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Grain for Green: Cost-Effectiveness and Sustainability of China's Conservation Set-Aside Program

Emi Uchida, Jintao Xu, and Scott Rozelle

ABSTRACT. *Since 1999, China has pursued Grain for Green, an ambitious conservation set-aside program to prevent soil erosion. This paper evaluates its cost-effectiveness and sustainability. The results indicate that while the program has made a clear attempt to retire plots that are susceptible to soil erosion, there is room for better targeting. The government also may be able to generate fiscal savings if the payments more accurately reflect the differences in the opportunity costs of each plot. The study finds that some farmers may reconvert the land back to cultivation after program ends.* (JEL Q23, H43)

I. INTRODUCTION

According to scientists, deforestation is the primary cause of water and soil erosion in China's Yellow River and Yangtze River Basins (World Wildlife Fund 2003). Excessive commercial logging and the cutting down of the forest on hillsides for cultivation in the upper and middle reaches of the basins led to silted streams and caused higher frequencies of flooding (World Wildlife Fund 2003). Many environmental experts believe soil erosion is the primary cause of the devastating floods in the middle reaches of the Yangtze River and northeast China during the summer of 1998 (World Bank 2001).

Pushed into action by the floods, China's government responded with a nationwide cropland set-aside program known as Grain for Green to increase forest cover and prevent soil erosion on sloped cropland. When available in their communities, 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 the distribution of seedlings. The scale of Grain for Green, which was originally planned to reach nearly 15 million hectares and affect 40 to 60 million rural households, makes the program one of the world's largest conservation projects. The implementation of the program is designed to reduce China's long practice of cultivation on steep slopes.

Although Grain for Green is impressive in terms of its scale, a successful conservation set-aside program needs to be more than large; success of such programs in developing countries also depends on their ability to reduce erosion, provide adequate levels of income to participating farmers and do so in a cost-effective and sustainable way. Considering that most households in

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the target areas are poor and rely on farming, much of which is on steeply sloped cultivated area, the program must be able to provide incentives for farmers to participate and to be able to earn enough to make the program attractive. Since the plots of the participants vary greatly in terms of their productivity and susceptibility to soil erosion, a successful program also should be able to induce households to retire land that is subject to erosion and has relatively little effect on family income. If the cost-effectiveness of China's conservation set-aside program is to be optimized, both environmental and productive heterogeneity need to be considered (Just and Antle 1990; Babcock et al. 1996).

Given the size and overall goal of the program, sustainability also is an issue. Real gains in the long run can only be realized if the program is designed so that participants keep their land out of cultivation even after the end of the program. Post-program land use decisions of the participating farmers have been one of the biggest concerns in conservation set-aside programs elsewhere (e.g., Cooper and Osborn 1998; Johnson, Misra, and Ervin 1997). If the program does not target steeply sloped land, if it does not fairly compensate farmers and if it cannot keep the farmers from reconverting their land back into crop cultivation after the end of the program, the fear is that Grain for Green may be repeating some of China's afforestation failures of earlier decades (Smil 1993).

Surprisingly, given the large expenditures of effort and capital on China's Grain for Green, and the severity of the consequences if China cannot control soil erosion in the long run, the government has undertaken little or no systematic evaluation. With the exception of Xu and Cao (2002), there has been no empirical evaluation of the program. In addition to academic interest in understanding the effectiveness of the implementation of a conservation set-aside program in a large developing country, the nation's future plans to continue the current program and expand it further means that China's case deserves attention.

The overall goal of this paper is to provide an economic analysis of China's Grain for Green program. To meet this overall goal, we have two specific objectives. First, we seek to make an assessment of the cost-effectiveness of the program. To see how well the program has produced environmental benefits in a cost-effective way, this study uses a data set that was collected from households in two provinces in western China to explain what types of plots were set aside under the program. Second, we seek to understand the sustainability of the program's achievements. We mainly examine how the program affects a household's wealth by comparing the net income before and after the program. Although we are aware that there are other factors that affect the program's sustainability, the analysis focuses (primarily due to data limitations) on the types of income-earning activities and ways that household farming practices changed during the course of the program.

When drawing conclusions from the results, there are two caveats. First, we only examine households that participated in the program. This means that the results are conditional only on the actions of households that are participating in the program. This shortcoming also limits some of the questions that can be answered. Second, we do not have a direct measure of how well Grain for Green is doing in preventing soil erosion, the primary environmental objective of the program; the only proxy available for potential to prevent soil erosion is the slope of the Grain for Green plots.

II. CONSERVATION RESERVE PROGRAM IN THE UNITED STATES

While many countries that are members of the Organisation for Economic Cooperation and Development (OECD) have implemented ambitious conservation set-aside programs the Conservation Reserve Program (CRP) in the United States deserves special attention because of its scale, relatively long history, and the number of modifications it went through (OECD 1997). Authorized under the Farm Bill of 1985, the CRP provides farm owners or operators with annual per-acre rental payments

and half the cost of establishing permanent land covers in exchange for retiring highly erodible or otherwise environmentally sensitive cropland for ten to fifteen years. In 2000, 33.5 million acres (13.6 million hectares) were enrolled in the program, an area that is nearly 10% of the total cropland in the United States (USDA 2003). The average annual rental payment is $112.73 per hectare, which requires about $1.475 billion per year of budgetary support in 2001 (Farm Service Agency 2003; USDA 2003).[1]

Since its conception, economists have been concerned about several aspects of the CRP: the program's cost-effectiveness (e.g., Babcock et al. 1996, 1997; Smith 1995; Osborn 1993) and its sustainability or the post-contract land use decisions of participating farmers (e.g., Cooper and Osborn 1998; Johnson, Misra, and Ervin 1997; Skaggs, Kirksey, and Harper 1994; Parks and Schorr 1997). The issue of the cost-effectiveness of the CRP has been debated since its introduction. In particular, economic studies have examined how the environmental benefits of a conservation set-aside program can be increased if targeting were based on weighing both costs and benefits, instead of just targeting land with the least cost.[2] Officials in the United States also have been concerned about the sustainability of the program. Post-contract land use decisions, particularly whether or not farmers will reconvert the land to cropland at the conclusion of the program, are critical determinants as to whether CRP can sustain its environmental benefits in the long run. Studies have found that farmers with high current farm income and those with highly productive land will be less likely to reenroll in the CRP when the current contract expires (Cooper and Osborn 1998; Parks and Schorr 1997; Johnson, Misra, and Ervin 1997).

III. CHINA'S GRAIN FOR GREEN PROGRAM

China's leaders began a massive conservation set-aside program called Grain for Green in 1999. Starting with a pilot program, officials expanded the program to 20 provinces by the end of 2001. During the initial period of the program (1999 to 2001), participating farmers converted 1.16 million hectares of cropland into forest and pasture (Xu and Cao 2002). The program also afforested nearly 1 million hectares of barren land. By the end of the program in 2010, leaders plan to set aside nearly 15 million hectares of cropland, an area almost equivalent to the U.S. CRP program.

The large budgetary requirement for the program demonstrates the nation's commitment to Grain for Green. Between 1999 and 2001, the national government spent 3.65 billion yuan (approximately 2.4 billion dollars in Purchasing Power Parity, PPP terms) on the program.[3] The magnitude of the

[1] The budget outlay includes only the rental payments and does not include the cost-share payments. The average rental payment varies among regions in the United States, generally reflecting the differences in land rental. In 2000, the regional average ranged from $84 per hectare in the Northern Great Plains Region to $200 per hectare in the Heartland Region (USDA 2003). It should be noted, however, that China's payments, on average, are still higher than the highest payments in the United States.

[2] For example, using data from the CRP, Babcock et al. (1996) show that even if there were a 50% budget cut, with more careful site selection—based on both costs and benefits—the program could achieve more than 90% of the current environmental benefits. In response, the program has improved its targeting mechanism to improve its cost-effectiveness. Before 1990, farmer bids were accepted not to maximize the program's environmental benefits, but rather to enroll the maximum number of acres susceptible to soil erosion, similar to Grain for Green. After 1990, the program began to enroll land based on both the contribution of a plot to environmental quality and on per acre rental rates. This change was made with the objective of improving the environmental performance of the program (Osborn 1993). Since its reauthorization in 1996, the program adopted innovative measures to more carefully target enrolled acreage to maximize environmental benefits, one of which is to use an index of multiple environmental benefits that includes not only soil erosion prevention, but also air and water quality improvement and wildlife habitat protection.

[3] The Purchasing Power Parity conversion factor is 1.78 yuan to the dollar. Out of 3.65 billion yuan, 83% was used for grain and cash payments and the remainder for the provision of free seedlings. Annual expenditure for grain and cash payments alone amounts to about $1 billion in 2001 in PPP terms.

program can be seen by the fact that although the land area under China's program is 15% of the CRP in the United States, the annual outlay for the compensation payments is nearly 70% of the annual expenditure for the CRP. In addition, the Grain for Green's 2001 budget outlays do not include compensation for all of the land retired by the end of that year.

The program offers three types of compensation to farmers: grain, cash, and free seedlings. According to program rules, each year farmers receive 1,500 to 2,250 kilograms of grain per hectare per year, or in cash equivalent terms about 2,100 to 3,150 yuan.[4] The farmers also receive a cash payment of 300 yuan per hectare per year. Finally, forestry agencies supply free seedlings to farmers at the beginning of the conversion program. On average, the seedlings are worth approximately 750 yuan per hectare.[5] In total, the three types of compensation amount to 3,150 yuan per hectare in the middle and upper reaches of Yellow River for the first year of conversion and 2,400 yuan per year from the second year on. Reflecting in part the higher opportunity cost of land in the upper reaches of the Yangtze River, the program pays a farmer 4,200 yuan per hectare the first year and 3,450 yuan per year from the second year on. In PPP terms, the average annual compensation amounts to a payment that is nearly *fifteen times* the average per hectare rental payment under the CRP in the United States.[6]

Since the main objective of China's program is 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 to participate. In the northwest the program targets land with 15 degrees of slope or more.

While the policy's criterion is clear, case studies of Grain for Green have shown that practice is not always consistent with theory. Xu and Cao (2002) report that, in addition to land with high slopes, some regions have given priority to sites close to a road system in order to facilitate inspections and monitoring.[7] The China Council for International Cooperation on Environment and Development (CCICED) reports that some regions required the plots to be contiguous to each other to minimize the implementation cost, which resulted in the inclusion of cropland which covered relatively flat areas (CCICED 2002). These facts generate the concern that the cost-effectiveness of the program and its targeting of environmentally sensitive plots may be compromised.

The relatively high fraction of farmers willing to go back to crop production or livestock haying/grazing in the United States also suggest that officials in China should be concerned about the long-run sustainability of the environmental bene-

[4] The grain payment is higher for cropland in the upper and middle reaches of the Yangtze River Basin than in the upper reaches of the Yellow River Basin. China's government uses a conversion rate of 1 kg of grain = 1.4 yuan (about $0.79 in PPP terms).

[5] The compensation is given only if the farmer passes an annual inspection carried out by the local Grain for Green project implementation office. To reduce the shock of retiring the land from agriculture in the initial year, 50% of the grain and cash subsidies, together with the seedlings, are supposed to be given to the farmers when they first enter the program and the rest when they pass the first-year inspection. Xu and Cao (2002) found, however, that this advance payment system had not been adopted in some areas.

[6] In PPP terms, the average annual payment of the Grain for Green program is $1,643 per hectare. Using the current exchange rate it is equivalent to $353, which is still three times as much as the annual rental payment in CRP. We believe that the differences in the levels between the payment under the CRP in the United States and the Grain for Green program in China may not be as large if non-CRP program subsidies that U.S. farmers receive (that is, payments from various farm subsidy programs) are added to the CRP rental payment when being compared.

[7] For example, it was reported that in Southwest China more than 70% of the farm households in the program were located along a road. This does not imply, however, that more than 70% of the plots in the program are adjacent to a road. In fact, in another study, we found that the distance for the road was not a significant determinant of plots included in the program.

fits of Grain for Green.[8] CCICED (2002) raises concern that uncertainty over the lack of property rights and the future responsibility for management of the trees may mean that farmers do not have strong incentives to maintain their forest plots in the long term. One of the main concerns is that farmers may reconvert their plots to cropping if the gains from the plots from conversions do not exceed the gains from reconversion.

IV. DATA

To evaluate the cost-effectiveness and sustainability of Grain for Green, the study draws on a data set that was collected with our collaborators in 2000. Designed to enumerate households in the pilot Grain for Green program, the survey covered 144 participating households from 16 randomly selected villages in two provinces, Ningxia and Guizhou Provinces. Data from a series of community surveys in six provinces supplemented the analysis (Xu and Cao 2002).

The household survey, conducted approximately one year after the initial Grain for Green programs began in the sample counties, asked respondents about a number of activities and household characteristics before and after the program. Enumerators collected information on the household's on-farm production activities on a plot by plot basis. The household survey also asked for detailed information on each household's total asset holdings, its demographics and other income earning activities from both on- and off-farm enterprises. The final block of the survey asked farmers about their perceptions of the Grain for Green program.[9]

Our analysis heavily utilizes a section of the survey instrument that provides a census of each household's cultivated plots. On average, each household cultivated four plots. For each plot, respondents reported the crop(s) grown, yield, total output and inputs in 1999 before the program started. In addition, respondents provided a number of other plot attributes including its slope (no slope; moderately sloped; highly sloped); plot size and location; cropping pattern; and whether or not the plot was entered in the Grain for Green program, and if so, how many seedlings and other inputs were used.

V. COST-EFFECTIVENESS

A policy is cost-effective if it achieves the policy objective at the lowest possible cost. The main outlays for the government associated with implementing Grain for Green are the set-aside payments that it must make to farmers. If the government wants to at least provide participating farmers with an income that is at least as high as before the program, the cost of the program will increase as the opportunity costs of the set-aside land rises. Hence, if set-aside plots have higher yields, program

[8] In the ongoing management of U.S. CRP the percentage of reenrolled acres among the total acres enrolled since 1996 has been declining from around 70% in 1997 to 8% in 2000 (USDA 2003). Based on our calculation, which uses data available from USDA (2003), on average, roughly 40% to 80% of the contracts are being renewed upon expiration. While it is true that academics and policymakers in China are concerned about re-enrollment in Grain for Green and that they are aware of the low re-enrollment rates in the United States, we want to caution the reader that the reasons for the unwillingness of the farmers in China may be different from the decision making process in the United States. In China, leaders are worried the reconversion will happen when the program finishes due to the actions of households that are searching for higher profits. In the United States, it is not always the case that farmers want to go back into cultivation. In fact, many participating farmers were willing to reenroll, but changes in the program criteria (e.g., changes to the Environmental Benefit Index) made it so that many of the participating farmers in the first round of the CRP were not eligible (or more precisely, they were not competitive) and thus were not selected for inclusion into a later signup. It should also be remembered that when some households in the U.S. CRP withdraw their land (or are not allowed to reenroll), the land is not put back into cultivation, but is put into pasture (which will likely have fewer negative environmental consequences).

[9] To evaluate the cost-effectiveness and sustainability of a land set-aside program, it would be ideal to have information from participating and non-participating households and compare the environmental benefits and opportunity costs of plots from both sets of households. Unfortunately, in the first round of household level data collection only information on program participants was collected.

costs will rise, and vice versa. Based on this criterion, the cost-effectiveness of Grain for Green would be greatest if payments were indexed on the basis of each plot's slope (choosing the steepest ones—which would provide for the greatest environmental benefit) and yield history (choosing the lowest yielding ones—which would allow for the lowest payment to cover the plot's opportunity cost). Under the current mechanism, however, Grain for Green may be compromising its cost-effectiveness. Above all, there has been little effort to match payments to maximize the environmental benefit and minimize payments. Across all of China, the government offers only two levels of compensation for participation, differentiated only by the grain compensation component of the payment package.[10]

In our study, four steps are needed to test the cost-effectiveness of the program. First, to get an intuition for how well the cropland was targeted on the basis of cost-effectiveness, we utilize the descriptive statistics from case studies reviewed by Xu and Cao (2002) to observe the mean slopes and yields of the plots in the program in a number of different provinces and compare them with the plots not in the program. Second, a multivariate discrete choice analysis will be performed to investigate the determinants of plot selection. The goal is to test whether or not we can statistically show that plots with high slopes and low yields were indeed targeted in the program, controlling for other household and plot characteristics.[11] Third, the opportunity costs of sloped land (that which is more susceptible to soil erosion) and less sloped land are compared. Comparisons include both those plots selected for the program and those not. Instead of the yield for each plot, the levels of net revenue associated with both plots are compared.[12]

[10] As discussed above, in the upper reaches of the Yangtze River Basin farmers receive 2,250 kilograms per hectare annually, while those in the Yellow River Basin receive 1,500 kilograms per hectare. In one sense, this strategy was adopted for cost-effectiveness reasons, since the opportunity cost of plots in the Yellow River Basin is lower because the plots are lower yielding, on average. In another sense, however, given the tremendous heterogeneity that exists throughout the Grain for Green program areas within each river basin, it would seem that a compensation scheme with only one level per basin was adopted for ease of implementation since a one-payment-for-all-plots system could not do a precise job of matching payments to both the environmental benefit of the plot being set aside and the amount of income that the farmer gives up.

[11] For a simple analytical model readers should refer to a long version of this paper on http://www.agecon.ucdavis.edu/facultypages/rozelle/publications/NatRes Environment.htm. The model characterizes the selection of the plots by a local government. This choice model characterizes the local government as the decisionmaker. While Grain for Green is officially "voluntary," case studies report that the degree of voluntarism was often ignored from the targeting process.

[12] We assume that the opportunity cost equals the *net* revenue that the plot generated the year before the plot entered the program. In the analysis net revenue per mu is gross revenue per mu minus variable costs per mu. Gross revenue for each mu is the price of the crop times its yield. Variable costs include the farmer's per mu expenditure on fertilizer, pesticide, plastic sheeting and hired labor. To calculate the cost and benefits of the inclusion of a plot in the Grain for Green program, we make several assumptions. First, since crop prices were not asked in the survey, we utilized crop prices from another survey that we conducted in 2000 in 60 villages in six provinces in rural China (deBrauw et al. 2002). Since the survey did not include Guizhou and Ningxia, we utilized prices from Shaanxi and Sichuan, two provinces having similar economic and agro-climatic characteristics as the sample provinces. Second, because of the way the data were reported, the analysis includes only those plots that grow a single crop throughout the year. The proportion of total plots that farmers cultivated for only a single-season in the sample was much higher in Ningxia (86%) than Guizhou (33%). This should not affect the results significantly, because we found that the proportion of plots entered under the program does not differ significantly between plots cultivated with a single-season crop and those cultivated with a double-season crop. Third, in calculating net revenue the value of the household labor that is freed up by Grain for Green also is not accounted for. When a farm household retires a plot, it has access to the labor that originally had spent cultivating the plot. While it is arguable that the value of freed-up labor should be subtracted from the net revenue, we do not include it for simplicity. Finally, we also are concerned whether the net revenue one year prior to entering the program is a representative year or not. In order to test this we utilized a section of the survey in which each household was asked about the gross crop revenue for "normal year since 1995," "in 1999," and "in 2000" for three crop types (grain, oil producing crops, and other cash crops). Using the sum of revenue from each of these crops during each year, we conducted *t*-tests to test the null hypothesis that the means are equal for "normal year since 1995" and "in 1999." We tried three alternative

TABLE 1
COMPARISON OF YIELDS AND SLOPES FROM CASE STUDIES IN CHINA'S GRAIN FOR GREEN (GFG) PROGRAM, 2000

Counties in Case Study	Average Yield before Program (kg/ha)		Total Area Set Aside (ha)	Proportion of Land with Slope 15 Degrees or Greater (%)		Grain Payment Received per Hectare (kg)
	Plots Set Aside under GFG	Plots Not Set Aside under GFG		Cropland Set Aside under GFG	Cropland Not Set Aside under GFG	
Dingxi, Gansu	1,369	2,220	2,000[a]	83	45	1,500
Zuozi, Inner Mongolia	1,125	—	9,367[b]	16	33	1,500
Pengyang, Ningxia	1,464	2,076	5,080	93	72	1,500
Heqing, Yunnan	—	—	1,000	96	91	2,250
Dafang, Guizhou	2,329	2,731	1,333	98	69	2,250
Tianquan, Sichuan	3,106	8,646	4,600	86	65	2,250

Source: Adapted from Xu and Cao (2002).
[a] Data from 2001.
[b] Includes areas of afforested barren hills.

Finally, per hectare net revenues of plots in the program are compared against those plots not in the program, controlling for the steepness of the slopes of the plots.

Results of the Cost-Effectiveness Analysis

Based on our criterion of cost-effectiveness, the data suggest that China's Grain for Green program has been designed to generate environmental benefits (Table 1). In five out of six counties in the case studies reviewed by Xu and Cao (2002), more than 80% of the plots selected for Grain for Green had slopes of more than 15 degrees. In some counties, the program was even more effective. For example, in Dafang County of Guizhou Province 98% of the plots enrolled in Grain for Green had slopes of more than 15 degrees.

While many of the plots selected for the program are steeply sloped, there still is evidence that the program could be implemented more cost-effectively. A share (albeit a fairly small share) of the participating plots in the program is not sloped. At the same time, there are also a fairly large number of steeply-sloped plots that program officials did not include in the program.[13] According to the cost-effectiveness standard, the distribution of participating and non-participating plots suggests that officials could improve Grain for Green by replacing the non-sloped cropland under the program with the highly sloped cropland currently not in the program. For example, in Dingxi, Gansu, 83% of the cropland set aside under the program was steeply sloped; however, 17% of the cropland was not. To increase the environmental benefit of Grain for Green, an alternative design would replace the relatively flat

hypotheses: (1) the two means are not equal, (2) a normal year since 1995 is higher than 1999, and (3) a normal year since 1995 is lower than 1999. We conducted this test for each province. For both provinces and for all three alternative hypotheses we could not reject the null hypothesis. This implies that the means of the crop revenue for "normal year since 1995" and "in 1999" are statistically equal. From this exercise, we make the assumption that 1999 was not an abnormal year. Although this is not a perfect test we believe that there is at least some support for our claim that 1999 is a representative year for the sample.

[13] Unfortunately, the survey did not ask the precise reason why the plots were excluded from the program. Therefore, we do not know precisely whether or not these plots were not included because the officials did not allow their inclusion or because farmers did not volunteer to have them in the program.

plots with more steeply sloped land currently not under the program. Such a swap would be fairly easy to accomplish logistically, since nearly half of the remaining non-program plots in the study site were highly sloped.

The data also show that while the program appears to have chosen plots that were fairly low yielding (implying the cost of the environmental benefit was relatively low), there may be room for improvement. Specifically, in the sample the participating plots on average have lower yields than non-participating ones. From this perspective, plots that have lower opportunity cost were selected for the program on average, a positive sign that the program is cost-effective. Within the group of participating and non-participating plots, however, there is still substantial heterogeneity (Table 1). In fact, nearly 40% of the plots in the sample have yields that fall below the compensation rate of 1,500 kg (or 2,250 kg). Clearly, the owners of the lower yielding plots are in some sense being over-compensated. Likewise, the plots with yields above the compensation rate are under-compensated. Having such a large portion of the plots either above or below the compensation rate is an indicator of poor efficiency.

Beyond the unconditional comparisons of yields between participating and non-participating plots, multivariate analysis demonstrates that China's program has at least in part been successful in maximizing benefits and minimizing costs (Table 2). In assessing the performance of the limited dependent regression model with fixed household effects, the results show that it performed well overall, with an R-square of 0.50. To control for possible omitted variable bias of the OLS estimator (column 1), we also report the results of the random-effect and fixed-effect logit models (columns 2 and 3) in order to check for the robustness of the results. The signs and magnitudes of the coefficients are stable across all three versions of the model.

The multivariate analysis also demonstrates that plots with lower yields and higher slopes were more likely to be selected for the program, holding other plot and household characteristics constant (Table 2). In all cases, the coefficients of the variables of interest are significant. In particular, the positive and significant coefficient on the slope variable suggests that plots with higher slopes were more likely to be selected for Grain for Green. In contrast, the negative coefficient on the yield variable indicates that plots with higher yields were less likely to be selected for Grain for Green. In sum, the results imply that on average the program is enrolling plots with positive environmental benefits and relatively low opportunity costs.

Using measures of net revenue, however, the data show that if anything the program is making too high of payments to farmers. In particular, the payments paid to farmers for entering their plots into China's Grain for Green program largely exceed the plot's opportunity cost (Figure 1, panels A and B). In the Ningxia sample, for example, 84% of the program plots have payments (140 yuan per mu) that are higher than the net revenue that the plot earned during the year before it was entered into the program, where one mu is 1/15 of a hectare. The average gap between the plot's payment and its net revenue exceeded 80 yuan, a level that is nearly 58% of the compensation level. In the Guizhou sample, 60% of the program plots have payments (210 yuan per mu) that are higher than the plot's net revenue, an average overpayment of about 39%. On a household basis, 76% of households in Ningxia and 23% in Guizhou received payments that exceeded the net revenue that they had made on the plots the year before

Despite the fact that program plots had lower net revenues on average than non-program ones, targeting was far from perfect. In Ningxia, while 15% of the program plots had higher net revenue than the compensation level (140 yuan), nearly 70% of the non-program plots had lower net revenues than this level. Likewise, in Guizhou, while 40% of the program plots had higher net revenue than the compensation level (210 yuan), nearly 30% of the non-program plots had lower net revenue than this level. Better targeting could have reduced the cost to the government as well as to the farmers by including non-program plots that had

TABLE 2
REGRESSION RESULTS OF IMPACT OF PLOT CHARACTERISTICS ON PARTICIPATION IN CHINA'S GRAIN FOR GREEN PROGRAM, 2000

	Dependent Variable: 1 = Plot in the Program, 0 = Otherwise		
Independent Variables	(1) OLS with Fixed Effect	(2) Random Effect Logit	(3) Fixed-Effect Logit
Plot yield[a]	−0.000227*	−0.000585*	−0.000617*
	(−1.93)	(−1.95)	(−1.93)
Distance from home (km)	0.618*	0.224*	0.365**
	(2.58)	(2.05)	(2.68)
Slope of plot	0.276***	1.389***	1.372***
	(7.65)	(6.69)	(5.83)
Constant	0.187	−3.269***	–
	(1.10)	(−5.87)	–
Number of plots	416	416	325
Number of households	144	119	86
R-squared	0.5003	–	–
Log-likelihood	–	−243.00	−87.49
Prob > Chi2	–	0.0000	0.0000

Note: Parentheses indicate *t*-statistics based on robust standard errors for pooled OLS, and *z*-statistics for random and fixed effects.
[a] Plot yield is based on 1999, before the program was implemented in the two sites.
*Significant at the 10% level; ** significant at the 5% level; *** significant at the 1% level.

lower net revenues instead of the more profitable program plots.[14]

Based solely on these comparisons, it is not surprising that the program has been so enthusiastically embraced by farmers and their local leaders. For a vast majority of the program plots, farmers received more in payments after entering the Grain for Green program compared to before the program. From the household's point of view, Grain for Green must be considered a lucrative program. As long as the government does not fail to deliver on its promised support payments, Grain for Green is a win-win proposition at least in the short-run. Not only does the program provide higher incomes, but the farm households have access to additional family labor that is now *not* needed for use on the set-aside plots.[15]

The data also illustrate that the degree of over-compensation varies across the study areas and reveal the potential to improve the cost-effectiveness of China's Grain for Green program. To show this, we compare the program payments and the level of compensation needed to compensate the

[14] While we do not have the precise information as to why the excluded plots were not selected for the program, we believe that it may have been partially due to some program selection strategies adopted by local officials. For example, in some regions the plots were required to be contiguous to each other or to be located along a road to minimize implementation costs. Targeting based on these rules is likely to lead to selection of plots that do not have high slopes. While implementation costs cannot be ignored, they need to be weighed against the benefit of selecting highly-sloped plots.

[15] Compensation for some plots, however, is less than the foregone net revenue. On average, for the plots in which payments were lower than net revenues, the average gap was 190 yuan or 135% of the compensation level in Ningxia, and 160 yuan or 76% of the compensation level in Guizhou. If the government were to pay exactly for the loss in net revenue, the plots would have been under-compensated. As a result, the government saved more than half of what it would have had to pay for these plots. At first it seems surprising that some plots would be set aside although the net revenue was higher than the compensation level. Setting aside such plots may still be worthwhile, however, given the presumably lower risk of the program compared to agriculture and savings in family labor. If plot participation was voluntary, this would be evidence of it being worth it. Since it is unclear whether or not plot participation is voluntary, more research is needed to determine the perceived value of the inclusion of such plots.

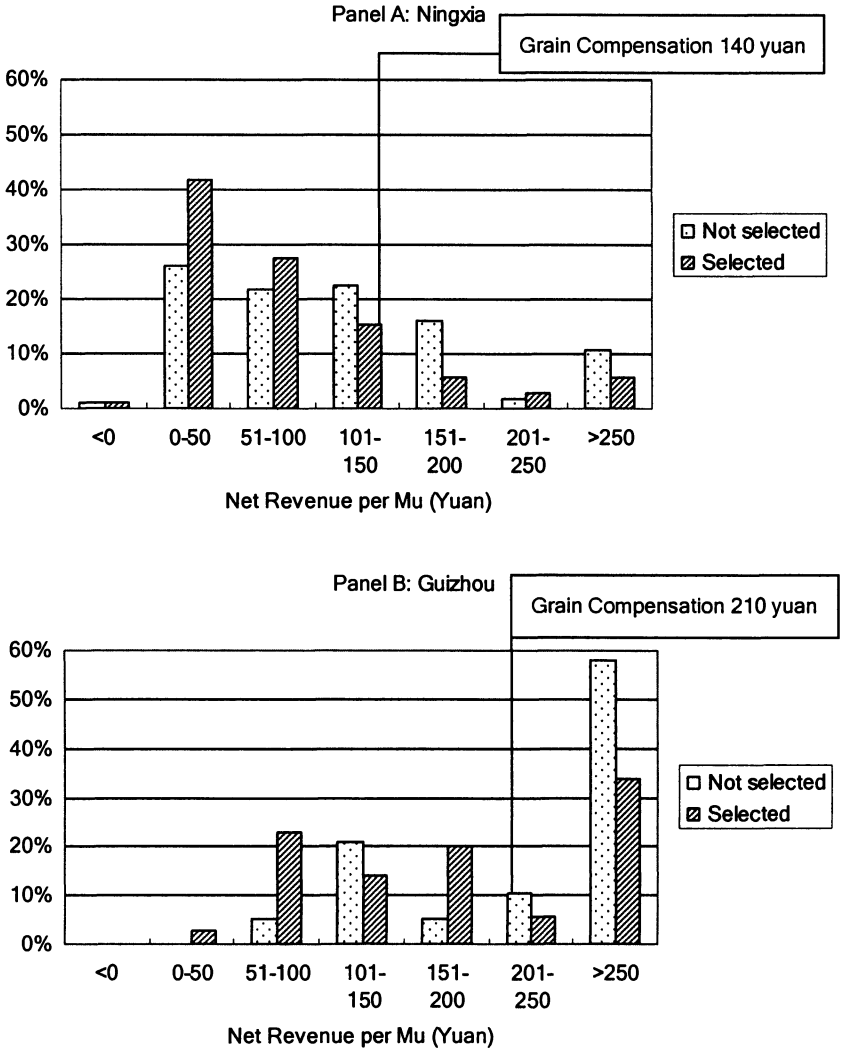

FIGURE 1
DISTRIBUTION OF NET REVENUE PER MU, PER YEAR, FOR GRAIN FOR GREEN PROGRAM PLOTS AND NON-PROGRAM PLOTS IN CHINA, 2000

household for its lost net revenue (Table 3).[16] In Ningxia, the number of over-compensated plots exceeds the number of under-compensated ones by a large fraction, resulting in clear over-compensation. In contrast, in Guizhou, the amount of under-compensation exceeds that of over-compensation, resulting in net under-compensation. As a result, if officials had compensated farmers at levels equaling the plot's pre-program net revenue, it could have reduced expenditures by 60% in Ningxia. In Guizhou, however, officials would have had to increase expenditures by 18% to elimi-

[16] The analysis requires that we create two new variables: *over-compensation*, which is generated by subtracting the actual payment from the plot's net revenue, when the actual payment is greater than net revenue; and *under-compensation* which is generated when the actual payment is smaller than net revenue

TABLE 3

ACTUAL COMPENSATION VERSUS COMPENSATION BASED ON NET REVENUE FOR TOTAL AREA UNDER GRAIN FOR GREEN PROGRAM IN NINGXIA AND GUIZHOU, 2000

	Ningxia	Guizhou
	(yuan)	
Actual compensation for program plots (A)[a]	137,942	21,364
Amount of over-compensation (B)[b]	−75,557	−1,994
Amount of under-compensation (C)[b]	24,063	6,603
Compensation based on net revenue		
In value terms – yuan (D = A + B + C)	86,448	25,973
In percentage terms (A)/(D) × 100	160	82

Source: Authors' survey.

[a] To calculate the actual compensation this study assumes that the farm households in the survey were fully compensated for their program plots.

[b] The amounts of over-compensation and under-compensation were derived by taking the difference between the estimated net revenue and compensation per mu for each plot and then multiplying by the plot area.

nate the under-compensation. Although the results are only from our sample, if this is indicative of the situation across China, it implies that even if China wants to completely compensate farmers for their foregone net crop revenue, there are still gains to be made from considering reallocating resources across regions and among households.

Before drawing final conclusions about cost-effectiveness, however, we also need to take into consideration the environmental benefits. This is done by accounting for both opportunity costs and environmental benefits for each group of plots categorized by their slope. The survey respondents classified each of their plots into three levels: those with steep slopes (over 25 degrees), moderate slopes (15 to 25 degrees, and others (less steep and flat). We ranked the plots based on the net revenue and the steepness of the slopes and plotted the relationships on two-dimension graphs.[17]

When doing so, the data show that site selection was cost-effective for the Guizhou sample but not for Ningxia (Figure 2). The four panels include only the plots that were planted with a single crop before the program year. Consequently, the plots include 86% of the program plots in the Ningxia sample and 37% of those in Guizhou. From Panel C, it is found that all of the plots entering the program in Guizhou have high slopes, implying that the program there largely targeted plots that give maximum environmental benefit to the program. At the same time, some plots had high net revenues before entering the program. These plots could have been replaced by those having high slope and lower net revenue in Panel D. In contrast, in Ningxia, the costs and benefits are unsystematically dispersed in two-dimensional space (Panel A). For example, 11 set-aside plots in the sample have no slope and high net revenue; 45 set-aside plots have moderate slopes and low to high net revenues.

[17] When each plot is plotted on a graph from no slope to highest slope on the horizontal axis and from lowest net revenue to highest net revenue on the vertical axis, it is expected that all plots would be concentrated in the lower right hand triangle if the site-selection were based on maximizing the cost-effectiveness of the program. If this pattern appeared, it would be because all plots with high slopes (i.e., those with relatively high environmental benefit) and relatively low net revenue (i.e., low opportunity cost) were selected for the program. Since the slope data are discrete, the distribution would be lumpy like the vertical bars, instead of continuous like the triangle. For an illustration please refer to a long version of this paper on http://www.agecon.ucdavis.edu/facultypages/rozelle/publications/NatResEnvironment.htm. If we had a continuous variable for the environmental benefit with ideal targeting, we would expect the plots to be ideally below the 45 degree line (Babcock et al. 1996).

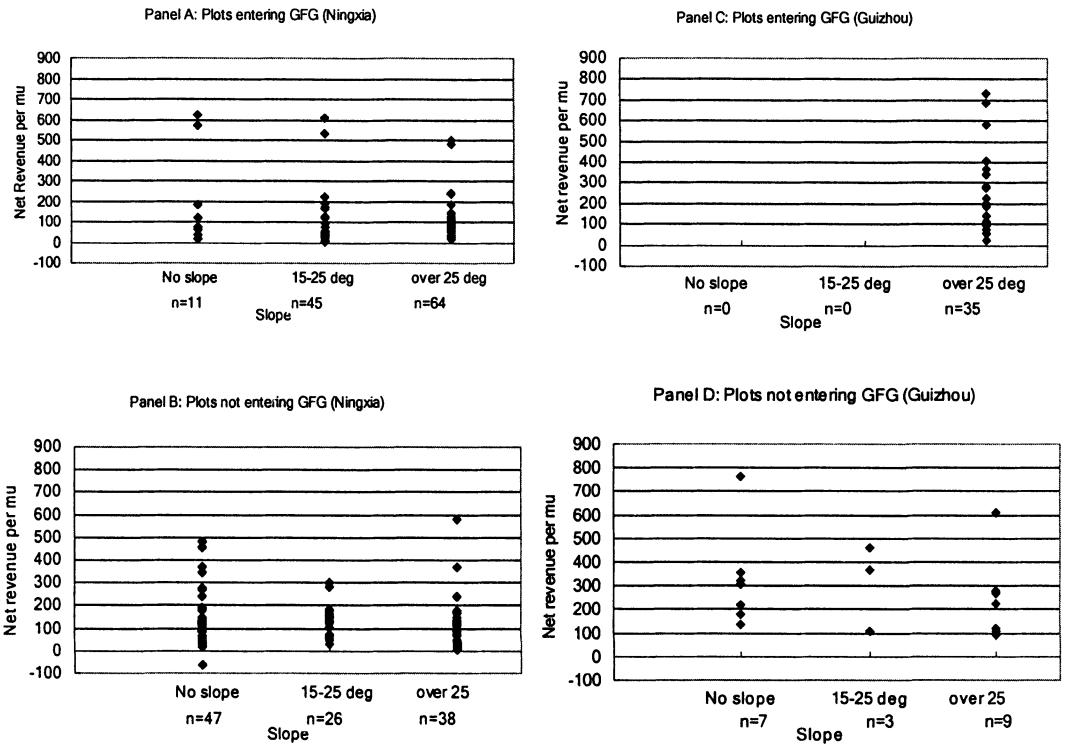

FIGURE 2
OPPORTUNITY COST (NET REVENUE PER MU) VERSUS ENVIRONMENTAL BENEFIT (PLOT SLOPES) OF GRAIN FOR GREEN PROGRAM IN GUIZHOU AND NINGXIA PROVINCES, 2000

Based on the observation that there are a number of plots with higher slopes and lower net revenue per mu (Panel B), the figures suggest that the site selection was not performed well in Ningxia from the cost-effectiveness point of view. Ningxia could have improved its cost-effectiveness performance considerably by targeting plots with higher slopes and lower opportunity costs.

In summary, in this section we have illustrated that although China's Grain for Green policies have pursued the dual goals of trying to reduce soil erosion while minimizing the cost borne by the farmers, China's government can improve cost-effectiveness in two ways. First, the program can decrease costs and avoid hurting certain program farmers by reducing the cases of over-compensation and increasing the compensation for (or removing from the program) the plots that are being under-compensated. In the similar way that is done in the CRP in the United States, this can be accomplished by changing the compensation schedule from a uniform rate to a more flexible payment schedule that is based on the actual opportunity costs and environmental benefits of each plot.[18] Second, the program can maximize its cost-effec-

[18] It should be recognized, however, that perfect targeting typically can not be achieved in practice since there are transaction costs involved in collecting information. It has been suggested that one of the main problems that has arisen from the bidding process for CRP contracts was that the strategic bidding process affected the rental rates. Based on our results we believe that Grain for Green program could benefit by adopting a more flexible payment schedule, such as differentiating based on the benefits of certain plot types, but not necessarily a bidding process. In fact, we believe the bidding system is not a realistic option in rural China where the administrative costs to set up such a mechanism would certainly be high.

tiveness by weighing both the opportunity cost and environmental benefit of each plot, and target as precisely as possible those sites that have low opportunity costs and high environmental benefits.

VI. SUSTAINABILITY

While the cost-effectiveness analysis suggests that a significant portion of the plots are compensated for more than their forgone net revenue, in this section we examine whether or not the overall income position of the participating farmers has improved between periods before and after the program. Our concern is that if farmers are under-compensated, they may decide to exit the program and reconvert the set-aside land back to farming after the compensation phase of the program ends. Unlike the previous analysis, in this section the analysis not only has to account for the forgone net revenue of the plots, but also need to consider the effect of Grain for Green on other income sources and expenditures. To test whether participating households are at least as well off after the program in the short-run, we first approximate the change in real income before and after the implementation of the program.[19] Since the data are restricted to participating households, we cannot test how the net income would have changed without the program; thus the results in this sense are conditional.

The income impact analysis illustrates that average household real net income has increased after participating in Grain for Green (Figure 3). In Ningxia, the average real net income increased from 1999 to 2000 by 75%, from 2,694 yuan to 4,728 yuan. In Guizhou, it increased by 8%, from 3,691 yuan to 3,969 yuan. Importantly, most of the *increase* from 1999 to 2000 is due to the Grain for Green payment. The differences in program payments, which themselves reflect differences in land holdings and participation in the program, explain most of the inter-provincial differences in income rises.[20] With more land in the program, the Grain for Green payments allowed Ningxia households to increase their income substantially more than households in Guizhou.[21]

Assessing Sustainability

Our last key concern of a land set-aside program is the long-term sustainability of program achievements. While Grain for Green officially lasts for ten years, the program will make payments for only five years for "economic trees" and for eight years for "ecological trees."[22] Whether or not the government will continue the program after ten years is still uncertain. Officials hope that after allocating such a large amount of fiscal resources to the program, the positive effects of setting aside the cropland

[19] Real revenue was calculated by adding the revenue from agricultural and non-agricultural activities including off-farm work plus the value of in-kind consumption, and then converting into real terms using a price deflator. Real income was calculated by subtracting real agricultural production cost from total real revenue.

[20] For example, the average land holding per household in Ningxia was 36 mu, four times higher than the average holdings in Guizhou (9 mu). With greater land holdings, the average household in Ningxia was able to enroll more land, 21 mu in Ningxia, than in Guizhou, 5 mu.

[21] While the commitment of the government to making Grain for Green work is shown best perhaps by the large increase in income that directly comes from the program payments, part of its success may also be due to the somewhat surprising outcome that after the implementation of the program, there was only a small decrease in income from crop production. Because the program set aside more than half of the sown area of the participating households, we would expect that there would be a significant drop in crop production. Contrary to such an expectation, crop production fell only marginally (Figure 3). While this may seem somewhat low, it must be remembered that households typically set aside their lowest yielding land. In addition, although we cannot verify with the data, it is likely that the farmers reallocated their freed-up household labor to the remaining plots and intensified the production. Overall, then, the large increases in household income should allay any concerns that the program, as currently designed, is either reducing the income of participating households or is leading to substantial falls in grain production. In fact, since the program areas are in poor regions, the rise in income associated with the program means that Grain for Green also has had a positive effect on poverty alleviation.

[22] In the program areas, officials classify trees to be planted under Grain for Green into two types: ecological trees, such as Chinese fir and Japanese cedar, and economic trees, such as chestnut, walnut, and peach.

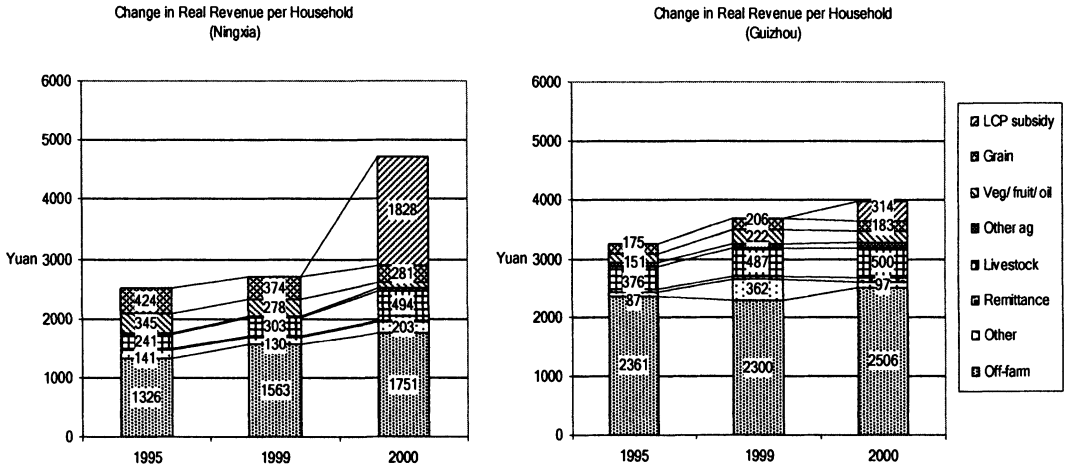

FIGURE 3
CHANGES IN REAL INCOME PER CAPITA OF FARM HOUSEHOLDS PARTICIPATING IN GRAIN FOR GREEN PROGRAM IN NINGXIA AND GUIZHOU PROVINCES, 1995 TO 2000

can be sustained. Although the data indicate that the participating farmers are economically better off under the program in the current period, officials still need to be concerned that farmers might convert their program forest lands back into cultivated area at some time after the program. If so, the long run environmental benefits would be compromised.

Two strategies can help promote the sustainability of the program's environmental benefits. Assuming the current set of payments at least compensates farmers for their foregone cropping income, the government could continue to make payments to subsidize program households. Alternatively, sustainability also could occur if during the time between the start of Grain for Green and the time that program payments cease, households find more profitable uses for the labor (and other resources) that they gained access to as a result of the program. If the opportunity cost of the farm household's labor rises during the program period, it is possible that the cost of reconverting land back into cropping and the use of the labor on that land will not be worth it. It also could be that the program plots may have been transformed in such a way that the expected value of leaving the plot in the program (e.g., the fruit one could harvest from the new orchards planted during Grain for Green) exceed that of putting it back under crop cultivation. However, if the farmers do not find alternative uses for those resources within the time span of the program (or if the Grain for Green plots do not offer a source of income to the household) and the payments cease, households may find the most rational use of their labor resource is to reconvert the land in the program back into cultivation.

To examine sustainability and forecast the farm household's post-contract land-use decisions, two sets of analyses are undertaken. First, we see if the farmers are shifting their resources away from cultivation to productive uses, so that they are increasing the opportunity cost of reconversion. This is tested by analyzing changes in livestock activities, off-farm labor, and non-agricultural activities that have occurred since the start of the project. We also examine the types of trees that are being planted under the program. If households have been able to plant tree species that allow them to harvest a non-timber product (or cash tree crop), this will mean that there will be a greater likelihood that the Grain for Green

investment will be long term and generate cash flows in the future. Second, we analyze a question in the survey that asks directly what the household intends to do after program payments stop.

Results of Sustainability Analysis

Our sample shows that there have been some changes in the sources of household income between times before and after the program (Figure 4). From 1995 to 1999 the number of households gaining revenue from off-farm labor and livestock production in Ningxia has increased on average by 3% and 4% per year, respectively, and by 5% and 8% from 1999 to 2000. In contrast, in Guizhou, the number of households engaging in these activities increased by 8% per year on average from 1995 to 1999, but hardly changed from 1999 to 2000. It could be the case, of course, that one year is too short to observe changes in income sources.[23]

The program's requirement to keep farmers from planting trees that offer cash income in the future also raises concerns since the absence of cash income sources after the program may induce reconversion of the set-aside plots.[24] A case study of one program in Guizhou notes that in practice rules dictated by government officials decided the types of trees that were planted (Gong and Xu 2002). Among the two tree types, the central government required 80% of the land be planted with ecological trees and 20% with economic trees. While the actual implementation in Guizhou was consistent with the government's requirement, the survey shows that more than 50% of households stated that they would have preferred to plant economic trees. If such trees had been successful in producing fruit, nuts and other nontimber products, farmers not only may have had more of an incentive to manage the trees more intensively, they also could be creating an alternative income source that might dampen the propensity for reconversion. Because of the high proportion of relatively economically non-productive, ecological trees, there may be more of a danger of reconversion in the future when program payments cease.

Finally, the survey has direct evidence on the opinions of farmers that suggests that the government needs to be concerned that a number of farmers may be planning to reconvert parts of the set-aside area into cultivated area at some point in the future. In the sample, 34% of the participating farmers in Guizhou responded that that if the government were to stop the payments after five years, they would shift their land back into the cropping activities. The sample farmers in Ningxia responded they had similar intentions 29% of the time.

While farmers in both sample provinces told enumerators that they would consider shifting land back into cropping activities, assuming equal access to off-farm employment, the pressure to reconvert back may be more serious in Guizhou because of low average land holdings per household and thus farmers there may be in more need of finding an off-farm alternative income source. Of the farmers in Ningxia, 44% replied that they believe their new mix of forestry and livestock enterprises would sustain their livelihood after the Grain for Green program. In contrast, only 11% of the farmers in Guizhou replied that they would be able to do so. Not surprisingly, more farmers in Guizhou (29%) replied that if payment were to stop, they also would seek off-farm jobs outside the village (versus 13% in Ningxia). Hence, if the program encourages or pressures farmers to shift

[23] The caveat of these comparisons, however, is that since the sample is restricted to participating households, we cannot separate the effect of the program itself from the trend that we might have seen without the program. We can only thus speculate on what could have been the underlying causes of the trend. This limitation in analyses calls for further investigation on nonparticipating households.

[24] While this is a real issue and a hotly debated topic in China, according to policy documents and discussions with officials in the State Forest Administration, this policy exists because economic trees, compared to ecological trees, require more frequent replanting and provide (in some cases) fewer environmental services. More frequent replanting may compromise the objective of the program—reducing soil erosion.

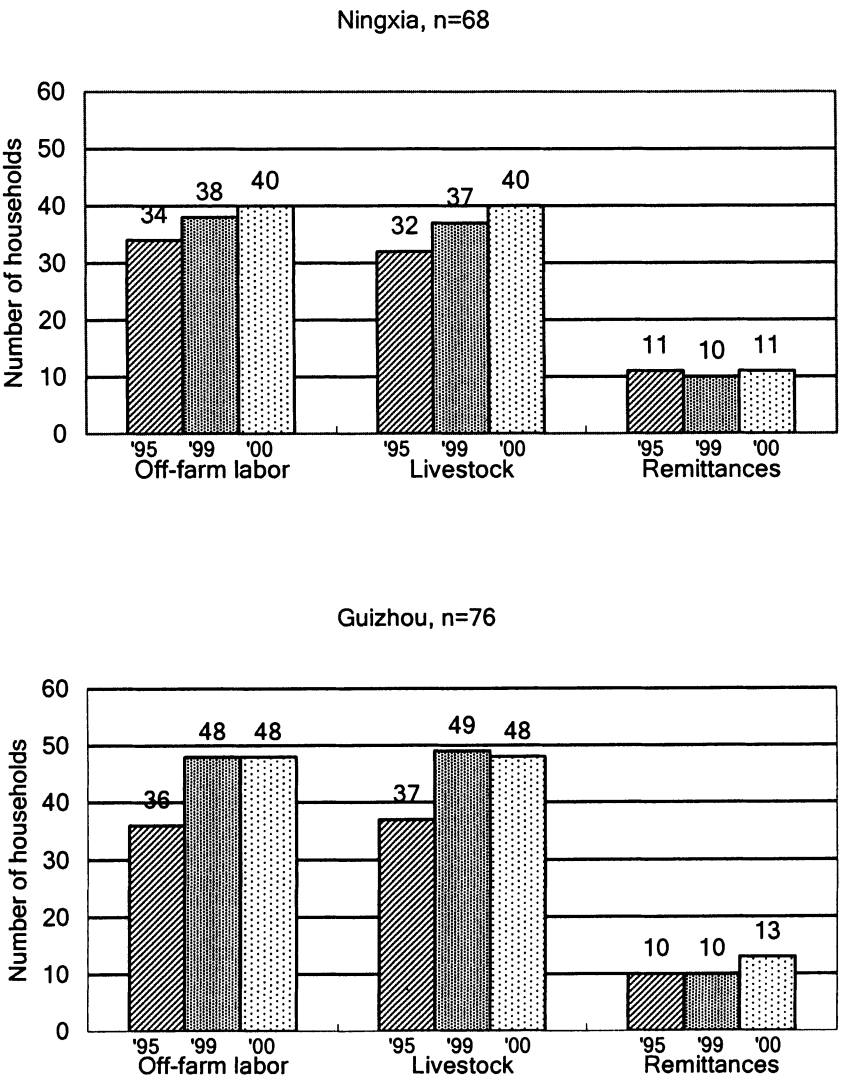

FIGURE 4
CHANGES IN THE NUMBER OF HOUSEHOLDS PARTICIPATING IN GRAIN FOR GREEN PROGRAM WITH INCOME FROM OFF-FARM LABOR/BUSINESSES, LIVESTOCK, AND REMITTANCES IN NINGXIA AND GUIZHOU PROVINCES, 1995 TO 2000

into activities that can provide them with income even after the program subsidies are completed, there likely will be less pressure to return the set-aside land back to cultivation.

The differences between the answers from farmers between the two provinces in the need for off-farm alternative jobs also may reflect the different economic environments that exist in the two provinces. First, land is scarcer in Guizhou than in Ningxia. The average holdings of land per household in the sample are lower in Guizhou than Ningxia. Although in both provinces more than 50% of the sown area of households was set aside under Grain for Green, the land remaining under cultivation on average is much smaller for farmers

in Guizhou. Therefore, farmers in Guizhou have a greater need to either find alternative income sources outside the land-intensive agricultural sector. While the choice to seek more off-farm labor in Guizhou may reflect the demand in the off-farm labor market, if the farmers cannot find off-farm jobs by the end of the program, it is plausible that the optimal choice for them would be to go back to cultivation.

VII. CONCLUSION

Since 1999, China's government has pursued one of the most ambitious conservation set-aside programs in the developing world to prevent soil erosion, investing billions of dollars for afforestation and providing compensation to farmers that have set aside their cultivated land. Although the Grain for Green program is impressive in terms of its scale, a successful, effective conservation set-aside program needs to be more than large; the success of such a program in a developing country also depends on its ability to reduce erosion, sustain income of participating farmers, and do so in a cost-effective and sustainable way.

This paper offers one of the first formal economic analysis of China's Grain for Green. The findings show that while the program has made a clear attempt to retire land that has the highest probability of contributing to soil erosion, the program's targeting was far from perfect. While Grain for Green officials on average targeted plots with lower opportunity cost, cost-effectiveness could be improved by replacing the higher profit program plots with lower profit non-program ones. The study also found that there is a potential for significant savings in government expenditures if the payment schedule reflected the differences in the return from each plot. The higher cost per hectare of China's Grain for Green when compared to the average rental payment of CRP in the United States may be one indicator that payments are "too high." While the high rate of payment may be being made for poverty alleviation reasons, to the extent that the payments could be lowered and still be above the opportunity cost in cropping, lower payments would undoubtedly allow the program leadership to expand the program even more either across space or over time. However, one must include the administrative costs involved in targeting.

The study also found that real net income of participants has increased in both sample provinces, and the increase was mainly due to program payments. The increase in real net income differed greatly, however, between the two provinces, a finding that can be traced largely to differences in the average land holdings of farmers in the two provinces. The increase in participants' income offers an explanation of why the program has successfully expanded nationwide. It also indicates that officials do not need to be concerned about the exit of participating farmers as long as the payments are delivered.

Finally, the paper demonstrates that program officials *should* be concerned about the sustainability of the program in the future. An alarming number of farmers, in particular those in the Guizhou sample, expect to reconvert their set-aside land back into cultivation once the program payments stop. If the program encourages or pressures farmers to shift into activities that can provide them with income even after the program payments are over, the survey shows that there likely will be less incentive to return the set-aside land back to cultivation.

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