"Grain for Green" Policy in China:
Cost-effectiveness and Sustainability of a Conservation Set-aside Program

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Since 1999, China has pursued one of the most ambitious conservation set-aside programs, known as Grain for Green. The overall goal of our paper is to analyze this program's cost-effectiveness and sustainability. We find that while the program has made a clear attempt to retire land that has the highest potential of contributing to soil erosion, cost-effectiveness can be improved by targeting plots with highest environmental benefits and allowing payments to reflect heterogeneous opportunity costs. We also find indications that preventing farmers from reconverting plots to cultivation will be critical to sustain environmental benefits of the program.

Key words: conservation set-aside program, China, cost-effectiveness, sustainability

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According to scientists and resource economists, deforestation is the primary cause of the degradation in China's Yellow River and Yangtze River Basin (World Wildlife Fund). Excessive commercial logging and the cutting down of the forest on hillsides for cultivation in the upper and middle reaches of the basins have lead to severe consequences in downstream areas, including increased soil erosion that has silted streams, reduced hydraulic capacity of the rivers and caused higher frequencies of floods (Huang, et al., Smil, World Wildlife Fund). Records show that the annual soil loss in the two rivers to be high as 4 billion tons (World Wildlife Fund). 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).

Pushed into action by the 1998 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 community, farmers set aside all or parts 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 makes the program one of the world's largest conservation projects. When completed, officials in charge of Grain for Green plan to convert more than 13 million hectares of cropland, 6 million of which are to be on cultivated land that has a slope of at least 25 degrees (World Wildlife Fund). During the first three years, the program has spread to 20 provinces, 400 counties and 27 thousand villages. In the program villages, more than 15 million

farmers have set aside their land in the program and received payments. The implementation of the program is designed to greatly reduce China's long practice of cultivation on steep slopes.

Although Grain for Green is impressive in terms of its scale, a successful, effective conservation set-aside program needs to be more than large; success of such a program in a developing country also depends on its 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 the target areas are poor and rely on farming, much of which is on steeply sloped land, the program must be able to provide an incentive 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 environmental impact and the cost effectiveness of China's conservation set-aside program is to be improved, both environmental heterogeneity and agricultural heterogeneity need to be considered (Babcock, et al., Just, et al.). Given the size and overall goal of the program, the real gains in the long run can only be realized if the program is designed so 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, et al., Johnson, et al.).

If the program does not fairly compensate farmers, if it does not target steeply sloped land 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

"disasters" of earlier decades. For example, during the massive afforestation campaigns during the Mao era, although huge numbers of seedlings were planted using a vast amount of labor resources, the survival rates were extremely low, often only a few percent (Smil). According to Smil, the principal causes included careless planting, inadequate management and inappropriate choice of tree species. Aware of previous failure, forestry officials hope that more careful program design can make Grain for Grain succeed where other programs have failed.

Surprisingly, given the large expenditure of effort and capital on China's Grain for Green, the government has undertaken little or no systematic evaluation. With the exception of Xu and Cao, there has been no rigorous, statistically-based evaluation of the program. In addition to the 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 our paper is to provide a multi-dimensional economic analysis of China's Grain for Green. To meet our overall goal, we have two specific objectives. First, we seek to make an assessment of the cost-effectiveness of the program. We evaluate the cost-effectiveness for the program by weighing environmental benefits of the program against the opportunity costs of retiring the croplands. Such a calculation will give us an indication of whether or not the program has targeted cultivated area that should be expected to reduce erosion at as low of an opportunity cost as possible. Second, we seek to understand the sustainability of the program's achievements. Sustainability of a land set-aside program will only be ensured if the changes induced by the set-aside efforts are environmentally and financially lasting. In other

words, environmental benefits of soil erosion prevention should be sustained even after the program ends, which implies that the participating farmers need to find an alternative income source so that they no longer depend on the subsidies after the program is over.

To meet our objectives, we utilize a set of survey data that we collected from 144 participating households from 16 randomly selected villages in two provinces in western China (Ningxia and Guizhou). The household survey gathered detailed information before and after the program on wealth, farming and non-farm activities, characteristics of cropland and agricultural production. To see how well the program targeted plots from the perspective of cost–effectiveness and its environmental benefit, we use our data to explain what types of plots were set aside under the program. We examine the net revenue of a plot, as an indicator for a plot's opportunity cost, and the steepness of its slope, as the indicator of the environmental benefit of preventing soil erosion. We then compare the distribution of plots that were set aside under the program and those that were not. From this information, we can draw some conclusions about how much the program paid for how much environmental protection.

To examine the sustainability of the program's impacts, we examine how the program will affect the household's wealth by comparing the net income before and after the program. The analysis also considers how the types of income-earning activities and ways that the household farms have changed during the course of the program. Finally, to understand how farmers will behave when the current program's payments expire, we examine what farmers say they intend to do when their set-aside subsidies end.

When drawing conclusions from our results, there are two caveats. First, we examine

only 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 and limits some of the questions that we can answer. Second, we do not have a good measure of how well Grain for Green is doing in preventing soil erosion, the primary environmental objective of the program. The only proxy we have for potential to prevent soil erosion is the slope of the Grain for Green plots.

Conservation Set-aside Program in the U.S.

While many OECD countries have implemented ambitious conservation set-aside programs (OECD), 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. Authorized under the Farm Bill of 1985, the CRP provides farmers with an annual per-acre rental payment and half the cost of establishing a permanent land cover in exchange for retiring highly erodible or other environmentally sensitive cropland for ten to fifteen years. In 2000, 33.5 million acres were enrolled in the program, which is nearly 10 percent of the total cropland in the U.S. (USDA) The average rental payment is $113.23/hectare/year, which requires about $1.7 billion per year to support.

Since its conception, economists have been concerned about several aspects of CRP: the program's cost-effectiveness (e.g., Babcock, et al., Babcock, et al., Osborn, Smith) and its sustainability or the post-contract land use decisions of participating farmers (e.g., Cooper, et al., Johnson, et al., Parks, et al., Skaggs, et al.). The issue of the cost-effectiveness of CRP has been debated since its introduction. In particular, economic studies have examined how environmental benefits of a conservation set-aside program can be increased if targeting was based on weighing

costs and benefits, instead of just targeting land with the least cost. For example, using data from CRP, Babcock, et al. showed that if there was a 50 percent cut in the budget for CRP, with more careful site selection--based on both costs and benefits—the program could achieve more than 90 percent of the current environmental benefit.

Leaders also have been concerned about the sustainability of programs. Post-contract land use decisions, particularly whether or not farmers will return the land to cropland, are critical determinants to whether CRP can sustain its environmental benefits. Studies have found that the higher the current income from farming and productivity of land, the less likely that they would reenroll in CRP upon expiry of current contract (Cooper, et al., Johnson, et al., Parks, et al.). A farmer who is less risk averse, higher discount rate, or who has more debt was also found to be more likely to return to cultivation (Kalaitzandonakes, et al.) These findings from the U.S. experience are useful for China as they try to improve the performance of Grain for Green in terms of cost-effectiveness and sustainability.

China's Grain for Green

While starting more recently than those developed countries, in 1999 China's leaders began a massive conservation set-aside program called Grain for Green. Starting with a pilot program in 1999, officials expanded the program to 20 provinces by the end of 2001. During this time, participating farmers converted 1.16 million hectares of cropland into forest and pasture (Xu, et al.). The program also afforested nearly 1 million hectares of barren land. Hence, by the end of the first three years, the program covered an area of more than 2 million hectares. By the end of the program in 2010, leaders plan to set aside more than 13 million hectares of cropland, an area

equivalent to more than one half of the U.S. CRP program. Six million of the Grain for Green area are supposed to be on sloped cropland of over 25 degrees (World Wildlife Fund).

The large budget requirement for the program demonstrates the nation's commitment to Grain for Green. Between 1999 and 2001, forestry officials spent 3.65 billion yuan (approximately 2.4 billion dollars in PPP) on the program.[1] Using PPP, the magnitude of the program can be seen by the fact that although China's program is smaller, the outlay is 40 percent more than annual expenditure for CRP in the U.S. The largest share of the budgetary outlay is used by officials to compensate the farmers for setting aside their cropland and planting seedlings on their land.

The program offers three types of compensation to farmers: grain, cash, and free seedlings. According to program rules, each year farmers receive 1500 to 2250 kilograms of grain per hectare per year, or in cash equivalent terms about 2100 to 3150 yuan.[2] The farmers also receive a cash compensation of 300 yuan per hectare per year. Finally, forestry agencies also supply free seedlings to farmers, a value of approximately 750 yuan per hectare. The subsidies are given if the farmer passes the annual inspection. In total, the three types of compensation amounts to 4200 yuan per hectare annually in the middle and upper reaches of Yangtze River, and 3150 yuan per hectare annually in the upper reaches of Yellow River. In PPP terms, this amounts to a payment that is more than *fifteen times* the average rental payment under CRP in U.S.

Since the main objective of China's program is to restore the nation'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 would be 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. This site-selection criterion is much simpler compared to other cropland set-aside programs such as CRP that uses an index to consider a number of different environmental benefits for site selection.

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 report that, in addition to land with high slopes, some regions gave priorities to sites close to a road system, giving consideration for easy inspections and monitoring. For example, in Southwest China, more than 70 percent of the farmer households in the program were located along a road. CCICED reports that some regions required the plots to be contiguous to each other to minimize the implementation cost, which resulted in allowing participation of croplands on flat areas. Case studies also report that the program lacks a systematic indicator to measure the environmental benefits of each site (CCICED, Xu and Cao). These facts lead us to our concern that the cost-effectiveness of the program and its targeting of environmentally sensitive plots may be severely compromised.

The high proportion of farmers willing to go back to cultivation in the U.S. alarms officials in China about the sustainability of the environmental benefits of Grain for Green. CCICED reports the uncertainty over lack of property rights and the responsibility for management of the trees in the future suggests that farmers may not have a great enough incentive to maintain their forest plots in the long term. Farmers may reconvert their plots to cropping if they do not expect to gain from the plots in the future to exceed the gains from reconversion. Incentives to preserve

natural resources and to invest in trees and other land improvements for future benefits will be hindered without well-established property rights, because the future benefits will not otherwise accrue to those who manage them (Besley). The institutional settings also may discourage the participating farmers from managing the trees, thereby diminishing the long-term environmental benefit of the program.

Data

To evaluate the cost-effectiveness and sustainability of Grain for Green, we primarily use a data set that we collected with our collaborators in 2000. Designed to enumerate participating households in the pilot Grain for Green program, the survey covered 144 participating households from 16 randomly selected villages in 2 provinces Ninxia and Guizhou Provinces. We also use data from a series of community surveys in 6 provinces to supplemental our analysis. This more encompassing set of data is described in Xu and Cao.

The household survey, conducted approximately one year after the initial Grain for Green programs commenced in the sample counties, 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 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.[3]

To evaluate the cost-effectiveness of Grain for Green, we heavily utilized a section of the survey that provided a census of each household's cultivated plots. On average, each household

cultivated four plots. For each plot, respondents reported the crop(s) grown, their yield, production and inputs in 1999, before the program started. In addition, respondents provided a number of other plot attributes including slope (no slope, moderately sloped, highly sloped); plot size; cropping pattern; whether or not the plot was entered in Grain for Green, and if so, how many seedlings and other inputs were used; and distance of the plot from the respondent's home.

To evaluate the sustainability of the program, we analyzed three sections of the survey. First, we used a section of the survey on detailed revenue and expenditures before and after the program. Second, we employed a section that asked about the amount and types of trees that they planted under the program. Finally, we also utilized a section asking about the household's perception on Grain for Green, which includes a question asking what the farmer intend to do with the set-aside cropland after the payment period comes to an end.

Cost-effectiveness

A policy is cost-effective if it achieves the policy objective at the lowest possible cost (Tietenberg). Grain for Green would be cost-effective if the program achieves the goal of preventing soil erosion at the lowest possible cost. We measure the potential of preventing soil erosion on cropland by observing the steepness of each plot. Using such a measure assumes that the steeper the slope of the plot, the more susceptible it is to soil erosion. Given the level of environmental benefit, we evaluate cost effectiveness by analyzing whether this is being done at the lowest possible cost.

The main costs from the government's point of view 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 would be higher, the higher the opportunity cost of the land that is retired. Hence, if retired plots have higher yields, then program costs will rise, and vice versa. Based on this criteria, 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. In the upper reaches of the Yangtze River Basin, farmers receive 2250 kilogram per hectare annually, while those in the Yellow River Basin receive 1500 kg per hectare. In one sense, this strategy was adopted for cost-effectiveness, 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 regions, it would seem that a compensation scheme with only two levels would not do a precise job of matching payments to either the environmental benefit the plots provide or the amount of income loss the farmer gives up.

To test the cost-effectiveness of the program, our strategy includes four steps. First, to get an intuition for how well the cropland were targeted on the basis of cost-effectiveness, we will utilize the descriptive statistics from case studies reviewed by Xu and Cao to observe the mean

slopes and yields of the plots in the program and compare them with the plots not in the program. Second, we will perform a multivariate discrete choice analysis to investigate the determinants for plot selection. Our goal is to test whether 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.[4] Third, we compare the opportunity cost between sloped land (that which is more susceptible to soil erosion) and less sloped land—both differences on those selected for the program and those not. In this analysis, instead of using the yield for each plot, we compare net income associated with each plots.[5] Finally, we will compare the net revenue on a per hectare basis of plots under program against plots not under the program and will do so considering the steepness of the slopes of the plots.

Results

Based on our criteria of cost-effectiveness, our 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, more than 80 percent 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 percent 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 is evidence that the program could be implemented more cost-effectively. A share (albeit fairly small) of the participating plots in the program are not sloped. At the same time, there were also a fairly large number of steeply-sloped plots that program officials did not include in the program. According to

the cost-effectiveness standard, the distributions of participating and non-participating plots suggest 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 percent of the cropland set aside under the program had high slope. Seventeen percent of the plots were not highly sloped. To increase the environmental benefit of Grain for Green, an alternative design would replace the relatively flat plots with more highly 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.

Our 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 a lot of room for improvement. Specifically, in our sample, the yields of the participating plots have a lower yield than non-participating plots. 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. However, within the group of participating and non-participating plots, there is still substantial heterogeneity (Table 1). In fact, nearly 40 percent of the plots in the sample have yields that fall below the compensation rate of 1500 kg (or 2250 kg). Clearly the owners of the lower yielding plots are in some sense being over-compensated. Likewise, those plots with yield above the compensation rate are relatively under-compensated. Having such a large portion of the plots either way above or way below the compensation rate is an indicator of poor efficiency.

Beyond the unconditional comparisons of yields between participating and nonparticipating 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 effects, our results show that it performed well overall, with a R-square of 0.50 . The signs and magnitudes of the coefficients are stable across all three versions of the model.

Most poignantly, the multivariate analysis 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 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 yield were less likely to be selected for Grain for Green. Taken together, the results imply that on average the program is enrolling plots with positive environmental benefits and lower opportunity costs.

Using our measures of net revenue, however, our 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 Grain program largely exceed the plot's opportunity cost (Figure 1, Panels A and B). In the Ningxia sample, for example, 84 percent 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. The average gap between the plot's payment and its net revenue exceeded 80 yuan, a level that is nearly 58 percent of the compensation level. In the Guizhou sample, 60 percent 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 percent. On a household basis, 76

percent of participating households in Ninxia and 23 percent in Guizhou received payments that exceeded the net revenue that they had made on the plots the year before.

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, after entering becoming the Grain for Green program, farmers receive more in payments for not planting any crop. From the household's point of view, Grain for Green must be considered a lucrative program. As long as the government does not fall through on its support payments, at least in the short-run, this is a win-win proposition. Not only does the program provide higher incomes, the risk is lower and the farmer has access to additional family labor, which is now not needed for use on the set-aside plots.

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 percent of the program plots had higher net revenue than the compensation level (140 yuan), nearly 70 percent of the non-program plots had lower net revenues than this level. Likewise, in Guizhou, while 40 percent of the program plots had higher net revenue than the compensation level (210 yuan), nearly 30 percent of the non-program plots had lower net revenue than this level. Thus, better targeting could have reduced the cost to the government as well as to the farmers by including non-program plots that had lower net revenues instead of the higher profitable program plots.[6]

Before drawing final conclusions about cost-effectiveness, however, we also need to take into consideration the environmental benefits. We do so by accounting for both opportunity costs and environmental benefit 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 plot the opportunity cost against the slopes of each plot. If the site-selection was based on maximizing the cost-effectiveness of the program, it would be because that would suggest that all plots with high slopes (i.e., high environmental benefit) and relatively low net revenue (i.e., low opportunity cost) were selected for the program.

When doing so, our data show that site selection was cost-effective for Guizhou sample but not for Ningxia (Figure 2, Panels A through D). The four panels include only single-crop plots in the program, and thus represent 86% of program plots in the Ninxia sample and 37% in Guizhou. From Panel C, we find that all of the single-crop plots entering the program in Guizhou have high slopes, implying that it 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. On the contrary, in Ningxia, the cost and benefits are unsystematically dispersed in the two-dimension space (Panel A). Eleven plots in our sample have no slope and high net revenue, and fourty-five plots with moderate slope and low to high net revenue. Based on the fact that there are a number of plots with higher slopes and lower net revenue per mu (Panel B), these figures suggest that the site selection did not perform well in Ningxia from the cost-effectiveness point of view. Ningxia could improve its cost-effectiveness performance considerably by instead targeting those plots with high slope and low opportunity costs.

Sustainability

While we found that the average participating household's real net income increased after the program, our second key concern of a land set-aside program in the long-term is its sustainability.[7] Grain for Green is designed to make program payments for ten-years, and 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 could be sustained. Although our data indicate that participating farmers are economically better off under the program in the current period, officials still need to be concerned that farmers might convert program plots back into cultivated area at some time after the program. If so, the long run environmental benefits, of course, would also be endangered.

To test for sustainability and forecast the farm household's post-contract land-use decisions, we take undertake two sets of analyses. First, we examine if the farmers are shifting away their resources from cultivation to productive uses, so that they are increasing the opportunity cost of reconversion. We test this by analyzing changes in livestock activities, off-farm labor and non-agricultural activities that have occurred since the start of the project. We will also examine the types of trees that are being planted under the program. If households had the opportunity to plant non-timber products (or cash crops), the Grain for Green investment may be successful in generating long-term conservation and economic benefits, since households will be able to generate future cash flows. Second, we analyze a question in our survey that asks directly what the household intends to do after program payments stop.

Results

Our sample shows that there has been little change in income source before and after the program (Figure 3). From 1995 to 1999, we find that number of households gaining revenue from off-farm labor and livestock production has increased steadily, but there has been little or no change from 1999 to 2000. In Guizhou, the number of households engaging in these activities increased rapidly by more than 30% from 1995 to 1999, but hardly changed from 1999 to 2000. It is clear that the program has not induced significant changes in income sources except for the program payments, at least within one year of the program. It could also be the case, however, that one year is too short of a time period to observe changes in income sources.[8]

The failure to plant trees that offer cash income in the future may induce reconversion after the program. In the program, officials classify trees to be planted under Grain for Green into three types: *ecological trees*, such as Chinese fir and Japanese cedar, *economic trees* such as chestnut, walnut and peach; and *timber trees*. In a case study of one program in Guizhou province, the observer notes that in practice rules dictated by government officials decided the types of trees that were planted (Gong, et al.). Among the three tree types, the central government required the ratio of 80 percent ecological trees to 20 percent economic trees. While the actual implementation in Guizhou was consistent with the government's requirement, the survey shows that more than 50 percent of the household strictly prefer economic trees. If so, then our survey suggests that if households had chosen on their own, they would have planted more economic trees. If such trees had been successful in producing fruit, nuts and other non-timber products, farmers may have more incentive to manage the trees, and this could create an alternative income source that would dampen the propensity for reconversion. Because of the high proportion of relatively nonproductive

(economically) ecological trees, there is more of a danger of reconversion in the future should program payments cease.

Finally, our survey suggests that the government needs to be concerned that a number of farmers may well begin to cultivate the retired area at some point in the future (Figure 4). In our sample, twenty-nine percent of the participating farmers in Ningxia and thirty-four percent in Guizhou responded that that if the government were to stop the payments after five years, the producers would shift their land back into the cropping activities.

While farmers in both sample provinces told enumerators that they would consider shifting land back into cropping activities, the pressure to revert back may be more serious in Guizhou because average land holdings per household is low and thus may be in more need to find a off-farm alternative income source. Forty-four percent of the farmers in Ningxia replied that they believe their new mix of forestry and livestock enterprises would sustain their livelihood after the Grain for Grain program. In contrast, only 11 percent of the farmers in Guizhou replied that they would be able to do so. Not surprisingly, more farmers in Guizhou (29 percent) replied that if payments were to stop, they may seek for off-farm employment outside their own villages (versus 13 percent in Ningxia). Hence, if the program encourages or pressures farmers to shift into activities that can provide them with income even after the program subsidies are completed, there will likely be less pressure to return the retired land back to cultivation.[9]

Conclusions

Since 1999, the Chinese government has pursued one of the most ambitious conservation set-aside programs in a developing country to prevent soil erosion, investing billions of dollars for

afforestation and compensation for farmers who 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; 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.

In this paper, we offer a multidimensional economic analysis of China's Grain for Green. We 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 the officials, on average, targeted plots with lower opportunity cost, cost-effectiveness could be improved by replacing the high profit program plots with low profit non-program ones. We also found that there is a potential for significant savings in government expenditure if the payment schedule reflected the differences in return from each plot. The higher cost per hectare of China's Grain for Green when compared to the US CRP program 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 government to expand the program even more.

We also found that real net income has increased in both sample provinces, and the increase was mainly due to the program payment. Our analysis shows, however, that the increase in real net income differed greatly 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 real net income offers an explanation of why the program has been successful in expanding the program

nationwide. It is also an indication that officials do not need to be concerned too much about exiting of farmers as long as the payments are being delivered.

Finally, our paper demonstrates that program officials should be concerned about the sustainability of the program in the future. The analysis found that an alarming number of farmers expect to convert back the retired land into cultivation once the program payments stops. If the program encourages farmers to shift into activities that can provide income even after the program payments are over, there will likely be less pressure to return the retired land back to cultivation.

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[1] The Purchasing Power Parity conversion factor is 1.78 yuan to the dollar (World Bank). Out of 3.65 billion yuan, 83% was used for grain and cash payments and the remainder for providing free seedlings.

[2] The Chinese government uses a conversion rate of 1 kg of grain = 1.4 yuan (about $0.79 in PPP). One mu is 1/15 of a hectare.

[3] 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 their plots' environmental benefits and opportunity costs. Unfortunately in the first round of household level data collection that was mandated by the government, only information on program participants was collected. The government is currently under way to implement another survey covering both participants and non-participants.

[4] Appendix I of the full version of the paper, available on http://www.agecon.ucdavis.edu/facultypages/rozelle /publications/NatResEnvironment.htm, shows a simple analytical model to characterize the selection of the plots by a local government.

[5] We assume that the opportunity cost equals the net revenue that the plot generated the year before the plot entered the program. In our analysis, net revenue per mu is gross revenue per mu minus variable cost 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 cover and hired labor.

[6] Our data also illustrate that the degree of over-compensaton varies across the study areas and reveals the potential to improve the cost-effectiveness of China's Grain for Green program. See the full version of the paper for details.

[7] In the full version of our paper, we have analyzed the immediate welfare impact of Grain for Green by comparing the real net income before and after the program.

[8] The caveat of these comparisons, however, is that since our 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 non-participating households.

[9] The differences between the answers from farmers between the two provinces in the need for off-farm alternative jobs may reflect the different economic environments that exist in the two provinces. The average holdings of land per household in our sample are lower in Guizhou than Ningxia. Although in both provinces more than 50 percent of the sown area of households was set aside under Grain for Grain, the remaining land on average is much smaller for farmers in Guizhou. Therefore, farmers in Guizhou have a higher need to either find alternative income sources outside the land-intensive agricultural sector.

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Table 1 Comparison of Yields and Slopes from Case Studies (2000)

Counties in Case Study	Average Yield before program (kg/ha)		Total area set aside (ha)	Proportion of sloped land (%)		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	1369	2220	2000*	83%	45%	1500
Zuozi, Inner Mongolia	1125	-	9367**	16%	33%	1500
Pengyang, Ningxia	1464	2076	5080	93%	72%	1500
Heqing, Yunnan	-	-	1000	96%	91%	2250
Dafang, Guizhou	2329	2731	1333	98%	69%	2250
Tianquan, Sichuan	3106	8646	4600	86%	65%	2250

Adapted from Xu and Cao (2002). * : data from 2001. **: Includes areas of afforested barren hills.

Table 2 Impact of Plot Characteristics on Program Entry with Household Fixed Effects

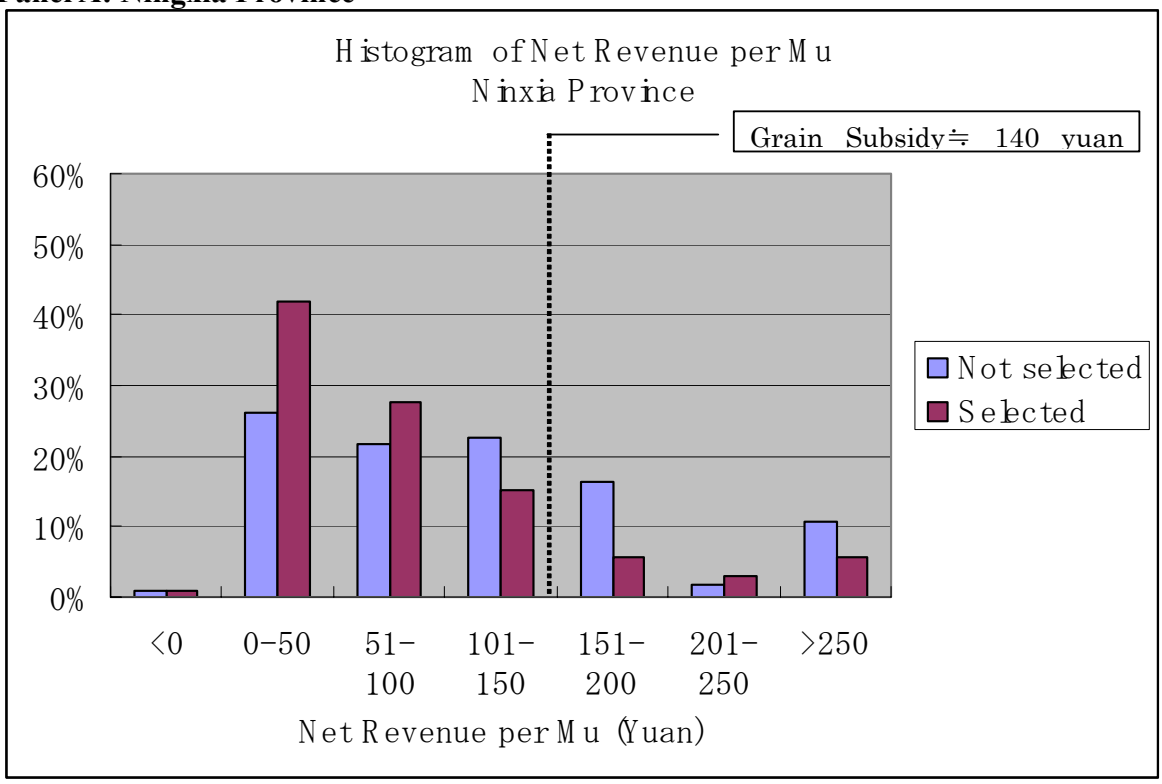
		Dependent variable: 1=Plot in the program, 0=otherwise		
		(1) OLS with fixed effect	(2) Random Effect Logit	(3) Fixed Effect Logit
1	**Current Yield**[b]	-0.000227*	-0.000585*	-0.000617*
		(-1.93)	(-1.95)	(-1.93)
2	**Distance from home (km)**	0.618*	0.224*	0.365**
		(2.58)	(2.05)	(2.68)
3	**Slope of plot**	0.276***	1.389***	1.372***
		(7.65)	(6.69)	(5.83)
4	**Constant**	0.187	-3.269***	-
		(1.10)	(-5.87)	-
5	**Number of plots**	416	416	325
6	**Number of households**	144	119	86
7	**R-squared**	0.5003	-	-
8	**Log-likelihood**	-	-243.00	-87.49
9	**Prob>Chi2**	-	0.0000	0.0000

[a] Parentheses indicate t-statistics based on robust standard errors for pooled OLS, and z-statistics for random and fixed effects. * significant at 10%; ** significant at 5%; *** significant at 1%.

[b] Current yield is based on 1999, before the program was implemented in the two sites.

Figure 1 Distribution of net revenue per mu per year for program plots and non-program plots

Panel A: Ningxia Province



Panel BGuizhou Province

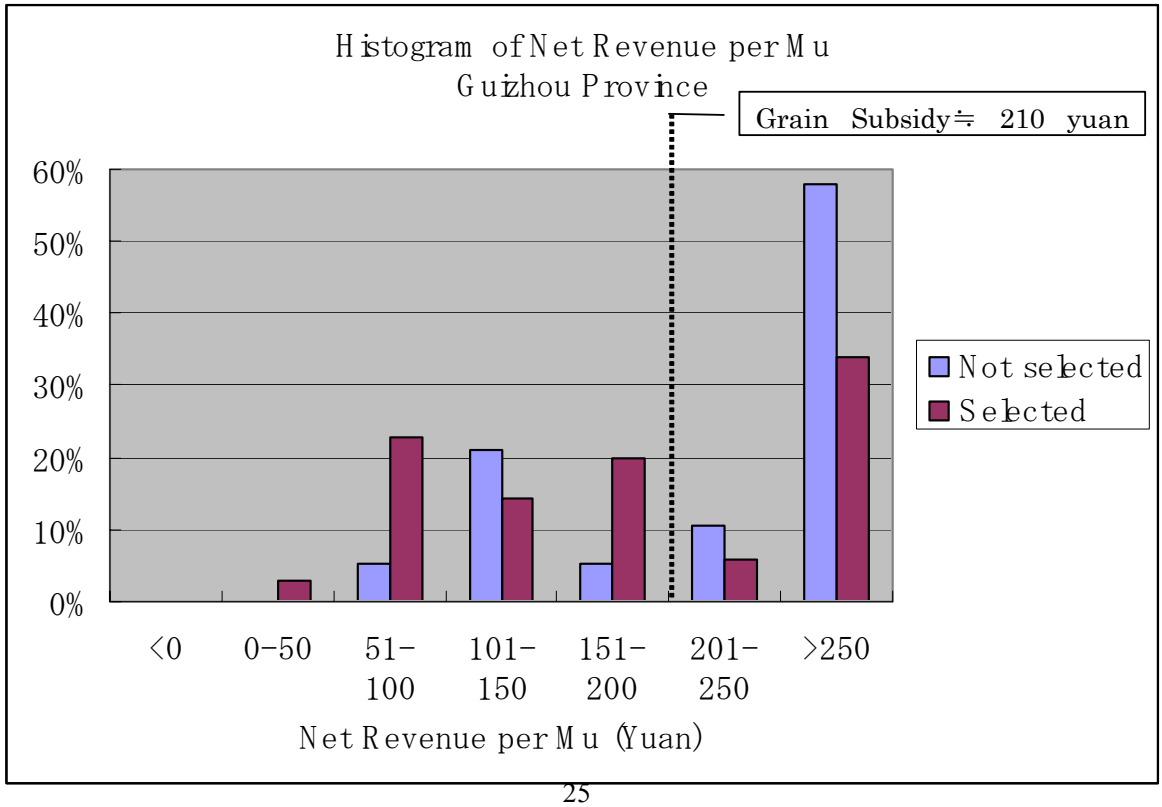


Figure 2 Opportunity cost vs. Environmental benefit

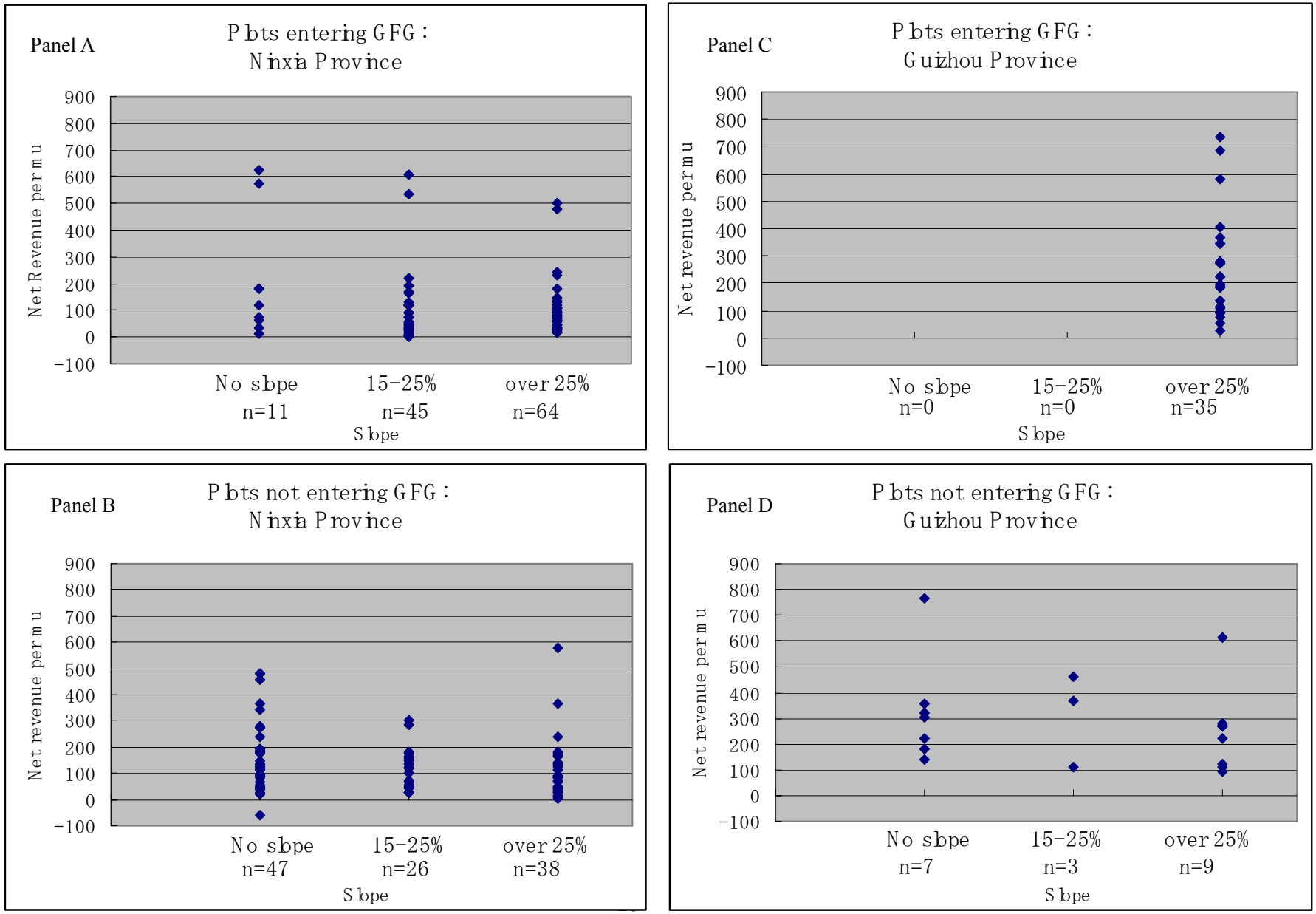


Figure 3 Change in Number of Households with Revenue from Off-farm Labor/Business, Livestock, and Remittance

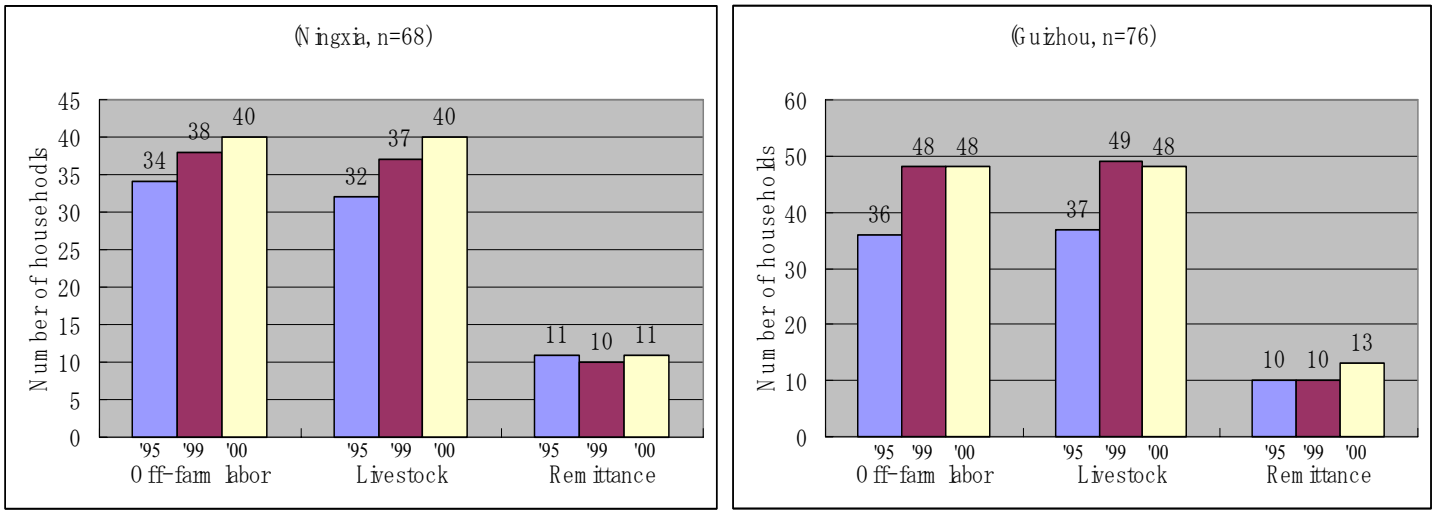


Figure 4 What would you do if the program payment stops after five years?