of each crop in China had the retirement of low-yielding land been accomplished without any response of farmers. As in the case of sown area, the absolute increases in yields for the four years of the program were then annualized (Table 2, column 11). The increases in yields ranged from 0.11% (for sweet potato) to 1.64% (for wheat). Again, it needs to be emphasized that in the analysis these yield changes are exogenously introduced into the model and are done so because we know that when low yielding land is taken out of production, the remaining land is systematically higher yielding.

6. SIMULATING THE IMPACT OF GRAIN FOR GREEN

Using CAPSIM, and the assumptions that we have used to parameterize the model, our findings are robust. Grain for Green has only a very small effect on China's grain economy. In the following analysis, if we examine the entire project period, 1999–2003 we get the same result—there is not a very large impact of Grain for Green. Moreover, no matter which component of the grain economy we examine—production, yields, prices, or imports—the conclusion is fairly clear: Grain for Green does not have a large effect.

The results for final sown area demonstrate part of the reason for the small impact. In addition to having a fairly small impact because the area that is retired is fairly low yielding, the effect is even less because of general equilibrium effects. Recall from Table 2 that during 1999–2003, 2.44 million hectares of wheat area was set aside by the program. According to our results, however, we find that at the end of 2003 the total amount of wheat area that is reduced due to the program is only 2.082 million hectare, a difference of 15% (Table 5, row 2, column 4). This means that by the end of the program, because of higher wheat and other prices due to the Grain for Green reductions, wheat area rose an additional 15%. Since the total cultivated area is assumed to be constant, the rise is either due to intensification, that is, the shift into double cropping from single cropping, or the conversion of non-wheat area into wheat area. The same is true for maize and other grains (rows 3 and 4, column 4). There are also reductions in sown area to other crops such as rice but they are fairly small (row 5). The same analysis in percentage terms is reported in Appendix A.

In the same way that we saw the production effect was much smaller then the sown areas effect in the descriptive statistics, the CAPSIM analysis shows that the production effects are also relatively small (Table 5, rows 6–9). For example, in the case of maize, during 1999–2003, production fell by 12.256 million tons (or 9.57%). Of this only 0.554 million tons (or 0.43%) is due to Grain for Green; the rest is due to other effects. This means that for the case of maize, although the fall in production is significant, only 4.5% of the overall change (or 554/12,256) is from Grain for Green. Clearly, although the level of retired sown area is substantial even after the general equilibrium effects reduced the amount, the low productivity of the plots versus the rest of China's plots accounts partly for the small impact. In addition, when comparing the overall naïve estimates of the fall in grain production (7.5 million tons) to those of the simulation analysis (only about two million tons—1.252 million tons of wheat; 0.554 million tons of maize; and 0.232 million tons of other grains), we can see that the general equilibrium effect is important. Interestingly, although as we saw from Table 5 part of the reason for the relatively small increase in production (versus the naïve estimates) is due to the rise in sown area from the general equilibrium effects, our analysis also shows that there is a positive yield effect that dampens the effect of Grain for Green on production (Table 6 and Appendix A).

With falling sown area and production, even after accounting for general equilibrium effects, the simulation analysis shows that grain prices do rise due to Grain for Green, but by almost any point of view the price increase is small and is small versus the total change in price (Table 7). According to our analysis, we find that during 1999–2003, the prices of wheat and other grains actually fell (by 7.06% and 6.91%, respectively) and that of maize rises somewhat (by 8.86). However, during this time period, the effect of Grain for Green is small. In the case of wheat, it is the largest crop and most important food grain affected by Grain for Green, although the price of wheat fell by 103 yuan per ton from 1,458 yuan per ton in 1999 to 1,355 yuan per ton in 2003, our analysis shows that the price effect was only 27 yuan per ton. And in the case of wheat this means that if it had not been for Grain for Green, the overall price of wheat would have fallen by 130 yuan

Table 5. *Simulated impact of Grain for Green policy on crop sown area and production in China*

Commodity	Period	Actual amount	Absolute change			Change in percentage (%)		
			Change over previous period	Change due to		Change over previous period	Change due to	
				Grain for Green policy	Other		Grain for Green policy	Other
Sown area (1,000 hectares)								
Rice	1999	31,284						
	2003	26,508	−4,776	−16	−4,760	−15.3	−0.1	−15.2
Wheat	1999	28,855						
	2003	21,997	−6,858	−2,082	−4,776	−23.8	−7.2	−16.6
Maize	1999	25,904						
	2003	24,068	−1,836	−725	−1,111	−7.1	−2.8	−4.3
Other coarse grains	1999	9,056						
	2003	8,057	−999	−483	−516	−11.0	−5.3	−5.7
Total sown area	1999	153,026						
	2003	147,343	−5,683	−3,960	−1,723	−3.7	−2.6	−1.1
Production (1,000 ton)								
Rice	1999	138,941						
	2003	112,459	−26,482	0	−26,482	−19.1	0.0	−19.1
Wheat	1999	113,880						
	2003	86,488	−27,392	−1,252	−26,140	−24.1	−1.1	−23.0
Maize	1999	128,086						
	2003	115,830	−12,256	−554	−11,702	−9.6	−0.4	−9.1
Other coarse grains	1999	16,835						
	2003	16,689	−146	−232	86	−0.9	−1.4	0.5

Note: The percentage changes are rounded to the first decimal; it is possible that the figure, 0.0, may not mean "no change."

Table 6. *Simulated impact of Grain for Green policy on yields of crops in China, 1999–2003*

Commodity	Period	Actual yield (ton/hectare)	Absolute change (ton/hectare)			Change in percentage (%)		
			Change over previous period	Change due to		Change over previous period	Change due to	
				Grain for Green policy	Other		Grain for Green policy	Other
Rice	1999	4.44						
	2003	4.24	−0.2	0	−0.2	−4.5	0	−4.5
Wheat	1999	3.95						
	2003	3.93	−0.02	0.28	−0.3	−0.51	7.09	−7.59
Maize	1999	4.94						
	2003	4.81	−0.13	0.12	−0.25	−2.63	2.43	−5.06
Other coarse grains	1999	1.86						
	2003	2.07	0.21	0.08	0.13	11.29	4.3	6.99

Table 7. *Simulated impact of Grain for Green policy on wholesale prices of agricultural commodities*

Commodity	Period	Actual price in 2003 (yuan/ton)	Absolute change (yuan/ton)			Change in percentage (%)		
			Change over previous period	Change due to		Change over previous period	Change due to	
				Grain for Green policy	Other		Grain for Green policy	Other
Rice	1999	1,659						
	2003	1,685	26	5	21	1.57	0.30	1.27
Wheat	1999	1,458						
	2003	1,355	−103	27	−130	−7.06	1.85	−8.92
Maize	1999	1,117						
	2003	1,216	99	19	80	8.86	1.70	7.16
Other coarse grains	1999	1,375						
	2003	1,280	−95	31	−126	−6.91	2.25	−9.16

Table 8. *Average annual simulated impact of Grain for Green policy on trade and food self-sufficiency in China, 1999–2003*

Commodity	Impact on annual net import (1,000 ton)	Impacts as percentage (%) of	
		Average production	Average consumption
Three major cereals	96.0	0.025	0.027
Rice	12.3	0.010	0.010
Wheat	14.0	0.013	0.013
Maize	69.8	0.055	0.060
Other coarse grains	75.8	0.450	0.363

Table 9. *Simulated impacts of 2003 crop land conversion on trade and food self-sufficiency in 2003 in China*

Commodity	Impact on net import (1,000 ton)	Impacts as percentage of	
		Production	Consumption
Three major cereals	159	0.051	0.047
Rice	7	0.006	0.006
Wheat	31	0.036	0.032
Maize	121	0.104	0.097
Other coarse grains	48	0.288	0.251

per ton (instead of 103). Hence, during a time that the government was trying to support agricultural prices, Grain for Green did help. However, by any metric, the support was minimal, only 1.85%. [8] The effect on maize (other grains) was also small; Grain for Green only raises prices by 1.70% (2.25%). Interestingly, because of cross price effects, the price of rice also rose, but in this case it was extremely small (only by 0.3%). In other words, Grain for Green had only a small impact on prices. The same results can be seen (Grain for Green has only a negligible effect on prices) if we focus only on the price rise of 2003 (see Appendix A).

Finally, the other critique of China's Grain for Green was that it would lead to a reduction in national food security and would induce China to import more. However, according to our analysis in either the entire study period (1999–2003—Table 8) or in 2003 alone (Table 9), the rise of imports due to Grain for Green is negligible. In either period, the rise of the imports of the main grains (rice, wheat and maize) is below 159 thousand tons, a number that is almost zero when compared to total domestic production of consumption. In fact, according to our analysis Grain for Green increases imports by less than 0.05% of production or consumption. This small amount, even if increased by 100 times (to 5%) is still within the national government's tolerance for imports. Hence, the assertion that Grain for Green is harming food security has absolutely no basis.

7. CONCLUSION

In this paper, we are examining two fundamental questions about China's Grain for Green program, the largest conservation set-aside program in the developing world: Does this program adversely affect the country's grain prices or does it affect its food security. It is a program that set aside nearly seven million hectares of cultivated area. And it happened during a time of falling sown area, yields, and production. The question is "are the two trends connected?"

In our analysis, we believe that despite back-of-the-envelope calculations that could be construed to show that Grain for Green could have a significant production effect, and from there affect prices and imports, in fact, when examined more closely with more realistic assumptions, only a very small effect is found. In fact, when the naïve assumption that the reduction of sown area will lead to proportional reduction in output is discarded in favor of more realistic assumptions, the price and import effects are almost non-existent. The two main offsetting effects are: (a) when retiring land through the Grain for Green program, low quality land is retired; as a consequence, the production effect is much smaller than the sown area reduction; and (b) when prices do rise due to the reduction of production, farmers respond by increasing production intensity. As a result, the direct reduction in sown area is mitigated and the program-initiated rise in yield is enhanced.

All of these effects lead us to conclude that a reasonable estimate of the rise in price is at most 1% even during 2003 and is less during the whole period. In other words, had there not been a Grain for Green program for crops that saw their price fall during 1999–2003 (like wheat and other grains), the prices would have been 1% lower. For those crops, such as maize, although the price rose during 1999–2003, without Grain for Green, the price rise would have been 1% lower. And, although there is an effect, it should be noted that compared to other supply and demand shifters, Grain for Green accounts for less than 10% of the price shifts. There is even less of an effect on food security.

Given our results, we have a strong set of policy advice to officials. The decision to continue or decelerate Grain for Green should not be made based on the effects that the program will have on grain prices. This effect is really not relevant; it is just too small.

Therefore, according to our paper, our main conclusion is that in the case of China there is not much of a trade-off between food security and conservation set-aside. It is important to note, that our results are not saying that the program should be continued and/or expanded. To do so, a much more comprehensive assessment of the full benefits and costs is needed. Far beyond food security effect, the main costs of Grain for Green include the implementation/administration costs, the costs associated with tree planting and the adjustment costs that are needed for farmers to shift their enterprise choice from grain/other crops to other activities. There are many potential benefits. Mostly the benefits derive from the effectiveness of program in being able to aid in the reduction of the build up of silt in irrigation networks and reservoirs and the reduction in downstream flooding. According to the work of MacKinnon and Xie (2001), the benefits could be as great as 3.9 billion yuan per year in foregone soil loss (which would be realized by less effort needed to clean up irrigation canals and reservoirs and the higher yields associated with more effective water control). Ning and Chang (2002) have estimated that the value of reducing soil erosion in net present value terms would be more than 50 billion yuan (a figure that is consistent with the numbers in MacKinnon and Xie). There would also be significantly less flooding that could benefit China (Xu *et al.*, 2002). Ultimately, the final decision to implement or expand (or contract) the program needs to be made on the prospects for successful implementation, and assessments if the program is meeting its environmental protection and poverty alleviation goals.

NOTES

1. Xu *et al.* (2002) have an excellent detailed description of the mechanism of the Grain for Green program and how it was implemented in their case study regions.

2. In fact, in more recent years, US economists have become concerned about a number of unintended "slippage effects" of conservation efforts. For example, in the case of the US CRP program, the price increase of commodities as a consequence of conservation programs may have provided an incentive for farmers to produce additional amounts of the higher priced goods on land that heretofore was idle. Some of the new expansion could offset the conservation efforts. Using analytical models, one set of researchers demonstrate that ignoring output price impacts on idle land will reduce the environmental benefits of conservation efforts (Wu, Zilberman, & Babcock, 2001).

3. Unlike in the past (i.e., during the 1980s and early 1990s), by the end of the 1990s, and certainly after 2000, China's markets have become quite competitive and unaffected by policy intervention at least at the village level. For example, since the late 1990s, there has been no mandatory procurement of any commodity by the national government in any part of China. Mandatory procurement was abolished earlier in most poor areas. See Huang, Rozelle, and Chang (2004), Wu (2004), Sonntag, Huang, Rozelle, and Skerritt (2005) for a more complete discussion.

4. CAPSiM explicitly accounts for urbanization and market development of the demand side. In our supply side analysis, we account for changes in technology, other agricultural investment, environmental trends, and competition for labor and land use. Supply, demand,

and trade respond to changes in both producer and consumer prices. Details of the model description can be found in Huang and Li (2003).

5. In other words, CAPSiM can account for production and price dynamics of changes to the environment over time. In particular, CAPSiM only uses the baseline prices and production levels, and then based on the baseline assumptions (e.g., national income growth, investment flows, technological change), solves the model each year for price, sown area, and yield levels (as well as other aspects, such as consumption). Consequently, the model is appropriate for analyzing the dynamic and accumulated effects of a program (such as Grain for Green) on grain production and prices.

6. Because we expect (based on the experience in all rapidly developing countries) the supply (area and yield) and demand elasticities to change over time, we mimic these changes by adjusting them periodically throughout the scenario period. For example, research stock and irrigation stock elasticities of yield and income elasticities of demand only change once every five years. Hence, for a study that is only concerned with changes during 1999–2003, they are constant for this study. Cross-price elasticities of area (or demand) change each year. Although this means that these assumptions will affect our results, the change in each year is very small and thus is not very important.

7. Although there are a number of reports of implementation problems with Grain for Green (e.g., Liu, 2002; Xu & Cao, 2002; Zuo, 2002), there are not many that are concerned with the fact that farmers (in collaboration with local leaders) may be over-reporting the amount of land that they convert. Of course, there is an incentive for them to do so; farmers could receive higher program payments while continuing to be able to farm. If this were a widespread practice, it would ultimately mean that our estimates of the reduction in sown area due to the program were overestimated. This, in turn, would mean that our estimated price effects were also overestimated. Hence, considering the focus of our paper, our estimates should be considered as conservative, erring on the side that there is more of an effect than there might in fact be.

8. It might be argued that even a small percentage increase in food price poses a threat to the country's food security. However, at this stage of China's development grain accounts for less than 8% of the food budget (or 3% of total expenditure budget) for urban residents and 33% of food budget (or 15% of total expenditure budget) for rural residents in 2003 (NSBC, 2004). Those rural residents that are producers would also face higher prices on the production side. This means that, everything else held equal, the impact of grain price increase (1.85%) on total expenditures would be between 0.28% in rural and 0.06% in urban.

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APPENDIX A. SUPPLEMENTAL ANALYSIS OF EFFECT OF GRAIN FOR GREEN ON GRAIN SOWN AREA, YIELDS AND PRODUCTION

A.1. *The change in sown area—seen in percentage terms*

When examining the same information in percentage terms, it is easy to see that our analysis demonstrates that even in the case of the main Grain for Green crops, such as wheat, maize, and other grains, there are many other forces that affect sown area (Table 5, columns 6–8). The analysis presents the actual sown area changes in percentage terms and then decomposes the actual change into the part from Grain for Green (column 4) and the part from other factors (column 5). For example, in the case of wheat during 1999–2003 sown area fell by 23.8%. According to our analysis, however, only 7.22% (or 30% of the change) is due to Grain for Green. The rest is due to other factors such as rises in incomes, which in the case of wheat in China means falling demand. The same is true for the other grain crops: only a part of the total sown area decline is due to Grain for Green.

A.2. *The yield effect*

The way the program affects crop yield can be illustrated by the case of wheat. As shown in Table 2, since farmers set aside lower yielding land, the average yield of China's wheat area should have risen by 1.64% per year. Over the four years of the Grain for Green program, this would mean that due to the higher yield effect, observed wheat yields would have risen by 6.72% (that is 1.64% compounded for four years). However, according to the simulation analysis, yields rose by 7.09% due to the program. This means that in addition to the 6.72 direct program effect, because wheat prices rose, farmers should have intensified their cultivation and raised yields even further. In this respect, the results are consistent with the household level analysis on the effects of Grain for Green on households. It is important to note that these positive yield effects that are arising due to the Grain for Green program, in fact, are actually helping to offset the secular decline in the yield of the major grains, that is, wheat, maize, and other grains. In other words, without these direct and indirect effects, yields would have been even lower.

Table 10. *Simulated impacts of 2003 crop land conversion on commodity prices in 2003 in China*

Commodity	Period	Actual price (yuan/ton)	Change over previous period (%)	Percentage change due to	
				Grain for Green policy (%)	Other (%)
Rice	2002	1,630			
	2003	1,685	3.37	0.12	3.25
Wheat	2002	1,236			
	2003	1,355	9.63	1.13	8.5
Maize	2002	1,132			
	2003	1,216	7.42	0.53	6.89
Other coarse grains	2002	1,239			
	2003	1,280	3.31	1.05	2.26

A.3. *The effect of Grain for Green on the 2003 price rise*

The same conclusion is found when looking only at the price rise during 2003. On a weighted average basis (accounting for rice, wheat, and maize), the entire negative production impact of Grain for Green was less than 0.50% (or less 10% of the overall effect—results not shown). The overall price effect on China's major grains (on a weighted average basis) also is small, only about 0.7% (Table 10). In other words, during a year when China's grain price began to rise (by around 7% on weighted average basis, according to our data), less than 1% rise (or about 10% of the total price rise) can be attributed to Grain for Green. Clearly, if Grain for Green is contributing in other ways, for example, to poverty alleviation or to environmental protection, the price effects of these magnitudes during the entire period (1999–2003) or during 2003 alone are negligible.