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Government Initiated Community Resource Management and Local Resource Extraction from Nepal's Forests

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Abstract: This paper considers the effect on local resource extraction of an ambitious, government initiated community forestry program in Nepal. Beginning in 1993, the government of Nepal began to transfer all accessible forestland from the national government to local communities by creating local groups of forest users. This study uses institutional details about the implementation of this program to evaluate its impact on the extraction of wood for fuel. Transferring forests to local groups of forest users is associated with a significant reduction in resource extraction in communities that receive new forest user groups.

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1. Introduction

Recent widespread concern about the destruction of the world's forests has elevated forest management issues to the forefront of development policy discussions. A consensus has emerged that local communities should be involved in managing their forests, and nearly every country in the world is experimenting with some form of "Community Forestry."[1] However, the capacity for governments to initiate and organize local communities to manage and protect their forests has not been established, especially not on a national scale. This study exploits an unusual policy experiment in Nepal to consider the impact of a nationwide community forestry program on resource extraction from local forests.

Forests have always been of tremendous policy importance in Nepal. Ninety-four percent of rural households in the hill and mountain areas of Nepal rely on fuelwood as their primary fuel for heating and cooking.[2] In 1957, in order to protect local forests, the government of Nepal nationalized all forests in hill or mountain areas on greater than 1.25 hectares of land (Bromley, et al 1984). Subsequent to nationalization, the government of Nepal created an administrative structure to protect and manage national forests, the Department of Forests. Deforestation and degradation appears to have accelerated under national management (Palit 1996). Consequently, in 1993, the government of Nepal abandoned national management, passing the Forest Act of 1993 that transferred all accessible forestland from the central government to local communities through the creation of "Forest User Groups."

The Forest Act redirects the field staff ("foresters") of the Department of Forests from protecting national forests towards building forest user groups to manage all of the nation's forestland without interference from outside of the community. In a climate of excessive

[1] For surveys of the academic literature on community resource management, see Wade (1987), Ostrom (1990), Bardhan (1993), or Baland and Platteau (1996). Sharma (1992) describes forestry programs in several countries.
[2] Author's calculations from the 1996 Nepali Living Standards Survey (NLSS).

degradation, the first action of newly created forest groups is to restrict local resource extraction.[3] Forest groups created under the Forest Act receive a set of guidelines describing how to accomplish this. They can ration access to the group's forest and tax anything removed from the forest. Most groups receive funding and assistance to hire guards and build fences around the forestland, both of which make rationing and taxation enforceable. In addition, transferring land to local users may cause users to internalize any externalities associated with extraction (as with privatization), or it may spur users to cooperate and coordinate their forest use (as in Runge 1981). While forest groups have the capacity to affect reductions in resource extraction, it is an empirical question as to whether government initiated community institutions actually function and constrain extraction after they have been created.

This paper takes advantage of the fact that building forest user groups for every forest in Nepal is a long, time-consuming process. By 1996, foresters have built more than four thousand new forest user groups, but these forest groups cover less than ten percent of Nepal's forestland (Edmonds 2000). Using household survey data from 1995/96 merged with an administrative census of forest groups in the Arun Valley of eastern Nepal, this study compares resource extraction in areas with and without forest groups. In the cross-sectional (unconditional) mean, I find resource extraction to be fourteen percent lower in areas with forest groups.

However, forest groups are not randomly placed. Thus, in this paper, I discuss forest group formation (in section 2) and use this institutional detail in three distinct approaches to evaluate the robustness of this fourteen percent difference. First (in section 3), I include a variety of sets of control variables to control for observable differences in the placement of forest

[3] Forest groups are also encouraged to plant additional forest cover. Forests in the area of this study face a long regeneration cycle, and the dataset used in this paper was collected only 3 years after the reform. Hence, regeneration is unlikely to be an issue in this paper. Moreover, regeneration would attenuate the observed effect of forest groups on the extraction of wood for fuel.

groups. I consider parametric, semi-parametric, and non-parametric functional forms. With this *"conditioning on observables"* approach, I am unable to reject the fourteen percent difference in resource extraction observable in the raw means. The obvious criticism of *conditioning on observables* is that there is no way to test for whether one is controlling for all the differences associated with forest group placement. In my second estimation approach (section 4A), I compare resource extraction by households in communities that receive forest groups immediately before the household survey to extraction by households that receive forest groups immediately after the survey. This comparison identifies the effect of forest groups under the assumption that communities receiving forest groups at a similar point in time are most comparable. The results of this "*switching communities"* approach suggest larger reductions in resource extraction than the *conditioning on observables* approach, but the two estimates are not statistically different from the fourteen percent sample mean.

Finally (in section 4B), I treat the placement of forest groups as an endogenous variable that depends on the accessibility of a community to foresters. In this *"endogenous programs"* approach, I use a set of variables describing the accessibility of a community to foresters as instruments to predict the location of forest groups in the first stage of an instrumental variables model. The results of the *endogenous programs* approach are of a similar magnitude to the *switching communities* findings and within a ninety-nine percent confidence interval of the *conditioning on observables* results. As I discuss in section 5, the evidence in this paper is consistent with government initiated community institutions having the capacity to operate without extensive external oversight to reduce local resource extraction relative to the resource management regime that exists in the absence of forest user groups.

2. The Evaluation Problem

A. Background Information

In this paper, I use data from the Arun Valley of Nepal.[4] The household survey used in this paper, the Arun Valley Living Standards Survey ("ALSS"), is a random sample of 1200 households in 100 communities that were interviewed during one Nepali calendar year spanning 1995 and 1996 of the Gregorian calendar.[5] The ALSS is a multi-purpose household survey conducted by the Central Bureau of Statistics in Kathmandu with assistance from the World Bank. The survey follows the format of the Living Standards Measurement Surveys, collecting a wide array of information about the household and the activities of its members.

Throughout this paper, I focus on the household's fuelwood collection problem as my measure of resource extraction. The collection of wood for fuel is one of the two main causes of deforestation in Nepal (agricultural conversion of forest land is the other: Soussan, et al 1995). While forest user groups generally have well defined boundaries that limit agricultural conversion of forest user group land, the impact of forest user groups on household collection activities is unclear. The ALSS questionnaire asks each household: "On average, how many bharis of firewood do you collect each month?" The answer to this question (annualized) is my measure of firewood extraction. A bhari is a basket that people carry on their backs usually supported by a brace on the head.[6]

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[4] The Arun Valley refers to the watershed surrounding the Arun River in eastern Nepal. Shrestha (1989) describes the economy and the environment of the Arun Valley. Almost the entire valley is accessible only by footpath and the economy is largely subsistence. Over 70% of the adult population never received any schooling. The terrain is mountainous and varied, characterized by few flat areas, and ranging in elevation from sea level near the river's base to 8,470 meters at the top of Mt. Makalu-Barun.

[5] Nepal is divided into development regions that are divided into districts that are divided into VDCs (Village Development Committees). The VDC is the main local government agent, and typically there are more than thirty VDCs per district. In general, each VDC is divided into eight wards. The ward is the smallest level of administration in Nepal, and it is the definition of *community* used throughout this paper.

[6] Though imprecise. a bhari is the most meaningful measure of firewood collection to a Nepali household. Little variation in the definition of a bhari from region to region has been reported in the field. However, Filmer and Pritchett (1996) comment that the definition of a bhari could vary geographically. Throughout this paper, I assume that variation in the definition of a bhari from one community to the next is independent of other community characteristics.

In order to compare resource extraction in areas with and without forest groups, I require data on the location of forest groups. For this, I use a database assembled by the Nepali-United Kingdom Community Forestry Project (NUKCFP).[7] The NUKCFP operates all forest offices in the Arun Valley, and hence funds and trains all of the foresters in the three districts of the Arun Valley. It is responsible for all of the forest groups created under the Forest Act in the Arun Valley (Edmonds 2000 discusses the role of intergovernmental organizations in the creation of forest groups). The NUKCFP database (1997) is a census of all forest user groups in the Arun Valley and has been matched in this study to the location of communities in the ALSS.

Table 1 compares unconditional sample means of various household and community characteristics in areas with and without forest user groups at the time of the household survey. Households in areas with forest groups collect on average 15.5 less bharis per year than households in areas without forest groups. If firewood collection in households in areas without forest groups is an accurate measure of what firewood collection would look like in households in areas with forest groups absent the presence of those forest groups, then 15.5 less bharis per year corresponds to a 14% reduction in the extraction of wood for fuel as a result of the presence of a forest group.

The remaining rows of table 1 compare other characteristics of households and communities with and without forest groups at the time of the household survey. Column 3 of table 1 reports the difference in the means between areas with and without forest groups and, in parentheses, the t-statistics for the null-hypothesis that the difference in unconditional means is zero. In every case other than fuelwood collection, I cannot reject that the mean value of each characteristic is the same in areas with and without forest groups.

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[7] Since 1992, the NUKCFP database tracks all forest groups formed in the Arun Valley. I attained the version of the database used in this paper from the Koshi Hills field office in September 1997.

Forest characteristics appear similar. Forest cover is approximately the same in areas with and without forest groups. The density of the forest crown is similarly depleted in areas with and without forest groups. However, the data on forest cover come from a Land Resource Mapping Project conducted by His Majesty's Government in the early 1980s (Morgan and Nyborg 1996 describe the data in greater detail). Though it is the best available data on forest cover for the Arun Valley, its age limits its informational content. Even while forest conditions appear similar, table 1 hints at other differences that might be meaningful even though they are not statistically different. Communities with forest groups are more likely to have electricity of some form, are more likely to be within four hours of a local bazaar (market), are more likely to have piped water, and are slightly richer.

Differences between areas with and without forest groups imply that the 14% difference in resource extraction in table 1 may not reflect the impact of forest groups so much as it reflects something about the placement of forest groups. All accessible forestland will be transferred to local communities under the Forest Act, but the first communities to receive forest groups may differ from communities who receive forest groups later. For example in table 1, in addition to being closer to markets, areas that received forest groups before the household survey are more likely to be located next to a forestry offices ("range posts"), to have other types of user groups, and to receive agricultural technical assistance. Thus something associated with the accessibility of the community may be an important determinant of why certain communities receive forest groups first. In the next subsection, I consider how forest groups are placed in the Arun Valley. In sections three and four, I apply the insights from the next subsection to the data from the ALSS to control for the nonrandom placement of forest groups.

B. The Formation of Forest Groups

Foresters, working out of range posts scattered through the Arun Valley, create forest groups. The Forest Act does not stipulate how foresters decide what areas get user groups first, because all accessible forests are to be transferred to user groups immediately (Community Forestry Manual 1995). The implementation process is time consuming, and thus implementation has occurred more gradually than envisioned in the law. This section outlines a simple framework of how a forester forms forest groups when the forester knows that all forestland in his area must be transferred to forest groups under the Forest Act.[8]

Consider a forester faced with the decision of where to form a group next. The forester gets some payoff (utility) from forming a forest group. The forester's payoff depends on the effort the forester must put into forming the group, e, and the accessibility of a forest to the forester, a. Let the forester's payoff be represented by the function $v=V(e,a)$. Assume V is increasing in a and decreasing in e. The forester knows that all areas must receive forest groups, but discounts the future so he chooses to form groups in areas with the highest payoff (least effort, most accessible) first.

The forester's payoff does not depend on the quality of the forest area being transferred. Relaxing this assumption does not change the interpretation of the *switching communities* identification strategy, and it is likely to be a realistic assumption. All accessible forest area will be transferred to forest groups eventually. Thus, any payoff that varies with transferring more or less degraded land first would come from the payoff to the forester of transferring that land now rather than in a few years. Shrestha (1989) notes the forests in the Arun Valley face a long regenerative cycle. Consequently, forest regeneration is not likely to be affected significantly by

[8] Through 1995, the NUKCFP database asked each forester if there was any existing community management of local resources. The question was dropped from the database, because foresters were not finding evidence of existing indigenous institutions. There are few instances of communities requesting a forest group to be formed. There are no documented requests for forest groups from any of the communities in the ALSS.

a transfer today versus a transfer in a few years. Even a forester that cares strongly about forest regeneration is not likely to perceive a significant benefit to an earlier transfer. Thus the payoff a forester perceives to transferring one type of forest earlier is likely to be minimal when compared with the cost and inconvenience of going to an unfamiliar area several days trek from the range post. The similarity of forest characteristics in table 1 is also consistent with this assumption.

Effort *e* captures the forester's expectations about the difficulty of forming a forest group in an area. It is unclear whether or not this effort varies from community to community. When a forester enters a community to form a forest group, he has an operational plan and constitution provided by the NUKCFP that he must fill out for each community. Hence, this step does not require the active cooperation of community members. The process of creating forest groups is consuming almost all of the foresters' available time (Gibbon 1996), so there is virtually no monitoring of group activities subsequent to creations. Consequently, there is no reason why a community would object or obstruct the formation of a user group in its area. At the very least, a community opposed to a group, could take the funds directed towards group formation (such as for building a fence), and ignore the mandates of the constitution and operational plans. This contention is supported by the fact that there are no known instances in the Arun Valley of a community refusing to have its forest transferred to a user group.

Even if effort to form groups differed across communities, there is little reason to believe that this effort *e* will influence the analysis of this paper. Foresters are not generally from the area where they work, so their knowledge of local communities is limited (Shrestha 1996). It is plausible that a forester knows *e* for communities in close proximity to the range post he works from, but this knowledge is unlikely for more remote forest areas. Hence, there may be heterogeneity in *e* in the order of the first groups formed, but after 3 years and 4,000 groups (at the time of the household survey), it is very unlikely e is known to the forester any more than it is to the econometrician.[9] Consequently, for a given level of accessibility $\overline{a}$ I assume that foresters have the same expected payoff in communities with groups (subscript 1) and communities without (subscript 0): $E\left[V(e_1,\overline{a})\right]=E\left[V(e_0,\overline{a})\right]$. Thus, variation in the accessibility of a community to the Department of Forest's field staff and random variation determine whether or not a community receives a forest group.

In this framework, when I compare an area with a forest group to one without, I know these two areas differ by $v_1 > v_0$. Foresters form groups first in areas where the payoff from forming a group is higher. If v is continuous, at any given point of time, there exists some v^* such that $v_0 < v^* < v_1$. I expect v^* to vary both across range posts and within range posts depending on both the staffing and the staff's tastes at different range posts. In the next subsection, I consider the implications of this formation process for the program evaluation problem.

C. The Formation of Forest Groups in the Evaluation Problem.

The household's collection of wood for fuel Y depends on household and community characteristics X (see Heltberg, et al 2000 for a model). The function g represents how these characteristics translate into fuelwood collection. This function might be different in areas with forest groups. Hence I write household i's collection of wood for fuel in areas without forest groups as $Y_{0i} = g_0\left(X_i\right)+\varepsilon_{0i}$ and in areas with forest groups as $Y_{1i} = g_1\left(X_i\right)+\varepsilon_{1i}$. The identification problem in this paper is that I never observe Y_{0i} and Y_{1i} for the same household. Rather, I only observe Y_i:

[9] Gibbon (1996) discusses the formation of forest groups in the Arun Valley. He emphasizes the limitations imposed by time constraints and how foresters tend to choose locations based on their accessibility to the forester. The same point is made by Dahal (1994).

$$(1) \qquad Y_i = (1 - D_i) Y_{0i} + D_i Y_{1i}$$

where D_i indicates the presence of a forest group in household *i*'s community. Rewriting (1), I have:

$$(2) \qquad Y_i = Y_{0i} + D_i (Y_{1i} - Y_{0i}) = a_i + D_i b_i \ .$$

Whether or not an area has a forest group depends on the forester's payoff from selecting an area and forming a forest group. For household *i*'s area:

$$(3) \qquad D_i = \begin{cases} 1 \text{ if } v_i > v^* \\ 0 \text{ if } v_i < v^* \end{cases} .$$

If I do not control for *v*, then the error in estimating Y_0 may depend on the indicator of forest group placement: $E[\varepsilon_0 | X, D = 1] \neq E[\varepsilon_0 | X, D = 0] \Leftrightarrow E[\varepsilon_0 | X, v > v^*] \neq E[\varepsilon_0 | X, v < v^*]$.

Hence, substituting for Y_0 and Y_1 into (2):

$$Y_i = a_i + D_i b_i = g_o(X_i) + D_i [g_1(X_i) - g_o(X_i) + \varepsilon_{1i} - \varepsilon_{0i}] + \varepsilon_{0i} = a_i + D_i b_i + \varepsilon_{0i}$$

The effect of forest groups in general is not identified because of the correlation between ε_{0i} and D_i.

In the next two sections, I follow three approaches to remove this correlation. First, I attempt to control for observable differences between areas with and without user groups (the *conditioning on observables* approach). The inclusion of a variety of controls does not change the association that I observe in the raw means. Then, I follow two strategies that do not rely on having regression controls to absorb all of the heterogeneity in the placement of forest groups. First, I compare households immediately around v^* (the *switching communities* approach). Second, I model v^* and use it to attain estimates of program effects associated with marginal changes in *v* (the *endogenous programs* approach). Of course, in both the *switching communities* and *endogenous programs* approaches, I also include regression controls. The distinction between these two approaches and the *conditioning on observables* approach is that only *conditioning on observables* relies on regression controls to pick up all of the heterogeneity coming from the forester's placement rule (3).

3. Controlling for Observable Heterogeneity by *Conditioning on Observables*

I first attempt to control for differences between areas induced by the placement rule (3) using various controls for the determinants of household fuelwood collection and for the placement of forest groups. Let *X* denote this vector of controls. The impact of forest groups is identified, if conditional on the control variables *X*, the error in estimating Y_{0i} is the same in areas with and without user groups: $E\left[\varepsilon_0 \middle| X, v > v^*\right] = E\left[\varepsilon_0 \middle| X, v < v^*\right]$. Moreover, the identification of the impact of forest groups on the extraction of wood for fuel, conditional on *X*, requires that the support of the control variables, X, in areas with forest groups overlaps with the support of X in areas without forest user groups: $0 < \Pr(D = 1 | X) < 1$ (Heckman, Ichimura, and Todd 1998).[10] My strategy in this section is to impose strong restrictions on *g()*, relying on those assumptions for identification, then weaken those restrictions.

A. A Linear Framework

I begin with a linear model. I also assume that the process driving firewood collection is the same in areas with and without forest groups, $g_0(X) = g_1(X) = X\beta$. Then, I can estimate the effect of forest user groups as the coefficient, *b*, on the dummy variable indicating that a forest group is in the household's community:

$$(4) \qquad Y = X\beta + Db + \varepsilon$$

[10] If I do not observe at least some overlap in the support of X^*, then it is impossible to ever find comparable households in communities with and without forest groups, and I need additional (in this paper, functional form) assumptions for identification.

where X includes a constant. If the support of X is identical in areas with and without forest groups, then b summarizes the mean difference in fuelwood collection associated with the presence of forest groups. b is not necessarily the impact a forester would expect to see if he created a new forest group in the future. For b to have this stronger interpretation, a forester would need to assume that all forest groups have the same impact on communities that get them and that this impact does not depend on X.[11]

If conditional on X, $E\left[D\varepsilon_1\right] = 0 = E\left[D\varepsilon_0\right]$, the coefficient on the forest user group dummy in an OLS regression provides an estimate of the impact of forest groups on fuelwood extraction. Table 2 contains the results of this regression, varying the set of conditioning variables. The first column of table 2 reports the results of estimating (4) with controls for total expenditure per capita, household size, the time it takes a household to collect a bhari of firewood, and the household's latitude.[12] Per capita expenditure does not include wood and fuel expenditures, and I include it to control for household wealth and the value of time within the household.[13] Latitude is a control for a household's remoteness. The further north the household, the more distant the household is from any road and the greater the elevation of the terrain. The time it takes a household to collect 1 bhari of firewood controls for the scarcity of

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[11] As a robustness check, in a set of regressions not shown, I have interacted the effect of forest groups with all of the controls discussed in this section. This produces estimates of treatment effects that are very similar to the estimates reported here. However, the aim of this paper is not to forecast the effect of future forest groups, and this paper does not identify how forest groups influence fuelwood collection.

[12] All regressions throughout this paper also include a constant and a vector of dummy variables to indicate the month of the survey (October is the omitted month). Standard errors are corrected for heteroskedasticity with the Huber-White correction.

[13] Per capita expenditure is problematic as a control for two reasons. First, total expenditure and fuelwood collection are jointly determined. If household size is independent of the error term, it could break the correlation between the numerator (total consumption) and the error term in (4). Second, the "vicious circle" literature (Dasgupta 1995) suggests that household size depends on the scarcity of collected goods. Though household level empirical research supporting a positive correlation between fertility and scarcity is almost nonexistent (Loughran and Pritchett 1997 find no correlation in Nepal), this correlation between the error term and total consumption per capita potentially biases my results.

wood for fuel in the household's area.[14] This control set is used extensively throughout this paper when the econometric methodology requires a parsimonious specification. This minimal set of controls works well for this purpose, because its components are strongly (but not perfectly) correlated with many of the controls used in richer models.

Conditional on the minimal control set in column one, forest user groups are associated with 16.9 less bharis of firewood extracted per household per year. The heteroskedasticity corrected standard error of this estimate (in parenthesis of table 2) is 3.6. The t-statistic for the null hypothesis that the effect of forest groups is zero is 4.7. Hence, the results in the first column of table 1 are consistent with a significant reduction in the collection of wood for fuel. The interpretation of treatment effect estimates is clearer in percentage terms rather than levels. Throughout this paper, I calculate the percentage reduction in fuelwood collected by using the regression results to impute firewood collected in the absence of forest groups for areas with forest groups, then dividing the reduction associated with forest groups by this imputed firewood collection.[15] These percentage estimates are reported in the table 3A. Hence, the 16.9 coefficient on the forest group placement in indicator in column I of table 2 implies a 14.7% reduction in the collection for wood for fuel in table 3A. Each column number in table 3A matches the same column number in table 2.

[14]Including the time it takes a household to collect 1 bhari as a control may attenuate my observed effect of forest groups on the collection of wood for fuel. Forest groups limit a household's access to its nearest forest. Thus, the time a household spends collecting 1 bhari may increase as a result of the forest group. A separate issue is that while collection time is the household's roundtrip time to collect 1 bhari of firewood (and thus not directly dependent on how much firewood a given household collects), it does depend on how much wood the entire community is extracting. Given that these are small communities (89 households on average in communities with forest groups), there may be a direct effect of a household's fuelwood collection on collection time. Nevertheless, I condition on the time it takes to collect 1 bhari of firewood, because it is the only data I have on forest condition that is contemporaneous with fuelwood collection.

[15] Standard errors are then calculated by the delta-method for linear models and a clustered bootstrap (1000 replications) for the semi-parametric and non-parametric methods.

The second column of table 2 shows that the result in column one is not sensitive to the inclusion of the possible endogenous controls total expenditure per capita and the time to collect one bhari of firewood. In the second column of table 2, I include controls that are correlated with how wealthy the household is but are less apt to be determined jointly with current firewood collection (owning land, having a kitchen garden, having bonded walls, having piped water, having electricity in the community) and how remote the household is (time to market, distance to paved road).[16] Forest user groups still are associated with 12.6% less firewood collection. The forest user group effect estimates are not statistically different in columns one and two. They also do not differ statistically from the reduction in firewood collection calculated without controlling for differences between areas with and without groups of 14%.

In column three of table 2, I include all of the controls in the first two columns of table 2.[17] In column four of table 2, I control for the household's stove type, whether the household uses kerosene, and whether there are non-biomass based cooking fuels used in the community. Inclusion of these controls is common in the firewood extraction literature, though there is an obvious endogeneity concern.[18] In addition, controls for environmental characteristics (in addition to collection time: forest area, forest crown density, tree species) are also included in column 4. Because of missing data, the addition of these environment controls drops 12 households from my sample.[19] Although environmental characteristics predate the survey time

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[16] I also include a control for whether or not the household is located in the Makalu-Barun National Conservation Area. This is a national park in the Arun Valley.

[17] I can test the hypothesis that the factors in column two are jointly insignificant in the column 3 regression. The F-statistic associated with this hypothesis is 8.75 and has a p-value of 0.00.

[18] In the Arun Valley, kerosene is widespread for lighting, but almost never used as a cooking fuel (only 3 households report using kerosene as a cooking fuel). Likewise the presence of improved stoves in the Arun Valley seemed to have more to do with the activity of various non-governmental organizations than the household's response to fuelwood shortages, and it is likely that the distribution of improved stoves might be associated with the placement of forest user groups. In practice, the inclusion of these controls has no substantive impact on the measured effect of forest user groups.

[19] These 12 households are in Dhankuta, the wealthiest and most populated community in my sample.

period by over a decade, environmental characteristics tend to be correlated over time so they should have some informational value. Measurement error may attenuate the coefficients on these controls and contaminate some of the other coefficients. Nevertheless the estimate of the forest user group effect is not significantly different from its value without controls in table 1.

If the support of X is not identical and the effect of forest groups interacts with community or household characteristics, then the results in table 2 are identified from functional form. b captures both the effect of forest groups and any differences in fuelwood collection associated with the operation of forest groups. On the other hand, if I believe that the relationship between the controls and fuelwood collection is linear, I can use this functional form assumption to control for differences in the support of X.[20] I do not know of any reason to believe that fuelwood collection is a linear function of X. Thus, in the next two subsections, I relax the identical support and linear functional form assumptions.

B. A Partially Linear Framework

I begin to move from the linear functional form assumption by allowing individual variables to enter (4) non-linearly. I consider the effect of non-linearities in two variables: per capita expenditure and the time to collect 1 bhari. This partially linear approach is in reaction to the concern that non-linearities in either of these variables might be associated with the presence of forest groups. For example, if communities with forest groups have a slightly higher mean per capita expenditure and fuelwood collection is a positive, diminishing function of expenditure per capita, then, the linear functional form of (4) can force the diminishing part of the relationship

[20] For example, areas with forest groups have a slightly greater expenditure per capita than areas without forest groups. If linearity is correct, then implicitly, I use the variation in fuelwood collection in areas without forest groups to learn about this linear relationship between fuelwood collection and per capita expenditure, then project that linear relationship to control for the variation in fuelwood collection in areas with forest groups. Thus, if I know the functional form exactly, there is no need for overlapping support.

between expenditure per capita onto the forest group placement indicator. Thus, non-linearities might be an important source of bias in (4).

I partition the set of observed controls into $\left(X_i \quad x_i\right)$ where the lowercase *x* indicates that the variable is permitted to affect forest use non-linearly. Thus, (4) becomes:

$$(5) \qquad Y = X\beta + g\left(x\right) + Db + \varepsilon$$

I employ two methods to allow one variable to enter non-linearly. First, I follow Andrews (1991) and apply a flexible Fourier form to the non-linear variable. I transform the non-linear variable to be on the interval 0 to 2π and include *sin(jx)* and *cos(jx)* in the regression where *j=1,2,* and *3*. Second, I apply the first differencing approach of Estes and Honore (1995). Estes and Honore suggest sorting the data by the nonlinear variable, then subtracting observation *n* from observation *n+1*:

$$Y_{n+1} - Y_n = \pi\left(x_{n+1}\right) - \pi\left(x_n\right) + \left(X_{n+1} - X_n\right)\beta + \left(D_{n+1} - D_n\right)b + \left(\varepsilon_{n+1} - \varepsilon_n\right).$$

If *x* is continuous, for a sufficiently large sample size, this removes the effect of *x* on *Y* by treating *x* like a fixed effect. This differencing not only addresses the possible issue of nonlinearities but also removes any fixed effect (associated with *x*) in the error. Thus, the Estes-Honore approach differences out some forms of endogeneity bias stemming from the inclusion of per capita expenditure or time to collect 1 bhari in the regressions.

Table 3B contains all of the partially linear results.[21] In column 1, per capita expenditure is the non-linear variable. In column 2, the time to collect 1 bhari enters non-linearly. The top panel (the first three rows) contains the results of the flexible Fourier form. The bottom panel

[21] Standard errors are much larger in the partially linear models. For the linear model, I can calculate asymptotic standard errors, but I report bootstrap standard errors for both partially linear models. The bootstrap is a clustered bootstrap with 1000 replications. The asymptotic properties of the Esthes-Honore estimator are not well understood, and Miller (1997) discusses problems with the application of the bootstrap to this estimator.

(bottom three rows) reports the first-differencing results. Within each panel, table 3B contains the results from using three different sets of controls. Each control set number refers to all of the controls in the same column number in table 2. Thus, control set I includes latitude, household size, time to collect 1 bhari, and per capita expenditure.[22]

The results in table 3B are generally consistent with the linear model results for the corresponding control sets. With control set I, the linear model results were consistent with a 14.7% reduction in the collection of wood for fuel in the presence of a forest group. For the flexible Fourier form, the estimates are 14.4% when per capita expenditure enters non-linearly and 14.5% when the time to collect one bhari enters non-linearly. The first differencing approach gives estimates that are slightly smaller than the flexible Fourier forms with control set I. When first differencing total expenditure per capita, forest groups are associated with 14.0% less fuelwood collection and 12.8% when first differencing the time to collect one bhari. The smallest estimate of the reduction in fuelwood collection associated with forest groups is the estimate of a 9.5% reduction from first differencing the time to collect 1 bhari with control set IV. This estimate is not precisely calculated however (with month effects, control set IV includes 35 controls). Thus, this and all results in table 3C are not statistically different than the 14% reduction in the raw sample means.

C. A Matching Framework

In this subsection, I move away from linearity altogether by matching households in areas with and without forest groups that have similar observable characteristics. Thus, rather than relying on functional form assumptions or strong assumptions about the support of the observable control variables, I examine the association between forest groups and fuelwood

[22] The complete regression results for all treatment effect estimates in this paper can be found in the working paper version of this paper (Edmonds 2001) and from the author's web site: http://www.dartmouth.edu/~eedmonds.

extraction for households that have some range of common support. This ability to compare similar households comes at a cost. Because of the curse of dimensionality, I am only able to consider a very small set of control variables. The advantage of the partially linear framework relative to the nonparametric approach is that it does not face this curse of dimensionality, but it is clearly not as flexible.

The idea of the matching estimator is to compare households in areas with forest user groups to households that look like them in areas without forest user groups. The matching estimator of the average effect of forest groups on areas that receive forest groups can be written:

$$(6) \qquad \frac{1}{n_1} \sum_{i \in \{D=1\}} \left(Y_{1i} - \sum_{j \in \{D=0\}} W_{n_o n_1}(i,j) Y_{0j} \right).$$

This is the framework of Rosenbaum and Rubin (1983) and Heckman, Ichimura, and Todd (1998). n_1 is the sample size of households in areas with forest user groups. *{D=1}* is the set of household indicators for households in areas with forest user groups. *{D=0}* is similarly defined for areas without forest groups. Y_{1i} and Y_{0i} are the relevant observed outcome variables in areas with and without forest user groups respectively.

Matching estimators differ based on the choice of the weighting function $W_{n_o n_1}(i,j)$. In the table 3C, the reported matching estimators use a Gaussian kernel to weight observations *j* based on the joint density of characteristics between *i* and *j*. In the first row of table 3C, I match households in areas with forest groups to households in areas without forest group based on their total expenditure per capita. Households in areas with forest groups collect 12.8% less firewood than do households with similar per capita expenditure residing in areas without forest groups. In the second row, I match households based on their reported time to collect 1 bhari of fuelwood. I find that in comparing two households that spend a similar time collecting wood for fuel, a household in an area with forest groups collects 12.4% less. In the third row, I match households based on the similarity of their control set I (expenditure per capita, household size, time to collect 1 bhari, and latitude). In order to match based on this vector of controls, I standardize each variable and compute the norm for each vector of differences. Consequently, households are matched to households that are most similar across the full vector of characteristics with equal weight given to differences in every characteristic. The advantage of matching with this vector is that it is possible to consider households that are similar along more than one dimension. The disadvantage is it is unclear on what dimension comparable households are found. I find that households in areas with a forest group that have a similar set of observable characteristics tend to collect 10% less firewood. This estimate is very imprecise with a standard error of 6.5. All of the matching results are consistent with the results from the nonlinear models, the linear control strategies, and the raw sample mean difference of 14%.

4. Modeling Omitted Heterogeneity

The identification of the effect of forest user groups on fuelwood collection in the previous section relies on two assumptions. First, conditional on the control variables, the assignment of forest user groups is independent of firewood collection. Second, there must be overlapping support of the control variables. In this section, I estimate the effect of forest groups on fuelwood by exploiting the institutional detail of the user group formation process described in section two. First, in the *switching communities* approach, I compare areas that receive forest groups at approximately the same time, immediately before and after the household survey. In the language of the group formation model, these areas should have approximately the same payoffs to foresters from forming forest groups, v^*. Second, in the *endogenous programs* approach, I model the formation of forest groups as a function of the accessibility of a community to the field staff. If conditional on the other controls, the accessibility of a community to a range post has no impact on firewood collection other than through the presence of user groups, I have a valid instrumental variable.[23]

A. ***Switching Communities***

The model of forest group formation in section two suggests that households that receive groups at approximately the same point in time, should have similar payoffs to foresters from forming forest groups: a similar *v*. Thus, omitted differences between areas with and without groups should be smallest for this group. In this section, I compare households that receive forest groups immediately before the household survey ($v_i = v^* + u_i$) to households that receive forest groups immediately after the household survey ($v_i = v^* - u_i$) where u_i is assumed to be random variation between or within range posts that determines which side of the margin the household lies. Thus, the program effect I estimate for household *i* is:

$$E\left(Y_{1i} \middle| X_i, v_i = v^* + u_i\right) - E\left(Y_{0i} \middle| X_i, v_i = v^* - u_i\right)$$

To do this, I divide the household survey sample into four groups based on the timing of forest user group placement in the NUKCFP database. Let *t* indicate the period of the survey. Then, equation (3) is estimated as:

$$(7) \qquad Y_t = X_t\beta + D_{t-2}b_{t-2} + D_{t-1}b_{t-1} + D_0 b_0 + \varepsilon \; .$$

X is the matrix of controls, D_{t-2} is an indicator for a forest user group in place more than a year before the survey, D_{t-1} is an indicator for a forest user group in place in the year before the survey, and D_0 indicates that no forest user group forms in the community during the time of the

[23] In what follows, I condition on how remote the household is with its latitude (the further north the household is the more remote the household is). The results in this section are not sensitive to the choice of how one controls for the remoteness of the household. Using the household's distance to market or distance to a road gives similar results to those reported here with latitude. I use latitude in order to be consistent with the specification in the previous section.

NUKCFP database. Thus, the reference group is the group that receives a forest user group immediately after the survey. The first two rows of table 4 report the b_{t-1} transformed to percentage terms by dividing b_{t-1} by the predicted firewood collection in the absence of forest groups, inferred by looking at households that receive forest groups immediately after the household survey time. The first row of table 4 reports this average reduction in the collection of wood for fuel without controls. The second row of table 4 conditions on control set I. After conditioning on the controls in control set I, areas that receive forest groups immediately before the household survey collect 27.2% less wood for fuel than areas that receive forest groups immediately after the household survey. The standard error on this estimate is 6.3, so it does not differ in a statistically significant way from the reduction observed with control set 1 in the linear, *conditioning on observables* model.

If omitted differences associated with the placement of forest groups were creating a biased estimate of the treatment effect under *conditioning on observables* assumptions, I would expect to observe smaller (or no) estimates of treatment effects when I compare households that receive forest groups at a similar point in time. Thus, the first rows of table 4 are not consistent with omitted differences causing a spurious measure of the effect of building forest groups. However, it is impossible to separate whether the large estimate in row 2 of table 4 is actually larger (and not an artifact of sampling) or if it should be interpreted differently than the results in the previous section of the paper. If the impact of forest groups is common to all communities that receive treatment, then the estimates in this section should be directly comparable to the results in part A. Thus, the findings in this section would be consistent with omitted differences associated with the placement of forest groups attenuating rather than exaggerating treatment effects. However, if the impact of forest groups is heterogeneous, then the estimates of this section are local average treatment effects (Imbens and Angrist 1994). Comparing households around v^* gives the treatment effect associated with a change in v rather than the average reduction in firewood for all communities that have forest groups (i.e. the average across all $v \leq v^*$).

This *switching communities* approach also suggests a way to test whether forest group formation depends on fuelwood collection. The administrative records used in this *switching communities* approach identify communities receiving forest groups after the household survey. If forest user groups were formed based on fuelwood extraction, then fuelwood extraction at the time of household survey would predict forest group formation after the household survey. To test this hypothesis, I regress an indicator of whether a forest group forms in a community after the household survey on fuelwood extraction and other controls from the household survey (and thus before group formation). Table 5 contains the results of this regression, estimated with a probit model. Eleven new user groups form in surveyed communities between the end of the household survey and the end of the administrative records. Some of these groups are in communities that already have forest user groups operating. The coefficient on fuelwood extraction is close to zero and never significant. Column 1 of table 5 contains the probit of whether a forest group forms in the year (until September 1997) after the household survey, regressed on control set I plus controls for the accessibility of a community to the foresters who create forest groups.[24] In column 2, I add, to this same control set, fuelwood collection from the household survey (prior to new group formation). In column 3, I also condition on whether or not a forest group is already located in a household's community (it is negatively associated with

[24] There are three variables included in table 5 to control for the accessibility of a community to foresters. First, there is an indicator for whether or not there is some non-forest (other) user group in the community. Second, there is an indicator of whether there have been any agricultural technical assistance workers in the community. Third, there is an indicator for whether there is a range post in the household's region (VDC). These controls are included to be consistent with the next subsection.

forest groups forming). In column 4, I include all of control set IV from table 2. The evidence in table 5 is consistent with the assumption (as in section three) that, in the absence of forest groups, there is no link between the collection of wood for fuel and the placement of forest groups. Of course, an important qualification to this result is these findings are for a nonrandom group of communities receiving forest user groups after the household survey. It is possible that fuelwood collection drove the formation of the first groups and became unimportant in the later stages of forest user group formation. However, this would further justify focusing on communities around v^* or using the endogenous programs approach in the next section.

B. ***Endogenous Programs***

In the linear model of (4), the bias from an omitted variable arises from the correlation the omitted variable causes between the forest user group indicator D and the error term ε. The discussion in the preceding sections of the paper suggests that a community is more likely to have a forest user group if it is more accessible. The accessibility of the area to other types of assistance and proximity to range posts should be correlated with the accessibility of the area to foresters. Thus, I use indicators for the presence of a range post, other types of user groups, and agricultural technical assistance in a community as measures of the accessibility of a community to foresters. If the three variables do not have an independent effect on firewood collection conditional on the vector of controls X (hence they are uncorrelated with the error ε in (4)), then I consistently estimate the average effect of forest user groups by using these instruments.

The third row of table 4 contains results of using this instrument set in the linear model of equation (4). The F-Test of the joint significance of the instrument set in the first stage has an F-Statistic of 20.20 with an associated p-value of 0.00. Thus, the instruments have a great deal of predictive power. The IV estimator suggests that forest groups are associated with a statistically significant 34% reduction in the collection of wood for fuel. As with the *switching communities* results above, it is unclear if this estimate of the effect of forest groups is directly comparable to the *conditioning on observables* results. Again, the local average treatment effect interpretation might be appropriate. Namely, the instrumental variables estimates indicate the impact of forest groups associated with a change in the accessibility of the community to the forest staff. Nevertheless, the standard error on the IV estimate of the treatment effect is 9.1. Hence, if the IV results can be interpreted as comparable to the *conditioning on observables* results, the IV results do not suggest that that the raw mean difference of 14% is spurious.

The instrument set in this section is clearly imperfect. A potential problem is that other types of government activity or the presence of range posts could have a direct impact on fuelwood collection. Given the time pressure on range post staff discussed in section two, there is little reason to expect that less remote areas receive extra assistance or supervision after forest group formation (the absence of post-formation support is a well documented problem in the Arun Valley, Gibbon 1996). Nevertheless, one can imagine many explanations for why government activity might affect fuelwood collection directly, even though there is nothing systematic in the presence of range posts, other types of user groups, or agricultural technical assistance that necessarily affects fuelwood extraction.

I examine this problem in two ways. First, I perform a standard overidentification test. I regress the residuals from the second stage of the regression on the instrument set. If, conditional on the other controls, the instruments have a direct effect on forest use, I should reject the hypothesis that these instruments have no effect on forest use. I fail to reject this hypothesis. The chi-square statistic associated with this overidentification test is 1.28 with an associated p-value of 0.53. Unfortunately, the described overidentification test may not have any power if the instrument set affects firewood extraction only through the mechanism that the forest user group indicator is capturing.

A second diagnostic comes from examining the sub-sample without forest groups at the time of the household survey (the “control group”). The identification assumption for this subsection (the instruments have no direct impact on fuelwood collection) implies that they should not enter significantly into a regression of fuelwood collection on the instrument set using only the control group. The control group is by definition unaffected by the presence of forest user groups. Thus, I can test the hypothesis that the regression coefficients are individually zero and jointly insignificant predictors of fuelwood collection in the control group.

These results are reported in table 6. When I include each instrument individually (columns 1-3), I can never reject the implication of the identification assumptions: that the instruments do not impact fuelwood collection independently of their affect on the formation of forest groups. In column 4, I include all of the instruments together. The F-Statistic associated with the null hypothesis that the three instruments are jointly zero is .53 (the P-value is 0.66). Of course, the obvious problem with this test is that the regressions use only the control sample and might suffer from selection bias. The selection bias could counteract the instruments. Nevertheless, nothing in table 6 presents any reason to reject the identification assumptions employed in using the instrument set of this section.

5. Conclusion

This study uses a single cross-sectional dataset to assess the impact of forest groups on the collection of wood for fuel. The evidence in this paper is consistent with forest user groups reducing household extraction of fuelwood from the forest. Point estimates of the magnitude of this effect vary across estimation methods, but all results are within a 99% confidence interval of the 14% reduction in wood extraction found in the raw sample mean.

The principal econometric problem in this paper is that forest groups are not randomly placed. This paper explores the robustness of the 14% reduction in fuelwood extraction with three different approaches to the problem of non-random program placement. First, I control for observable differences in the location of forest groups (table 3A). Controlling for differences in wealth (per capita expenditures, housing characteristics), remoteness (latitude, travel time to roads or markets), and forest characteristics (time to collect 1 bhari of firewood, forest crown density, tree species) reduces the magnitude of the estimated effects of forest groups (to 11.3%), but the estimated treatment effect is still statistically significant. Further, I continue to fail to reject the treatment effect in the raw sample means when I move away from parametric assumptions (table 3B and 3C). Second, I exploit administrative records and institutional detail in two identification strategies that do not rely on observable characteristics to control for heterogeneity in the placement of forest groups (table 4). First, I have administrative records about forest group formation that cover the period after the household survey. I compare households that receive forest groups immediately before the household survey to areas that receive forest groups immediately after the survey. Second, I model the placement of forest groups as a function of the accessibility of communities to foresters. Both of these strategies do not rely on observing all of the differences in household and community characteristics associated with the placement of forest groups and yield estimates of the effect of forest groups on resource extraction that are larger than the 14% reduction in the raw means. Moreover, I do not find any evidence that suggests a relationship between the placement of forest groups in the years after the household survey and fuelwood collection at the time of the household survey (table 5).

Researchers differ in whether they describe the resource regime absent forest groups as national management (Shrestha 1996), open access (Dahal 1994), or informal institutions (Fisher 1992). Given this ambiguity, the findings in this paper cannot be interpreted as evidence that, in comparing two specific policy options, government initiated community management leads to greater resource reduction. Similarly, nothing in this paper suggests that the level of resource extraction associated with government initiated community forestry is "optimal" in any sense. Nevertheless, the results from this study do raise the possibility that governments may be able to initiate a successful, large-scale community resource management program.

A large theoretical literature shows that communities, under certain restrictive conditions, can develop mechanisms that limit extraction from common property. The potential for government to initiate community institutions is unclear in the theoretical literature on local resource management (Benhabib and Radner 1986; Dutta and Sundaram 1993, Seabright 1997), and in the model of Sethi and Somanathan (1996), government interference could destroy local norms that constrain resource use. Large-scale implementation of community-based management requires that communities manage the resource independent of the implementing agent. Hence, a priori, it is unclear whether these unsolicited institutions would continue to function after they have been initiated by the government. The small theoretical literature on government initiated community management focuses entirely on co-management of local resources by communities and governments (Baland and Platteau 1996, Ligon and Narian 1999), and the empirical literature on government initiated community institutions is limited to case studies of small, nonrandom projects operating with extensive external assistance and oversight.

While these case studies provide a great deal of institutional detail, they typically lack the degrees of freedom or breadth of a program necessary to make statistical statements about the success or failure of government initiated community management institutions. Nevertheless, within this selected sample, examples of failures of government initiated institutions permeate the literature (Morrow and Hull 1996 is an example). Thus, the evidence from Nepal in this paper is encouraging for the potential of governments to initiate community resource management.

This issue is of great importance in the lives of much of the world's population. Even without considering other types of common property, over a third of the world's population relies on their local forests to meet their household basic needs (Gregerson, et al 1989). Nerlove (1991) shows that increasing rates of deforestation may lead to greater population growth and even faster rates of deforestation. Dasgupta (1995) illustrates how this cycle can lead to an environmental poverty trap, trapping generations in worsening poverty. While nothing in this paper suggests that government initiated community institutions are the optimal policy instrument to break this "vicious circle", it appears that a large scale creation of these "sustainable development" institutions provides a policy instrument capable of influencing local resource use and is worthy of future study.

In this study, I have not been able to address two particularly important issues. First, although I find that government initiated user groups appear to reduce resource extraction, I cannot address the mechanism through which user groups influence household extraction of wood for fuel. That question requires a larger sample with greater variation in the characteristics of communities with forest groups and reliable information on the characteristics and operation of forest groups. Second, since the analysis of this paper focuses on household behavior three years after the passage of the institutional reform, I cannot evaluate the long-term effect of transferring forests. Most proponents of community forestry in Nepal want to reduce current forest extraction, giving the forest time to regenerate. If this happens, community forestry might lead to a greater abundance of forest products and increased resource extraction. The long-term consequences of government initiated community institutions and the mechanism through which they affect local resource use are clearly important topics for future research.

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Table 1: Household Characteristics by Forest User Group Location

	W/ FUG (s.e.)	W/O FUG (s.e.)	Difference (t-stat)
Population	37,542	21,540	
Forest Characteristics			
Bharis Firewood Collected	98.18	113.67	-15.50
	(3.91)	(6.71)	(2.00)
Roundtrip Time to Collect 1 Bhari	4.42	4.83	0.41
	(0.17)	(0.18)	(1.66)
Hectares Forest Cover[vL]	22.23	23.41	1.18
	(1.85)	(2.21)	(0.41)
Forest Crown Density <40%[1vL]	0.75	0.77	0.02
	(0.06)	(0.08)	(0.23)
Community Characteristics			
Electricity[1]	0.17	0.06	-0.11
	(0.05)	(0.04)	(1.79)
Number of Households	89.02	82.63	-6.38
	(6.02)	(6.05)	(0.75)
Non-forestry User Group[1]	0.45	0.34	-0.11
	(0.07)	(0.08)	(1.03)
Agricultural Technical Assistance[1]	0.31	0.11	-0.19
	(0.06)	(0.06)	(2.21)
Forestry Range Post in Region[1v]	0.27	0.17	-0.10
	(0.06)	(0.06)	(1.11)
Latitude[~^]	18.34	19.27	-0.93
	(1.15)	(1.58)	(0.48)
Longitude[v^]	16.22	14.97	-1.25
	(1.03)	(1.63)	(0.65)
Household Characteristics			
HH Size	5.83	5.84	0.01
	(0.14)	(0.19)	(0.05)
Buddhist[1]	0.09	0.17	0.08
	(0.02)	(0.05)	(1.54)
Total Expenditure Per Capita[+]	6.73	6.31	-0.42
	(0.35)	(0.28)	(0.93)
Wage Worker in HH[1]	0.37	0.40	0.03
	(0.03)	(0.04)	(0.65)
Piped Water[1]	0.40	0.32	-0.08
	(0.04)	(0.05)	(1.30)
Uses Open Stove[1]	0.64	0.72	0.08
	(0.03)	(0.04)	(1.44)
Purchases Kerosene[1]	0.94	0.92	-0.02
	(0.01)	(0.02)	(0.98)
Bazaar less than 1 hour away[1]	0.30	0.30	0.00
	(0.05)	(0.06)	(0.05)
Bazaar 1-2 hours away[1]	0.31	0.22	-0.09
	(0.04)	(0.05)	(1.41)
Bazaar 2-4 hours away[1]	0.26	0.29	0.03
	(0.04)	(0.06)	(0.43)
Bazaar greater than 4 hours away[1]	0.14	0.20	0.06
	(0.03)	(0.05)	(0.91)

[1] indicates that variable is a zero/one indicator variable. [+]Total expenditure is total expenditure per capita in 1,000 of NPR per year and does not include expenditure on fuel. [~] Latitude is minutes north of Dhankuta. [^] Longitude is in minutes west of Madimulkharka. [v] indicates that data are at VDC (region) level (see footnote 5). All other community characteristics are at the ward level. [L] signifies that data are from the LRMP. FUG location is from the NUKCFP database. Household characteristics are from the ALSS household questionnaire. Community characteristics are from the ALSS community questionnaire (except for the range post indicator which is from the NUKCFP database). Household characteristics are weighted to reflect sampling probabilities. Standard errors for household characteristics are corrected for clustering. Standard errors are in parentheses in columns 1 and 2. T-Statistics for the null hypothesis that the means in columns 1 and 2 are equal are in parentheses in column 3.

Table 2: Forest User Groups and the Fuelwood Collection, Linear Models

	I	II	III	IV
FUG in Ward	-16.87 **	-13.94 **	-13.17 **	-12.48 **
	(3.56)	(3.54)	(3.31)	(3.29)
Household Characteristics				
Tot Exp Per Cap	0.58		1.26 **	1.85 **
	(0.59)		(0.60)	(0.58)
Owns Agr Land		-32.94 **	-24.55 **	-15.92 **
		(6.98)	(7.03)	(7.14)
Has Kitchen Garden		-8.89	-11.19 **	-12.07 **
		(5.46)	(5.32)	(5.38)
Buddhist		15.77 **	13.35 **	17.32 **
		(5.37)	(5.11)	(5.11)
Household Size	7.61 **		7.70 **	7.81 **
	(0.66)		(0.64)	(0.63)
Bonded Walls		-0.34	-6.64	-7.49 *
		(4.41)	(4.21)	(4.12)
Bazaar 1 to 2 hours away		19.69 **	21.33 **	20.27 **
		(3.81)	(3.54)	(3.61)
Bazaar 2 to 4 hours		16.05 **	17.15 **	15.35 **
		(3.98)	(3.75)	(3.71)
Bazaar >4 hours		25.03 **	25.64 **	24.05 **
		(5.45)	(5.22)	(5.18)
Paved Road > 2 hours		45.97 **	35.58 **	38.46 **
		(14.79)	(13.88)	(13.80)
Piped Water in House		-5.16	-7.98 **	-4.93 *
		(3.21)	(3.06)	(2.99)
Uses Open Stove				8.73 **
				(3.15)
Purchases Kerosene				-17.37 **
				(7.27)
Time to Collect 1 Bhari	1.37 *		1.32	1.29
	(0.83)		(0.86)	(0.84)
Community Characteristics				
Electricity Present		-9.28 *	-8.70 *	-6.33
		(5.04)	(4.82)	(5.05)
Located in Makalu-Barun		10.49	15.80 **	12.48
		(8.22)	(8.05)	(7.68)
Alternative Fuel Present				-29.56 **
				(7.29)
Hectares Forest Cover				0.33 **
				(0.10)
Tropical Mixed Hardwood Forest				6.72 *
				(4.09)
Forest w/ Dense Crown				-0.50
				(4.63)
Barren Forest				-7.75 *
				(4.21)
Latitude	2.41 **	1.50 **	1.56 **	1.38 **
	(0.19)	(0.23)	(0.23)	(0.24)
N	1200	1200	1200	1188
Adjusted R2	0.239	0.219	0.307	0.332

OLS of bharis collected on various sets of controls. A constant and month effects are included in all regressions (the Nepali calendar month corresponding to October is the omitted month). Robust standard errors are in parentheses. Source: FUG location is from the NUKCFP database. Household characteristics are from the ALSS household questionnaire. Community characteristics are from the ALSS community questionnaire (except for the range post and Makalu-Barun indicators which are from the NUKCFP database). Environmental characteristics are from the LRMP data. I am missing environmental data for Dhankuta. Thus, it is omitted from column IV. Notes: * indicates significant at 10%. ** indicates significant at 5%.

Table 3A: Percentage Reduction in the Extraction of Wood for Fuel Conditioning on Observables, Linear Model

	I.	II.	III.	IV.
Control Set I	14.73 **			
	(2.79)			
Control Set II		12.56 **		
		(2.90)		
Control Set III			11.87 **	
			(2.73)	
Control Set IV				11.26 **
				(2.73)

Estimates are based on the regression results in table 2. Each control set number refers to the column label in table 2 (control set II is calculated from the column labeled II in table 2). Percentage reductions are based on dividing the reduction in firewood collection with forest groups by the predicted firewood collection absent forest groups for those areas with forest groups. Standard errors (in parentheses) are calculated by application of the delta method. ** significant at 5%. * significant at 10%.

Table 3B: Percentage Reduction in the Extraction of Wood for Fuel Conditioning on Observables, Partially Linear Models

Non-linear in:	Per Capita Expenditure	Time to Collect 1 Bhari
Flexible Fourier Form		
Control Set I	14.40 **	14.47 **
	(5.86)	(5.87)
Control Set III	11.69 **	11.63 **
	(5.23)	(5.23)
Control Set IV	11.28 **	10.80 **
	(5.33)	(5.38)
First Differencing		
Control Set I	13.96 **	12.75 **
	(5.32)	(6.07)
Control Set III	10.53 **	12.02 **
	(5.19)	(5.54)
Control Set IV	10.55 **	9.50 *
	(5.36)	(5.50)

Each cell in the table is calculated (as in table 3A) from a separate regression. Column 1 includes all regression results when per capita expenditure is allowed to enter the regression non-linearly. Column 2 includes all regression results when the time to collect 1 bhari of firewood is allowed to enter non-linearly. Standard errors are in parentheses. Each control set number corresponds to the set of covariates in the corresponding column of table 2. The regression variance covariance matrix for both partially linear models is bootstrapped using a clustered bootstrap with 1,000 replications. The bootstrap may give biased standard errors in the first differencing model. ** is significant at 5%. * is significant at 10%. Complete regression results are in Edmonds (2001) and available as an appendix from the author's web site.

Table 3C: Percentage Reduction in the Extraction of Wood for Fuel Conditioning on Observables, Kernel Matching Models

	1	2	3
Univariate Matching			
Total Expenditure Per Capita	12.77 **		
	(6.24)		
Time to Collect 1 Bhari		12.38 *	
		(6.34)	
Multivariate Matching			
Matching on Control Set I			10.02
			(6.54)

Standard errors are in parentheses. All matching estimators use a Gaussian Kernel with bandwidth selection by Silverman (1986): p48 for univariate matching, p 87 for multivariate matching. Standard errors for the matching estimators are bootstrapped with a clustered bootstrap, 1,000 replications. ** is significant at 5%. * is significant at 10%. Control set I referes to the set of regression covariates in column I of table 2.

Table 4: Percent Reduction in Fuelwood Collection
Omitted Variable Strategies

	1	2	3
Switching Communities			
Without Controls	32.95 *		
	(17.80)		
Control Set I		27.15 **	
		(6.27)	
Endogenous Programs			
Controls Set I			33.52 **
			(9.12)

The top panel compares areas that receive forest user groups in the year prior to the survey with areas that receive forest groups in the year after the survey. A forest group indicator, total expenditure per capita, roundtrip time to collect 1 bhari of firewood, household size, latitude, and a constant are included in all regressions . The bottom panel contains two stage least squares estimates of the coefficient on the forest user group indicator. Instruments are indicators for if there is a range post in the region (VDC), other non-forestry user groups in the community, or agricultural technical assistance in the community. Standard errors (in parentheses) are derived using the delta-method. * is significant at 10%. ** is significant at 5%. Complete regression results are in Edmonds (2001) and available as an appendix from the author's website.

Table 4: Percent Reduction in Fuelwood Collection
Omitted Variable Strategies

	1	2	3
Switching Communities			
Without Controls	32.95 *		
	(17.80)		
Control Set I		27.15 **	
		(6.27)	
Endogenous Programs			
Controls Set I			33.52 **
			(9.12)

The top panel compares areas that receive forest user groups in the year prior to the survey with areas that receive forest groups in the year after the survey. A forest group indicator, total expenditure per capita, roundtrip time to collect 1 bhari of firewood, household size, latitude, and a constant are included in all regressions . The bottom panel contains two stage least squares estimates of the coefficient on the forest user group indicator. Instruments are indicators for if there is a range post in the region (VDC), other non-forestry user groups in the community, or agricultural technical assistance in the community. Standard errors (in parentheses) are derived using the delta-method. * is significant at 10%. ** is significant at 5%. Complete regression results are in Edmonds (2001) and available as an appendix from the author's website.

Table 5:
FUG Formation After the Household Survey, Probit Results

	1	2	3	4
Household Characteristics				
Tot Exp Per Cap	0.001	0.000	0.001	0.005 **
	(0.002)	(0.002)	(0.002)	(0.001)
Wage Worker in HH				-0.019 **
				(0.008)
Owns Agr Land				0.057 **
				(0.016)
Has Kitchen Garden				0.009
				(0.008)
Buddhist				0.009
				(0.012)
Household Size	0.010 **	0.009 **	0.009 **	0.008 **
	(0.003)	(0.003)	(0.003)	(0.002)
# Adults				-0.004
				(0.003)
Bonded Walls				-0.037 **
				(0.017)
Bazaar 1 to 2 hours away				0.021 *
				(0.014)
Bazaar 2 to 4 hours				0.005
				(0.012)
Bazaar >4 hours				0.040 **
				(0.023)
Paved Road > 2 hours				0.216 **
				(0.103)
Piped Water in House				-0.007
				(0.008)
Time to Collect 1 Bhari	-0.022 **	-0.023 **	-0.023 **	-0.006 **
	(0.004)	(0.004)	(0.004)	(0.002)
Bharis Collected		0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)
Community Characteristics				
Electricity Present				-0.026 **
				(0.006)
Other User Groups Present	-0.051 **	-0.052 **	-0.051 **	-0.025 **
	(0.015)	(0.015)	(0.015)	(0.008)
Agr Tech Assistancein Community	-0.105 **	-0.104 **	-0.104 **	-0.047 **
	(0.012)	(0.012)	(0.012)	(0.008)
Forest User Group Already Present			-0.005	0.000
			(0.016)	(0.008)
Hectares Forest Cover				0.001 **
				(0.000)
# Dominant Tree Species				-0.014 **
				(0.006)
Tropical Mixed Hardwood Forest				0.045 **
				(0.008)
Forest w/ Dense Crown				-0.031 **
				(0.008)
Barren Forest				-0.143 **
				(0.040)
Range Post in Region	0.219 **	0.220 **	0.220 **	0.163 **
	(0.030)	(0.030)	(0.030)	(0.030)
Longitude				0.394 **
				(0.058)
Latitude	0.004 **	0.003 **	0.003 **	0.001 **
	(0.001)	(0.001)	(0.001)	(0.001)
N	1200	1200	1200	1188
Pseudo R2	0.215	0.217	0.217	0.410

Coefficients are probit results evaluated at the sample mean. For indicator variables, the coefficients are evaluated at a change from 0 to 1. The dependent variable is an indicator for if a forest user group forms in the community after the survey is completed. This can include both communities without a forest user group at survey time and communities that receive an additional forest user group after the survey. A constant and vector of month indicators are included in each regressions. Standard errors are heteroskedasticity corrected. * indicates significant at 10%. ** indicates significant at 5%.

Table 6:
Bharis Collected for Control Sub-Sample with Instrument Set

	1	2	3	4
Instruments (FUG)				
Range Post in Region	-6.92			-8.30
	(7.68)			(8.55)
Other User Groups in Community		4.23		5.20
		(5.31)		(5.46)
Agr. Tech Assist in Community			-1.51	2.71
			(6.66)	(8.05)
Controls				
Total Exp Per Capita	1.21	1.17	1.17	1.23
	(0.86)	(0.88)	(0.89)	(0.87)
Household Size	9.21 **	9.07 **	9.08 **	9.23 **
	(1.08)	(1.07)	(1.07)	(1.09)
Time to Collect 1 Bhari	-0.39	-0.33	-0.31	-0.44
	(1.32)	(1.32)	(1.33)	(1.34)
Latitude	2.37 **	2.35 **	2.31 **	2.43 **
	(0.37)	(0.36)	(0.36)	(0.39)
N	432	432	432	432
R2	0.350	0.349	0.348	0.351

OLS of bharis collected on control set I and instrument set for sub-sample that does not have forest groups at the time of the household survey. Heteroskedasticity corrected standard errors are in parentheses. A constant and a vector of month effects are included in the regressions. * indicates significant at 10%. ** indicates significant at 5%.

Appendix Table 1:
Full Regression Results for Fourier Series Model in Table 3B

	Non-Linear in Total Expenditure			Non-Linear in Collection Time		
	I	III	IV	I	III	IV
FUG in Ward	-16.52 **	-12.99 **	-12.48 **	-16.61 **	-12.92 **	-11.89 **
	(3.35)	(3.30)	(3.27)	(3.38)	(3.34)	(3.31)
Household Characteristics						
Tot Exp Per Cap				0.68	1.33 **	1.89 **
				(0.45)	(0.44)	(0.46)
Owns Agr Land		-22.20 **	-13.63 *		-23.23 **	-14.32 *
		(7.31)	(7.37)		(7.35)	(7.43)
Has Kitchen Garden		-13.35 **	-13.08 **		-10.64 **	-11.60 **
		(4.43)	(4.44)		(4.46)	(4.47)
Buddhist		13.27 **	16.43 **		13.32 **	17.70 **
		(4.66)	(4.78)		(4.67)	(4.81)
Household Size	7.98 **	8.15 **	8.12 **	7.67 **	7.75 **	7.87 **
	(0.65)	(0.65)	(0.64)	(0.65)	(0.65)	(0.64)
Bonded Walls		-9.06 **	-8.63 **		-6.66	-7.80 *
		(4.11)	(4.14)		(4.11)	(4.15)
Bazaar 1 to 2 hours away		21.43 **	20.44 **		20.92 **	19.78 **
		(3.85)	(3.81)		(3.88)	(3.83)
Bazaar 2 to 4 hours		17.27 **	15.78 **		17.04 **	15.18 **
		(4.03)	(3.97)		(4.07)	(4.00)
Bazaar >4 hours		26.31 **	24.91 **		26.10 **	24.21 **
		(5.06)	(5.04)		(5.09)	(5.07)
Paved Road > 2 hours		36.94 **	39.93 **		35.53 **	38.59 **
		(10.92)	(11.13)		(10.99)	(11.19)
Piped Water in House		-7.96 **	-4.84		-7.20 **	-4.21
		(3.07)	(3.10)		(3.11)	(3.14)
Uses Open Stove			7.50 **			9.09 **
			(3.26)			(3.28)
Purchases Kerosene			-17.04 **			-17.29 **
			(5.69)			(5.73)
Time to Collect 1 Bhari	1.42 *	1.40 *	1.40 *			
	(0.75)	(0.73)	(0.74)			
Ward Characteristics						
Electricity in Ward		-6.77	-4.69		-8.33 *	-6.14
		(4.85)	(5.12)		(4.89)	(5.16)
Makalu-Barun Ward		15.46 **	12.14 *		16.37 **	13.33 **
		(6.29)	(6.36)		(6.36)	(6.43)
Alternative Fuel in Ward			-28.47 **			-30.59 **
			(8.25)			(8.31)
VDC Characteristics						
Forest Area in VDC			0.33 **			0.34 **
			(0.11)			(0.11)
Tropical Mixed Hardwood Forest			6.96			6.76
			(4.40)			(4.44)
Forest w/ Dense Crown			0.72			-0.10
			(4.63)			(4.66)
Barren Forest			-7.74 **			-7.43 *
			(3.87)			(3.91)
Latitude	2.40 **	1.51 **	1.40 **	2.41 **	1.54 **	1.36 **
	(0.17)	(0.20)	(0.24)	(0.17)	(0.21)	(0.24)

* is significant at 10%. ** is significant at 5%. A constant and month effects are also included in each regression. Heteroskedasticity corrected standard errors in parenthesis. Standard errors (in this table) have not been corrected for the series expansion in the nonlinear variable. 1200 observations in columns I and III; 1188 observations in columns IV.

Appendix Table 2:
Full Regression Results for First Differencing Model in Table 3B

	Non-Linear in Total Expenditure			Non-Linear in Collection Time		
	I	III	IV	I	III	IV
FUG in Ward	-15.92 **	-11.56 **	-11.57 **	-18.13 **	-14.47 **	-17.76 **
	(3.38)	(3.37)	(3.36)	(3.24)	(3.17)	(3.19)
<u>**Household Characteristics**</u>						
Tot Exp Per Cap				0.74 *	1.79 **	1.73 **
				(0.43)	(0.43)	(0.43)
Owns Agr Land		-21.15 **	-10.69		-22.87 **	-10.96
		(7.62)	(7.68)		(7.00)	(6.91)
Has Kitchen Garden		-9.96 **	-12.26 **		-14.03 **	-13.61 **
		(4.59)	(4.65)		(4.29)	(4.29)
Buddhist		16.56 **	19.85 **		16.35 **	14.13 **
		(4.69)	(4.81)		(4.37)	(4.63)
Household Size	7.48 **	7.79 **	7.88 **	7.67 **	7.48 **	7.73 **
	(0.67)	(0.67)	(0.67)	(0.62)	(0.62)	(0.60)
Bonded Walls		-5.59	-5.91		-4.67	-3.83
		(4.21)	(4.25)		(4.01)	(4.02)
Bazaar 1 to 2 hours away		16.68 **	16.25 **		20.95 **	18.16 **
		(3.92)	(3.92)		(3.76)	(3.68)
Bazaar 2 to 4 hours		16.04 **	13.91 **		19.56 **	13.55 **
		(4.19)	(4.16)		(3.97)	(3.88)
Bazaar >4 hours		27.83 **	25.35 **		30.18 **	22.00 **
		(5.24)	(5.25)		(5.09)	(4.92)
Paved Road > 2 hours		29.59 **	32.42 **		32.33 **	30.60 **
		(11.20)	(11.28)		(10.83)	(10.89)
Piped Water in House		-7.57 **	-4.00		-5.26 *	-3.14
		(3.12)	(3.19)		(3.07)	(3.04)
Uses Open Stove			9.16 **			6.94 **
			(3.33)			(3.07)
Purchases Kerosene			-13.85 **			-20.80 **
			(5.92)			(5.46)
Time to Collect 1 Bhari	0.98	1.00	0.89			
	(0.75)	(0.74)	(0.75)			
<u>**Ward Characteristics**</u>						
Electricity in Ward		-6.80	-3.37		-3.75	-3.15
		(5.04)	(5.45)		(4.88)	(5.08)
Makalu-Barun Ward		14.54 **	10.43		4.05	5.01
		(6.42)	(6.53)		(6.22)	(6.23)
Alternative Fuel in Ward			-33.78 **			-36.85 **
			(8.48)			(7.99)
<u>**VDC Characteristics**</u>						
Forest Area in VDC			0.31 **			0.51 **
			(0.12)			(0.11)
Tropical Mixed Hardwood Forest			7.50 *			10.15 **
			(4.53)			(4.39)
Forest w/ Dense Crown			-4.99			4.08
			(4.92)			(4.49)
Barren Forest			-5.01			-9.18 **
			(3.96)			(3.84)
Latitude	2.40 **	1.59 **	1.55 **	2.24 **	1.46 **	1.39 **
	(0.18)	(0.21)	(0.25)	(0.17)	(0.21)	(0.23)

* is significant at 10%. ** is significant at 5%. A constant and month effects are included in each regression. Heteroskedasticity corrected standard errors in parenthesis. Standard errors (in this table) have not been corrected for the first differencing of the nonlinear variable. 1200 observations in columns I and III; 1188 observations in columns IV.

Appendix Table 3:
Full Regression Results for Omitted Variable Strategies

	Switching Communities	Endogenous Programs First Stage	Endogenous Programs Equation 4
FUG in Ward			-44.86 **
			(15.93)
FUG in t-1	-33.58 **		
	(10.08)		
FUG in t-2	-25.09 **		
	(9.64)		
No FUG	-11.81		
	(9.92)		
Controls			
Tot Exp Per Cap	0.48	0.01 **	0.83
	(0.60)	(0.00)	(0.60)
Household Size	7.50 **	0.00	7.54 **
	(0.66)	(0.01)	(0.66)
Time to Collect 1 Bhari	1.54 *	-0.02 **	0.92
	(0.83)	(0.01)	(0.88)
Latitude	2.33 **	0.00	2.43 **
	(0.19)	(0.00)	(0.19)
Instruments			
Other User Group in Ward		0.00	
		(0.03)	
Agr Tech Assistance in Ward		0.24 **	
		(0.03)	
Range Post in VDC		-0.02	
		(0.03)	
N	1200	1200	1200
Adjusted R2	0.242	0.190	0.195

* is significant at 10%. ** is significant at 5%. Heteroskedasticity corrected standard errors in parenthesis. All regressions also include a constant and vector of month effects. Column 1 corresponds to the switching communities regressions from equation 7 and reported in the second row of table 4. The dependent variable is bharis collected. The omitted category is communities that receive a FUG after the household survey. Column 2 is the first stage regression used in column 3. The dependent variable is an indicator for whether or not there is a FUG present in the ward. Column 3 is the structural equation from the two-stage least squares estimates of equation 4. The dependent variable is bharis collected.