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Does Decentralization Work? Forest Conservation in the Himalayas[1]

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Abstract

This paper studies the effect of decentralization of management and control on forest conservation in the central Himalayas. The density of forest cover (measured with satellite images and field surveys) in forests managed by village councils is compared with that in state-managed forests and in unmanaged village commons. Geographic proximity and historical and ecological information are used to identify the effects of the three types of management regimes. Village council management does no worse, and possibly better, at conservation than state management and costs an order of magnitude less per unit area. Relative to unmanaged commons, village council management raises crown cover in broadleaved forests (the type of forest that may provide the most benefits to villagers under the rules) but not in pine forests.

Keywords: Decentralization, devolution, community management, common property, deforestation, conservation.

JEL Codes: O13, Q23

1 Introduction

Decentralization has moved to the forefront of the discourse on development (World Bank, 1999). Yet empirical work that convincingly measures the impact of decentralization of governance is difficult because it is usually accompanied by many other changes. As Bardhan (2002) remarks "even though decentralization experiments are going on in many of these [developing] countries, hard quantitative evidence on their impact is rather scarce". This paper measures the effect of a devolution of control of forests to village communities in the Indian central Himalayas. The fact that forests managed by village councils are interspersed with unmanaged village commons and state-managed forests allows the use of geographic and ecological information to isolate the effects of property regimes on the density of forest.

Tropical deforestation has received considerable attention in academic and policy discourse. Tropical forest area has been estimated by remote sensing to have declined by 0.54 percent per year during the 1990's (Food and Agriculture Organization, 2000, chapter 1). Less attention has been paid to *degradation* of tropical forest, that is, of the loss of biomass from forests that are not converted to other land uses.[1] This is probably because there are no reliable data on which to base such estimates (FAO, 2000, chapter 2). However, Duraiappah's (1996) literature review finds several case studies showing that tropical forest degradation has adversely affected the welfare of rural residents owing to shortages of firewood, fodder, inputs for agriculture and ecological services (see also Dasgupta, 1993, chapter 10). Moreover, when forests degrade rather than being converted to something else, there is no compensating gain from a new land use.

Since most tropical forests have multiple users, the possibility of the 'tragedy of the commons' leading to degradation arises. However, a considerable literature on common property has arisen in economics which has shown, theoretically and by means of case studies and laboratory experiments, that common property does not necessarily lead to over-exploitation

[1] Foster and Rosenzweig's (2003) study of afforestation in India is unusual in assessing whether or not there were changes in forest density as well as area.

of resources (see, for example, Bromley (1992), Ostrom (1990), Ostrom, Gardner and Walker (1994), and Sethi and Somanathan (1996)).[2] The literature examines conditions under which common-property resource management is likely to be sustainable and efficient and the sorts of institutions that promote success.

Developing country governments often centralized control of forests during and after the colonial era. Towards the end of the twenthieth century, however, many countries started experimenting with decentralization in one form or the other. These include Mexico, Brazil, Bolivia, Tanzania, Uganda, Zambia, Zimbabwe, South Africa, India, Nepal, Thailand, Indonesia, China, and the Philippines (Edmunds et. al., 2003, Andersson and Gibson, 2004). As in the case of decentralization in other domains, however, there is scarcely any quantitative evidence on what impact these policies have had. The case studies from China, India and the Philippines in Edmunds and Wollenberg (2003) find some increases in forest area following decentralization but losses of grazing and farmland and, in China, increases in monitoring costs under the household responsibility system. However, it remains unclear how much of this can be attributed to decentralization. Andersson and Gibson (2004) review "the handful of studies [in Mexico, Indonesia, Bolivia, and Uganda] that actually use forest condition as an indicator of public policy performance" following decentralization, but conclude that none of them identify the impact of decentralization on degradation.

In their book *Halting Degradation of Natural Resources* Baland and Platteau (1996, p. 244) remark that

> Everybody seems to agree today that this centralized approach has been an outright failure in the sense that natural resources have not been better managed than before. *Even though a rigorous demonstration is impossible*, there are some grounds ... to believe that things have actually got worse than they would have been under an alternative management regime. [Emphasis

[2] When scholarship from other disciplines is included, the common-property literature is huge. The website of the International Association for the Study of Common Property lists nearly 40,000 citations in its online bibliography.

added.]

They go on to detail some of the problems observed with centralized government management of forests and other natural resources.

Edmonds (2002) studied the impact of the formation of forest user groups in formerly nationalized forests in the Arun valley of Nepal on fuelwood consumption. His study is unusual in being quantitative and careful in identification. He found that household fuelwood consumption in areas with forest user groups was about 14% lower than in comparable areas without user groups, which suggests that the groups were restraining harvesting in order to promote the regeneration of degraded forests. The data on fuelwood consumption were for 1995-96, within three years of the time of formation of the first forest user groups.

In this paper, we compare forests managed by village councils with state-managed forests to see which property regime did better at conservation, and at what cost. We also compare council managed village forests with unmanaged village commons in order to examine whether the existence of a formal institution to manage the forests led to better forest conservation. Our study differs from Edmonds (2002) in that we measure the long-run impact of decentralized management by village councils on forest stocks rather than the short-run impact on the flow of one forest product, and we also compare the costs of state and community management.

We measure forest degradation with the help of the first high-resolution satellite imagery that became available for civilian use in 2000. We combine our measure of forest density with property regime boundaries derived from extensive ground surveys and maps. Our method of identifying the effect of a property regime exploits the geographic proximity of forests under different regimes to control for unobservable factors that affect forest density but do not vary over small distances. We are able to do this because our ground surveys located property regime boundaries with a high degree of accuracy. We use historical information and ecological data that we collected to control for the possibility of endogenous choice of property regime boundaries.

To examine the possibility that forests near property boundaries are not representative of forests in the area as a whole, we collected data for larger areas. We analysed these data using both standard parametric regressions and propensity-score matching to check whether the results based on forests close to property boundaries were robust.

We examined the two main types of forest in the area, broadleaved, which covers about three-fourths of the forest area, and coniferous (mainly pine) which covers the remaining fourth. We find that in broadleaved forests, the existence of a village-level institution for management, raised forest density significantly compared to unmanaged village forests, but this was not the case in pine forests. We also find that village-council managed forests had crown cover no lower and possibly higher, than comparable state-managed forests, both broadleaved and pine. On the cost side, expenditure on state forests per unit area was an order of magnitude higher than that on village council forests. We calculate that the annual savings that would accrue if state forests were managed by village councils would be of the same order of magnitude as the value of the entire annual production of firewood from the state forests.

Before going into further details, some background on the region is necessary. We provide this in Sections 2.1 and 2.2. Section 3 presents the model that derives the long-run forest stock as a function of the property regime and other variables. Section 4 describes the data used and Section 5 the estimation and results. Section 6 concludes.

2 Forest Use[3]

2.1 Physical characteristics

The study area from which the sample was drawn is some 20,000 square kilometers in extent and comprises most of the eastern half of the state of Uttaranchal in northern India. It ranges from 300 to over 3000 meters in altitude. About three-quarters of the area is forest or scrub (Prabhakar et. al., 2001). Most of the agriculture, and, therefore, the population, is in elevations from 1000 to 1800 meters. There are two main kinds of forest in this elevation zone. From 1000 to 1800 meters there are pine (*Pinus roxburghii*) forests. From 1500 to 3000 meters, overlapping the range of the pines, is a broadleaf forest dominated by oaks of the genus *Quercus*.[4]

44% of the male labor force and 84% of the female labor force of the state was in agriculture in 2001 with most of these being owner-cultivators (Census of India, 2001). Forests are an essential component of agriculture. Leaf mould from oak forests is an important source of manure, and the forests are an important source of fodder and grazing for livestock. Cattle dung, in turn, is used in the preparation of compost for use in crop production.[5] The bulk of fuelwood, the main source of energy for heating and cooking,

[3] This section is based on Somanathan (1991), as well as Government of Uttar Pradesh (1984), Saxena (1987, 1995), Ballabh and Katar Singh (1988), Aggarwal (1996), Agrawal (2001), Satyajit Singh (1998), and Somanathan et. al. (forthcoming). Sarin et. al. (2004) discuss developments in the last six or seven years. They point out that, starting in the late 1990's, the government created a large number of "paper" council forests from unmanaged village forests without the informed consent of the villagers, and amended the Forest Council Rules in 2001 giving forest department officials powers over the councils and eroding their autonomy. The description we provide here predates these developments.

[4] Singh and Singh (1987) provide a detailed description of the forests.

[5] Ralhan et. al. (1991) found in their study of three villages that 90% of the energy input into crops was derived from the compost that was "mainly derived from forests". Tripathi and Sah's (2001) study of three villages found that about one-half of all energy used in agriculture was derived from forests. Measures of the percentage of fodder derived from forests range from about one-quarter in two of the villages studied by Tripathi and Sah (2001) to about one half (Jackson, 1984) to three-quarters in one of the villages studied by Ralhan et. al. (1991).

also comes from the forests.[6] Timber from pines is used in a limited way for building but commercial felling was banned by the government in 1981 following concerns about deforestation. Pines are also tapped for resin by contractors for the state Forest Department.

In addition to harvest flows from the forest, villagers perceive a direct benefit from the maintenance of the forest stock. The forest reduces runoff during the monsoon and enables percolation of rainwater into the rock, which is essential for maintaining flows in springs during the dry season. Water shortages are acute in many villages in the region, so the villagers see this as an important issue. Reducing the seasonality of water flows has enormous welfare implications for the much larger population of the Gangetic plains as well.

Despite the importance of maintaining the forest stock, it has degraded. Prabhakar et. al. (2001) estimate that more than half the forest in the study area has a crown cover of less than 40% (a commonly used, if arbitrary, cutoff for defining a forest as "degraded").[7] This has happened owing to uncoordinated or excessive extractive use. Oaks and other broadleaved species are lopped for fuelwood and leaf fodder for cattle. Care has to be taken during lopping to ensure that trees remain productive. When users do not exercise such care, trees are stunted and may die. Until the 1970's, oak forests were sometimes felled for making charcoal to be supplied to the hill towns and military bases. Following felling, grazing and lopping of the new growth by villagers often prevented effective regeneration and led to degradation into scrub. Pine saplings and mature trees being tapped for resin are vulnerable to fire. Villagers set fire to the forest floor in pine forests every spring to promote the growth of grass for their cattle. Fires that burn out of control are a major source of degradation of pine forest.

[6] 88% of the rural population used firewood according to the National Sample Survey data from 1999-2000.

[7] Rinki Sarkar and her collaborators also find considerable degradation based on ground surveys in areas overlapping our study area and carried out after ours (Sarkar, personal communication).

2.2 Forest Use: Institutional Aspects

The selection process for inclusion of lands in the different property regimes can be summarized as follows: State forests were demarcated first, by the government, followed by demarcation of village council forests over a 70-year period, requested by villagers and approved in each case by the government, and unmanaged village forests are left over village commons.

In the nineteenth century, virtually all the forest land was considered by the villagers to belong to one or another village with well-defined boundaries. These were sometimes managed, to a greater or lesser extent, by unofficial councils. Between 1890 and 1920, large areas of forest were demarcated by the colonial government and declared to be state property so that they could be commercially and "scientifically" exploited. After this, villagers were allowed limited rights and privileges to use these state (so-called Reserved) forests for fuelwood, fodder, grazing and timber. These rights extend to large blocks of state forests and are *not* exclusive to particular villages, a reversal of the situation that prevailed before reservation. Use is regulated by employees of the state forest department known as "forest guards". These guards may reach tacit understandings with the villagers to overlook illegal harvesting upto a limit (Vasan 2001).

Large-scale protests by villagers followed the restrictions on their use of the forests imposed after the second wave of state takeovers in 1911-1920. In response, restrictions were removed on the villagers' use of most state oak forests. This resulted in rapid degradation of oak forests. The government established the Van Panchayat (literally "forest council") system in 1930 as a means of arresting the degradation. It was meant to enable the villagers to form forests to be governed by village councils out of their remaining village forest, and out of state forests, provided they obtained, on a case-by-case basis, the consent of the government. In 1972, the state government issued a new set of much more bureacratic rules which prohibited the transfer of state forests to village councils and the sale of timber from council forests, and made it incumbent on the councils to obtain government permission before felling green trees for local use.

By 1998, more than one-third of the villages in the region had their own council forests. The rest use state forests and unmanaged village commons. Council members, are elected by a show of hands in front of a government official once every five years. There are usually 5 to 9 members of the council. The Forest Council Rules empower the councils to make rules and regulations to restrict and manage harvesting of forest products, and to levy fines on violators. Nevertheless, they lack the coercive authority of the state, in that if the accused refuses to pay the fine, a council's only legal recourse is to approach the government or the courts to recover the fine, a very costly procedure that is rarely resorted to. Instead, social pressure is applied to force the violator to pay. Another weakness of the system is that some councils have no source of revenue other than voluntary contributions from villagers to pay for a watchman. Others may have revenue from the sale of contracts for resin-tapping from pine trees or leases for stone quarries on council land. However, the councils often have difficulty in getting access to the funds from the proceeds of such activities, as their bank accounts are in the control of a state government official. These weaknesses imply that the councils are strongly dependent on informal collective action and social norms.

These problems notwithstanding, villagers are far more secure in their tenure in comparison to the system of Joint Forest Management between the state forest departments and forest user groups which has spread widely in India in the 1990's. Except for the tribal areas in the north-east, the institution of the forest council is the only one of its kind in India, in having permanent control over its forest, with legal recognition from the government.

The third category of forest land in the area, the unmanaged village commons[8], are a residual category, consisting of all village lands not in private hands or in a council forest. They are for the exclusive use of residents of their villages. The common pool problem is less severe in these lands than in state forests because the latter are open to the residents of several

[8] These are officially known as Civil and Soyam forests and are formally under the control of the Revenue deparment of the state government, which however, exercises no control other than to prevent the felling of green trees without permission.

villages. But the lack of any regulation other than a ban on felling means that they are subject to overgrazing and other excessive harvesting.

Villagers' incentive and ability to conserve forests vary by both species, principally whether the forest is broadleaved (mainly oak in the study area) or pine, and by property regime. Oaks provide fodder, superior leaf manure, and are believed to be more effective than pines in conserving the flow of water in springs. Pines provide building timber which oaks do not. However, in all three property regimes, government permission (not easily obtained) is needed for the felling of green trees, even for domestic use, and sale is prohibited. There is, moreover, a conflict between grass production for grazing and resin tapping in pine forests (due to the use of fire). For these reasons, the incentive to conserve pine forests may be lower for the villagers.

3 The Model

Denote the forest stock in a given area at any time by K. The natural rate of growth of the stock is given by a function $G(K)$, that is inverted-U shaped as in Figure 1.

The harvest of forest products from the area per unit of time, (a flow), is given by $H(X, K)$, where X denotes the total labor input by all users per unit of time. The function H is increasing in X and K. There are diminishing returns to labor (H concave in X). As an individual increases her harvest by putting in more labor, this means everyone has to go further (and so put in more labor) to get the same harvest as before. The marginal product of X is increasing in K. The net growth rate of the stock, taking account of harvesting, is given by

$$\dot{K} = G(K) - H(X, K). \tag{1}$$

Since none of the property regimes is private property, there are n users rather than one. User i's current payoff is

$$\frac{x_i}{X} H(X, K) - w x_i$$

where w is the opportunity cost of labor in terms of output. This formulation means that a user's share of the harvest is proportional to her input share.

For each K, the static Nash equilibrium of this game results in a total harvest $H^*(K)$ which is easily seen to be increasing in K (Sethi and Somanathan, 1996).

Restraints on harvesting, which differ across property regimes, change the game played by users and, in general, will lower each user's (privately) optimal harvest function and, therefore, the total harvest function $H^*(K)$. We can think of these restraints as lowering the marginal benefit or raising the marginal cost of harvesting in each regime. Thus, for each property regime, there correspond harvest functions, $H_j^*(K)$, $j = 1, 2, 3$. (Figure 1.) If, for a given K, the harvest $H_j^*(K)$ exceeds the natural regeneration rate $G(K)$, then K will decline until $H_j^*(K) = G(K)$, at which time K will reach a steady state. For a given plot, the steady-state value of K will depend on the values taken in that plot by the variables that shift $H^*(K)$ and $G(K)$. The property regime dummies, population density, and distance from road shift the optimal harvest function, while aspect and other unobserved ecological variables will shift the regeneration function. Thus the long-run stock, which is given as an intersection of the curves $H^*(K)$ and $G(K)$, is determined by the explanatory variables:

$$K = f(d, x, z)$$

where d is a vector of dummy variables for the three property regimes that shift H^*, x is a vector of variables such as population density and the round-trip time to the nearest road that also shift H^*, and z is a vector of ecological variables that shift G.

Following a change in property regime, it might take as long as fifteen years before the forest stock reaches a new steady state. Since we need high-resolution (1 meter) satellite images and ground surveys to measure forest cover with sufficient precision, we are limited to using data from a recent year, 1998. We restrict ourselves to a sample in which there were no changes in property regime in the 15 years preceding 1998 and use this to estimate the effects of property regimes on the long-run steady-state value of forest cover.[9] While it would have been possible to compare changes in

[9] The reader may wonder whether 15 years is long enough to reach a steady state. We

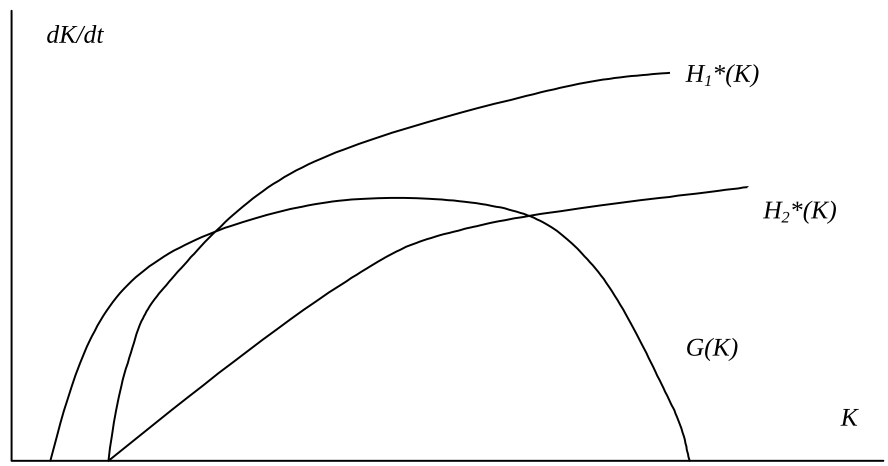

Figure 1: Harvest and Growth functions

the forest stock in different property regimes between two very recent years, this would pick up only small shifts in the intersections of $H^*(K)$ and $G(K)$ and would *not* yield an estimate of the difference in stocks induced by the property regimes.

In estimating the effects of d on K we control for the effects of x and z by comparing nearby plots of land so that most of the latter variables will vary little, by including explicit controls for variables like aspect which *do* vary over short distances, and by combining historical information on the demarcation of property regimes with the observable relation between the forest stock and some of the ecological (z) variables. This method of identification relies on comparisons of forests close to the boundaries of property regimes. We also use data at varying distances from the boundaries to check the robustness of these results to 'edge effects'. This is done using standard regression methods as well as propensity-score matching. In the next section we describe the data before describing the identification strategies and results in detail.

tested whether the length of time since the property regime changed made a significant difference to the results reported later in the paper. As will be seen below, it did not.

4 Data

4.1 Property regimes

The sample was selected by a random choice of thirteen 1:25000 Survey of India topographic maps from those available in the area covered by the IRS satellite image. The first 10 of these that contained villages were selected and one was dropped owing to lack of time to survey it. Each valley, (as we will refer to the areas from the maps), contains about 10-15 villages that were surveyed, as well as adjoining state forests. After we completed our field work, data on about 140 contiguous villages in the Gori Ganga valley which lies in the north-eastern part of the study area were collected by an NGO, the Foundation for Ecological Security, under the supervision of one of the authors.[10] The addition of the Gori valley effectively doubled the sample size. Throughout the paper we report, in addition, results on the original sample that excludes the Gori valley since the full sample results will be heavily influenced by a single subregion and therefore may not be representative of the entire area.

The location of state forest compartments, (the smallest units of management), were obtained from the state Forest Department's topographic maps. Council forest compartment boundaries were obtained from sketch maps in the possession of the head councillors and were transcribed on to Survey of India topographic maps during the three years of field surveys undertaken for the purpose from 1997 to 2000. Village boundaries were similarly transcribed on to topographic maps from the state Revenue Department's cadastral survey maps.[11] The property regime boundaries were then entered into a geographic information system so that satellite images and other digital data described below could be overlaid with errors not

[10] The Foundation began afforestation work in the area in the late 1990's. We are grateful to the Foundation for permission to use these data.

[11] Field surveys were necessary since the council forest and revenue maps are based on local landmarks and even landmarks that have disappeared and whose former locations were known only to local residents. Mapping the boundaries was thus a major cartographic exercise. In the Gori Ganga valley, the village boundaries were not mapped and are roughly estimated using place names and the proximity of council forests.

exceeding 70 meters. Unmanaged village forest polygons[12] were created by excluding council forests and cultivated areas shown on the Survey of India maps from areas within village boundaries. See Figure 2. The broadleaved and pine areas of each polygon are the final units of observation. Dummy variables for the three property regimes are the explanatory variables of interest.

We also created smaller polygons on both sides of state-council boundaries for finer geographic control in state-council forest comparisons. These are described in Section 5.2.1 below. We refer to the latter data as the 'cross-border data' and the original polygons as the 'valley data'.

[12] In a geographic information system, any contiguous area is referred to as a polygon because of its shape.

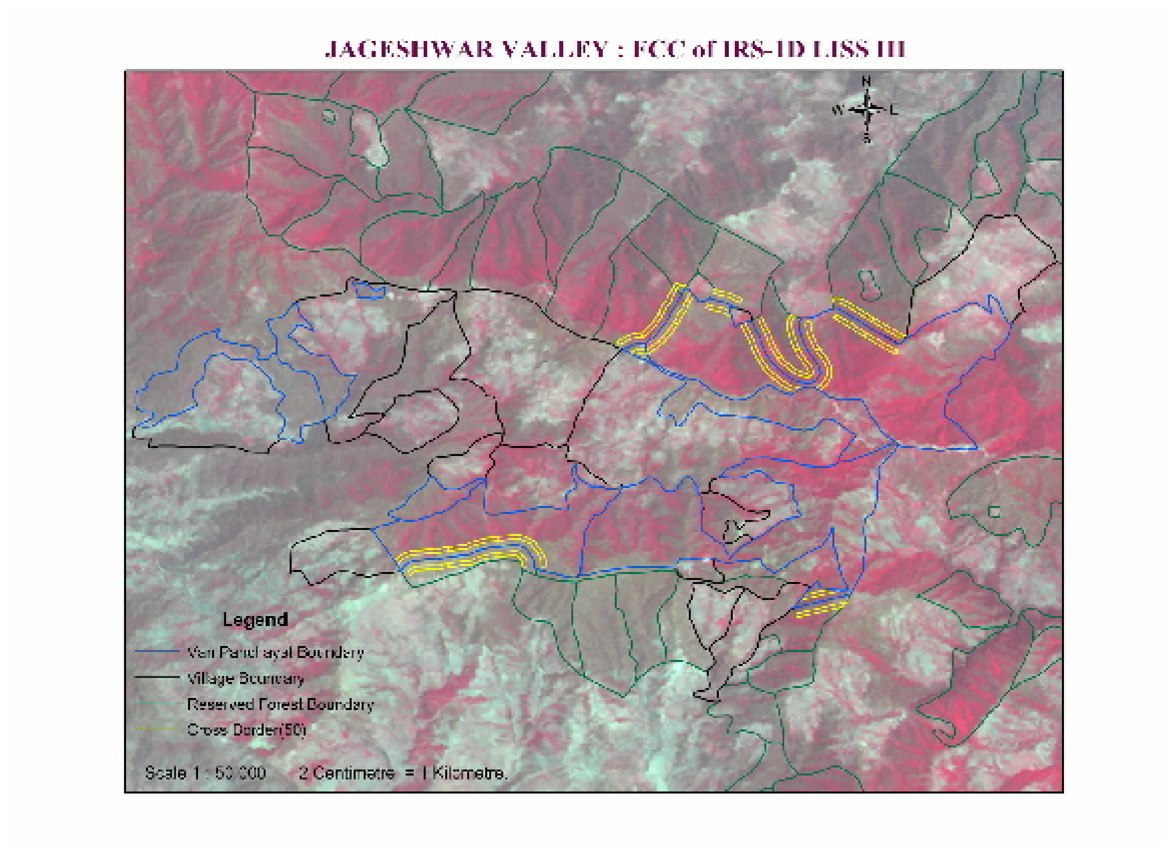

Figure 2: False color composite of the green, red and near-infrared bands of a segment of the IRS image. Red indicates broadleaved vegetation with darkness indicating density. Dark green indicates pines, light green degraded areas, grasslands or cultivation. Council forest (Van Panchayat) boundaries in blue are overlaid on village boundaries in brown which are overlaid on State (Reserved) forest compartment boundaries in green. Cross-border polygons are shown in yellow, each strip being 50 meters wide and 75 meters from the boundary. To avoid clutter, unmanaged village forest boundaries are not shown.

4.2 Dependent variables

The two dependent variables are percent crown cover, that is, the percent of the area covered by tree crowns, in the broadleaved and pine parts of each polygon respectively. Crown cover in these forests is known to be highly correlated with other measures of the forest stock such as bole biomass, total above ground biomass, and basal cover (Tiwari and Singh, 1984, 1987).[13] Crown cover is also of direct importance in improving water percolation, which reduces runoff and soil erosion and helps maintain the flow in springs in the dry season. Our measure of crown cover is obtained from interpretation of an IRS-1D LISS-3 image from May 31 1998, covering an area of about 20,000 square kilometers. Information collected on the ground during the course of two years of fieldwork from 1997 to 1999 was used as an input to classify each 23.5 x 23.5 meter pixel from the image into one of the following classes: broadleaved forest (including scrub), pine forest, and other categories (mainly grasslands and agriculture). Crown cover was visually measured in a random sample of plots using a grid placed over an April 24, 2000, 1-meter resolution Ikonos satellite image. Band ratios and the normalized difference vegetation index (NDVI) were computed for each IRS pixel.[14] Regressions of these measures on a logistic transform of crown cover and simulations with split samples revealed that the NDVI and the ratio of bands 2 to 5 were the best predictors of crown cover in broadleaved and pine forests respectively.[15] Accordingly, these were used to predict crown cover

[13] For example, Tiwari and Singh find r^2 of 0.98, 0.98, 0.84, 0.95, 0.79, 0.94, and 0.76 between logs of percent crown cover and total biomass for *Quercus leucotrichophora* (the commonest oak species), low altitude mixed oak, high altitude mixed oak, pine, pine-mixed broadleaf, *Shorea robusta*, and *S. robusta* mixed with other broadleaved species respectively. These formations comprise most of the forests in our study area.

[14] The details of these procedures are given in Prabhakar et. al. (2001). The data for each IRS pixel consist of 4 numbers: the intensities of reflected radiation in 4 spectral bands (intervals of wavelength) corresponding to green, red, and two intervals of near infrared. These are numbered from 2 to 5. Band ratios and the NDVI normalize the data so that variations in reflectance intensity resulting from topography are removed and what remains is variation in reflectance at different wavelengths that is related to vegetal cover.

[15] Crown cover measurements were obtained for 199 and 183 broadleaved and pine pixels respectively. These were randomly split into training (used in the regressions) and assess-

for each pixel. Broadleaved crown cover for each polygon was then defined as the mean over the broadleaved pixels of the polygon, with an analogous definition for pine crown cover.

4.3 Control variables

The control variables include aspect, population density, round-trip time to the nearest road, and nearby forest stocks. Aspect is the direction in which a slope faces. North-facing slopes receive less sunlight and so more soil moisture, influencing the vegetation. As we will see below, this results in denser forest. We used elevation data from the topographic maps to create a continuous aspect variable ranging from 0 for south-facing pixels to 1 for north-facing pixels with east-facing and west-facing pixels having values of 0.5. Means over the broadleaved pixels in a polygon defines aspect for the broadleaved regressions with a similar definition for pine regressions.

A population-density surface was constructed as a sum of cones centered on habitations, with radii of 4 hours round-trip time, and volumes equal to the populations of the habitations. The population of each village was obtained from the latest available (1991) Census of India and distributed over the habitations in each village in proportion to their prominence on the Survey of India maps. The units for population density are persons per hectare. Again, means over polygons were extracted for use in the analysis. The population density of a polygon is thus a measure of its accessibility to local residents.

A round-trip time variable was constructed by converting kilometers to round-trip time in hours (1 hour round-trip = 0.845 km) using a regression coefficient from a survey that we conducted in one of the valleys in the data.

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ment (excluded from the regressions) samples with the assessment samples containing 25 pixels, a procedure replicated 1000 times. The mean error in predicted crown cover for 25 pixels is 0.0% with a standard deviation of 5.7% for broadleaved forests while in pine forests the mean error is 3.2% with a standard deviation of 4.8%. Over 90% of the small strip polygons used in the state and council forest cross-border comparisons in Section 5.2.1 below contain at least 25 pixels of the relevant forest type (broadleaved or pine). For the much larger polygons that correspond to compartments of the three property regimes and contain hundreds of pixels the prediction errors would be still smaller.

This was used to calculate round-trip times of each pixel from the nearest road using the locations of roads obtained from the topographic maps and updated from the Public Works Department's maps. Means over polygons were extracted for use in the analysis.

For each polygon, nearby state, council and unmanaged village forest stocks in square kilometers were constructed by summing percent crown cover multiplied by area for all polygons with centroids within a two-hour round trip time of the centroid of the given polygon.

Table 1 describes these data.

Table 1: Summary Statistics

	State forests		Council forests		Unmanaged village forests	
Polygons	508		240		343	
Variable	Mean	S.D.	Mean	S.D.	Mean	S.D.
Area (ha.)	98.4	85.5	75.6	103.6	43.3	84.8
Broadleaved % Crown Cover	75.9	22.7	64.9	27.7	49.8	29.3
Pine % Crown Cover	33.9	27.3	42.2	31.8	37.9	30.8
% forest	97.2	7.6	93.2	13.1	83.4	22.2
% Broadleaved	67.9	30.3	75.7	23.2	69.07	25.15
% Pine	29.2	29.6	17.4	21.3	14.3	18.9
Aspect	.499	.234	.487	.219	.494	.223
Altitude (km)	1.68	.47	1.56	.42	1.44	.40
Pop. density	.673	.834	1.41	.93	1.57	1.16
Time to Road	2.13	1.93	1.55	1.68	1.45	1.48
Nearby SF stock	2.93	1.79	.84	1.25	.91	1.38
Nearby CF stock	.211	.549	1.13	1.25	1.21	1.37
Nearby UVF stock	.159	.431	.95	1.06	.71	.98

Note: SF= State Forest, CF = Council Forest, UVF = Unmanaged Village Forest. Aspect ranges from south-facing (0) to north-facing (1), population density is in persons per hectare, round-trip time to road is in hours, and nearby stocks are in square kilometers. 100 ha = 1 sq. km.

It is apparent that in broadleaved forests, crown cover is higher in state forests than in council forests, which in turn have higher crown cover than unmanaged village forests. Pine forests, unlike broadleaved forests, do not have naturally closed canopies and crown cover is generally much lower with council forests having the highest, followed by unmanaged village forests and then state forests. Notice also that population density in state forests is lower than in council forests, which in turn have a lower population density than unmanaged village forests. State forests are also further from roads than the other two categories. A fact not shown in this table is that broadleaved state forests have a mean population density of 0.52, about half that of pine state forests, because many are situated on mountains that rise above the cultivated zone and are thus less accessible. Population density in council and unmanaged village forests does not vary much with forest type.

5 Estimation and Results

5.1 Formal institution vs. no institution

In this section, we ask whether having a formal institution, the council, helps to maintain forest cover in village forests. We estimate separate equations for broadleaved and pine forests. Our estimating equations are:

$$\tilde{K}_i = \beta_1 \tilde{D}_i + \beta \tilde{X}_i + \tilde{\varepsilon}_i \tag{2}$$

where K_i denotes percent crown cover in the broadleaved (respectively, pine) part of polygon i, D is a dummy for council forests, and X is a vector of variables including aspect, population density and its square, and round-trip time to road and its square. The accents over the variables represent deviations of variables from the mean over all polygons in a village. This removes any omitted variables that do not vary within village boundaries. State forests, which lie outside village boundaries, are excluded from this regression. The results are reported in Table 2.

Table 2: Unmanaged vs. Council Forest: Village fixed effects

	% Crown cover (broadleaved)	% Crown cover (pine)	% of area forested
Council dummy	11.9 (2.0)***	2.4 (2.7)	7.3 (1.6)***
Aspect	29.4 (6.1)***	10.0 (7.7)	14.7 (4.8)***
Pop density	-12.4 (5.0)**	6.1 (10.5)	-6.9 (3.9)
Pop density sq.	0.65 (0.48)	-1.4 (2.8)	0.02 (0.38)
Time to road	-0.5 (3.1)	-10.8 (4.2)**	1.8 (2.4)
Time to road sq.	.58 (0.55)	1.47 (0.77)*	-0.10 (0.43)
# obs	573	498	578
# villages	264	243	264

Note: Standard errors in parentheses. 1, 2 and 3 *'s denote significance at the 10, 5 and 1 percent levels respectively.

It is clear that broadleaved council forests are denser than broadleaved unmanaged forests in the same villages, with crown cover being nearly 12 percentage points higher in the former. In pine forests, which are about a quarter of the forest area, there is no statistically significant difference in crown cover between council and unmanaged village forests. Given the incentive structure induced by the council forest rules (discussed above in Section 3) it is not surprising that in comparison to unmanaged village forests, councils are markedly more effective at protecting broadleaved forests than pine forests. Councils also have about 7 percent more of their land under forest (rather than grassland or agriculture). In the specifications in Table 2 we included only those controls in which some within-village variation is likely. Including the other control variables from Table 1 or dropping these controls does not affect the coefficients on the council dummy more than slightly.[16]

[16] When we include the age of the council as a regressor, we find that it is significant only in broadleaved forests at the 6 percent level with older councils having higher crown cover. A 40-year old council forest (the mean age in the sample) is predicted to have broadleaved crown cover that is 16 percentage points higher than an unmanaged village forest. However, the effect of council age seems to operate only for young council forests. Age is not significant ($p > 0.20$) if only councils older than 15 years are included in the regression.

Similar results are obtained if we exclude the Gori valley (in which village boundaries are only approximate), except that the difference in crown cover between council and unmanaged broadleaved forests rises to 16 percentage points.

Next, we test for possible endogeneity of the property regimes. Specifically, we check whether land more suitable for dense forest was more likely to be included in council rather than unmanaged village forests. Suppose

$$\tilde{K}_i = \beta_1 \tilde{D}_i + \beta \tilde{X}_i + \gamma \tilde{Z}_i + \tilde{\varepsilon}_i \tag{3}$$

where $\tilde{Z}_i$ is unobserved, $\gamma > 0$, and $\tilde{Z}_i$ uncorrelated with each $\tilde{X}_i$.[17] We will have over-estimated the effect of council management β_1 in Table 2 above if and only if $\mathrm{Cov}(\tilde{D}_i, \tilde{Z}_i) > 0$. Recall that council forests were demarcated at the villagers' request after the creation of the state forests, and that unmanaged village forests are left over community lands. The positive correlation between $\tilde{Z}_i$ and council management can arise in exactly two ways. First, if, at the time of demarcation of a council forest, villagers chose lands with denser forest for council management, then council forests will tend to have lands with characteristics that favor dense forest. Second, villagers may have directly preferred high values of $\tilde{Z}_i$.

To examine the first possibility, we first see which observable characteristics that vary within villages favor dense forest. Table 3 reports regressions of crown cover in broadleaved and pine forests, separately in each of the three property regimes. The results from the whole sample show that aspect has a strong positive and significant impact on crown cover. Excluding the Gori valley data, we get similar results, except that the coefficient on aspect in the pine regressions, while still positive, is roughly halved and not significant. About 75% of the forest area is broadleaved with the rest being coniferous.

[17] Without loss of generality we can confine ourselves to only those omitted factors that are orthogonal to the other explanatory variables.

Table 3: 2SLS with valley dummies

	Broadleaved crown cover			Pine crown cover		
	SF	CF	UVF	SF	CF	UVF
Aspect	21.9***	40.9***	29.2***	14.13**	29.9***	20.16***
	(4.9)	(7.01)	(6.3)	(6.007)	(9.06)	(6.93)
Population density	-19.5***	-15.32**	-11.6***	-1.14	-10.8	-10.05
	(4.09)	(6.58)	(3.6)	(4.27)	(9.1)	(7.58)
Population density sq	2.55***	2.11	1.96***	-1.13*	.81	1.00
	(.67)	(1.62)	(.69)	(.59)	(2.07)	(1.53)
Time to Road	-.54	-2.8	-2.44	-1.51	-8.2*	-9.69***
	(1.2)	(3.3)	(2.16)	(2.51)	(4.75)	(3.71)
Time to Road sq	.01	.48	.85***	-.07	1.32*	1.09*
	(.13)	(.45)	(.31)	(.35)	(.75)	(.66)
Nearby CF stock	-.87	.98	1.64	1.76	-2.06	2.87*
	(2.03)	(1.01)	(1.2)	(2.33)	(2.10)	(1.65)
Nearby SF stock	2.60***	1.18	-1.12	-.17	.078	-.125
	(.67)	(1.39)	(1.32)	(.98)	(1.95)	(1.66)
Nearby UVF stock	-3.72	-1.20	.25	1.88	-1.65	-.38
	(2.44)	(1.84)	(1.76)	(4.34)	(2.54)	(3.32)
Obs	355	227	341	318	186	224
Villages		140	211		126	156
R^2	0.44	0.47	0.50	0.39	0.34	0.34

Note: SF= State Forest, CF = Council Forest, UVF = Unmanaged Village Forest. Nearby forest stocks are instrumented by the respective areas of polygons with centroids within a two-hour round trip time. Robust standard errors clustered by village. 1, 2 and 3 *'s denote significance at the 10, 5 and 1 percent levels respectively.

The importance of aspect for crown cover means that if villagers preferentially included land with characteristics likely to result in dense forest in council forests, then council forests are more likely to be found on north-facing slopes than unmanaged village forests. To examine this possibility we run regressions of the council dummy variable on aspect using a sample containing only council and unmanaged village forests. Likewise, if dense forests were preferentially included in council forests, then council forests would be more north-facing than unmanaged village forests. So we also run regressions of aspect on the council dummy. The results are reported in Table 4 below.

Table 4: Council vs. Unmanaged Forest and Aspect

	PF dummy Logit	PF dummy Conditional Logit	Aspect OLS	Aspect Fixed Effects
Aspect	-0.17 (0.38)	-0.64 (0.80)		
PF dummy			-0.01 (0.01)	-0.013 (0.019)
# obs	589	331	589	588
# villages	270	97	270	270

Note: Standard errors in parentheses.

Table 3 shows that, in actual fact, north-facing areas were no more likely to be included in council forests than south-facing areas and council forests do not have higher average values of aspect than unmanaged village forests. The coefficient on aspect is not significant in either of the two regressions of the council dummy on aspect. The second regression reports the results of a conditional logit model which exploits only within-village variation in aspect. Accordingly, villages in which there is no variation in the council dummy, that is, which do not have both council and unmanaged polygons, are dropped, which is why there are fewer observations. The other two regressions (the second uses village fixed effects) show that aspect is not significantly higher in council as compared to unmanaged village forests.[18] We conclude that there is no evidence to indicate villagers chose denser forests for inclusion in council forests. (This result is in contrast to that with regard to the choice of lands to include in state forests, as we shall see in the next section.)

[18] The regressions reported in Table 4 include the Gori valley data in which village boundaries are only roughly accurate. When we exclude the Gori valley data, we find that the coefficients in all four regressions are insignificant with p-values exceeding 0.65 in every case.

We now turn to the second possible source of correlation between $\tilde{Z}$ and council management. Selection of lands more suitable for dense forest in council forests could also have occured if villagers preferred higher values of $\tilde{Z}$ for its own sake. Villagers' interest in the council forests arises largely from forests products: fuel, fodder, manure and timber. Species composition is the only factor apart from density that might have a significant effect on their availability or quality. However, the scope for selection on the basis of species composition is virtually nil in coniferous forests, these consisting almost exclusively of a single species: the *chir* pine (*Pinus roxburghii*), while if there was any such selection in broadleaved forests, it is unlikely to affect crown cover since all broadleaved forests in the region tend to form closed canopies when undisturbed (Singh and Singh, 1987, p118). It is unlikely, therefore, that such selection could account for the difference in crown cover in council and unmanaged broadleaved forests that was observed in Table 2.[19]

We conclude that having a formal institution to manage community forests does make a difference to forest conservation, as does the incentive structure induced by the interaction of rules and ecology. Broadleaved village forests have been better preserved under council management than no management, while pine village forests have not.

5.2 Common property vs State Property

5.2.1 Cross-border data

To examine the effectiveness of village councils as compared to the state Forest Department in forest conservation, we examine some 270 pairs of strips

[19] We examined the files maintained on council forests in the district government offices but descriptions of the forests at the time of council formation were too few to draw inferences about the nature of lands selected for inclusion. Out of 83 council forests for which we could find records, 11 were formed on degraded lands, 15 with dense forests, and there is insufficient information on the remainder to tell. There is no indication in the records that particular broadleaved species were favored for inclusion. Several petitions mentioned the threat of forest destruction or ongoing degradation as a reason for council formation.

of land on opposite sides of state and council forest boundaries. Each strip polygon is 50 meters wide and 75 meters from the boundary. The 150-meter gap between strips is large enough to eliminate the possibility that errors in geo-registration of the satellite image would result in mis-identification of the property regime. The small distance between polygons in each pair ensures that geographic variables (with the exception of aspect, on which, more below), do not differ very much between the polygons in a pair as can be seen from Table 5 below. While the differences in nearby forest stock, population density, and round-trip time to the nearest road between council and state polygons in each pair are systematic and statistically significant, they are small. As might be expected, state forests have larger nearby forest stocks, lower population densities, and are further from roads, due to their greater distance from villages.

Table 5: Cross-border data: summary statistics

	Mean	S.D.	Difference (Council - State)		# Pairs
			Mean	S.D.	
Aspect (BL)	0.53	0.26	-0.15***	0.02	242
Aspect (pine)	0.47	0.27	-0.10***	0.03	91
Nearby forest stock	4.19	2.32	-0.20***	0.07	276
Pop. density	0.91	0.95	0.04***	0.01	276
Time to Road	2.49	2.52	-0.07***	0.02	276
BL crown cover	77.6	28.6	-5.4***	1.5	242
Pine crown cover	36.4	33.6	-5.3**	2.5	91

Note: 1, 2 and 3 *'s denote significance at the 10, 5 and 1 percent levels respectively.

The exception is aspect, which, given the mountainous terrain varies considerably even locally. In fact, the Forest Settlement Officers who drew the boundaries of the state forests often found it convenient to situate them along ridges and streams, thus generating differences in aspect across the boundaries (Stiffe, 1915). What is of greater importance is that the differences in aspect are large and systematic with north-facing slopes much more likely to be in state rather than council forests. The strong positive influence of aspect on forest density that we noted in Table 3 suggests that the settlement officers systematically reserved land more suitable for dense forest for inclusion in state forests. One might suspect that other considerations might have played a role in determining the large aspect differential. For example, it is well known (and borne out in our data) that pine forests tend to be found on the drier south-facing slopes while oaks and their broad-leaved associates are more often found on north-facing slopes. So a preference for oaks on the part of the Forest Settlement Officers could also have generated the observed aspect differential between council and state forests. But, the forest settlement reports (Stiffe, 1915; Nelson, 1916) and Guha's (1983, 1989) examination of other government documents from the time make it clear that the colonial government was much more interested in pine forests because they were commercially more valuable than oaks and most other broadleaved species. The fact that, despite this, boundaries were drawn in a way that tended to leave state forests on the north-facing slopes, suggests that considerations of forest density took precedence. Table 5 shows that the aspect differential is smaller in areas in which pines are present, an observation that is consistent with this story.

Table 6 presents our comparison of crown cover in council and state forests from the cross-border data. The estimated equations (one each for broadleaved and coniferous forests) are

$$dK_i = \alpha_0 + \alpha_1 dX_i + d\varepsilon_i$$

where dy_i is the difference in crown cover between council and state forest polygons in pair i, α_0 the parameter of principal interest, is the expected difference in crown cover conditional on no difference in other variables, and α_1 is the vector of common coefficients on the control variables in state and council forests. Neighbouring forest stocks, when included in the model, are not instrumented since the strip polygons are quite small, and are, therefore, unlikely to have a significant effect on neighbouring stocks.

Table 6: Cross-border regressions of differences in percent crown cover between council and state forests

	Broadleaved	Broadleaved	Pine	Pine
Constant	1.2 (2.8)	-0.7 (2.6)	-2.4 (3.6)	-4.0 (2.8)
Aspect	32.2 *** (7.6)	30.5*** (7.9)	12.2 (8.7)	12.9 (8.8)
Population density	-25.2 (30.0)		-112.5 (84.2)	
Population density sq	0.71 (2.85)		16.5 (10.3)	
Time to Road	10.3 (6.3)		5.7 (11.8)	
Nearby forest stock	-0.24 (0.82)		-1.7 (2.1)	
# pairs	242	242	91	91
# councils	68	68	44	44

Note: Robust standard errors, clustered by council Forest, in parentheses. 1, 2 and 3 *'s denote significance at the 10, 5 and 1 percent levels respectively.

The coefficients on the constant term are the ones of interest. It is seen from the second column that in broadleaved forests, the most favourable for community management, council control does not have a significantly different effect on forest density than state control. In the third column we exclude the variables that are not significant in this regression, and the difference now turns negative although it remains small and not significant. Given the small but systematic differences in the excluded variables, this is exactly as we would expect. In pine forests, the results are very similar. These regressions produce very similar results if we distinguish between neighboring forest stocks in state, council and unmanaged village forests and so we do not report those separately.[20]

[20] We ran another set of regressions which included the age of a council in years as an explanatory variable (and added councils younger than 15 years to the sample). The coefficient on age is not significant and the coefficients on the constant term remain in-

If the effects of a control variable on broadleaved or pine crown cover are different in state and council forests then the regressions above are misspecified. To check this, we ran regressions (discussed further in Section 5.2.2 below) of crown cover on the explanatory variables using the valley data, including squared terms and found that only the coefficient on aspect in broadleaved forests differed significantly between state and council forests. To accomodate this in the cross-border data, we ran a regression of broadleaved crown cover on the explanatory variables using pair fixed effects and allowing the coefficient of aspect to be different in state and council forests.[21] We find that the difference in the aspect coefficient is very small and not significant in these data. However, we used the regression to predict the increase in crown cover that would result if state forests in the cross-border data were under council management. We find this to be 1.3 percentage points with a standard error of 2.0, not a significant increase, and a result almost identical with that in Table 6.

All the results reported above are qualitatively similar if we exclude the Gori valley. Finally, we also examined the difference in the percentage of the area under forest or scrub and find it to be −0.4 percentage points, not significant. We conclude that state forests do not have greater forest density than comparable council forests, at least along the boundaries. However, it *is* possible that council forests are denser than comparable state forests because of the evidence given in Table 5 that suggests that state forest lands were chosen in a way that favors higher forest density. While we controlled for the large difference in aspect in our regressions we cannot control for other factors like soil characteristics that may vary at small spatial scales and could have similar effects.

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significant at the 10 percent level in both broadleaved and pine forests. Most councils for which we have data are older than 15 years.

[21] $\tilde{K}_i = \beta_1 \tilde{D}_i + \beta \tilde{X}_i + \tilde{\varepsilon}_i$

where the accents denote deviations from the means of cross-border pairs and the X variables are those in Table 6 with the addition of an interaction between the council dummy D and aspect.

5.2.2 Valley data

While the cross-border sample offers a powerful way to control for unobservable differences between state and council forests, it is possible that it is not representative of the larger area. Officials of the state forest department sometimes argue that the presence of nearby state forests induces villagers to harvest from them while conserving their council forests. It should be pointed out that this argument suggests that in the long run, forest stocks in state forests could be *raised* by transferring them to council control since a higher harvest flow would be possible from a higher stock (unless the stock is already higher than that corresponding to the maximum sustainable yield, the peak of $G(K)$ in Figure 1).[22] Nevertheless, in this section, we will examine the possibility that, for whatever reason, the cross-border data underestimate crown cover in state forests relative to council forests.

Parametric analysis First, we run the following regressions separately for broadleaved and pine forests, using only state and council polygons from the valley data:

$$K_i = \sum_{k=1}^{9} \alpha_k V_{ki} + \sum_l \beta_l X_{li} + D_i + D_i \sum_l \gamma_l X_{li} + \varepsilon_i \tag{4}$$

where V_k is a dummy variable for valley k, the explanatory variables X_l include aspect, the first three powers of population density, the round-trip time to road and its square, and nearby council, state, and unmanaged village forest stocks, and D is a dummy for council forests. The coefficients on the nearby stocks and their interactions with the council dummy are reported in columns 2 and 4 of Table 7 below.

[22] Most of those who make this argument seem to have missed this implication.

Table 7: Crown cover in state and council forests, valley data

	Broadleaved crown cover	Pine crown cover
Nearby CF Stock	-0.91 (1.98)	-0.47 (2.33)
D*Nearby CF Stock	2.90 (2.08)	-0.70 (2.96)
Nearby SF Stock	2.53 (.66)	-0.56 (1.09)
D*Nearby SF Stock	-2.18 (1.56)	0.68 (2.17)
Obs	582	504
Clusters	495	444
R^2	0.50	0.36

Note: Reports some of the coefficient estimates from equation (4). CF = Council Forest, SF = State Forest. Standard errors in parentheses are clustered by council forest. Nearby forest stocks and their interactions with the council dummy (D) are instrumented by areas.

We begin by noting the insignificance, (and in broadleaved forests, also the negative sign), of the coefficient on D*(Nearby SF Stock). This means that in council forests, raising the level of nearby state forest stocks does *not* raise crown cover.[23] Similarly the insignificance of the coefficient on Nearby CF Stock indicates that crown cover in state forests does not fall if their proximity to council forests increases. The proposition that council forests have higher forest density at the expense of nearby state forests finds no support in the data.

A more general criticque of the cross-border comparison is that while it is suitable for evaluating the effect of a transfer of state forests to council control *at the boundary*, a more realistic policy change could result in transfers of state forests to council control across the board. In that case, we need to account for the fact that when a polygon changes from state to council management, so will its neighbors. Therefore, if the effect of

[23] All nearby stocks are instrumented by nearby areas, so the variation being measured in them in these equations is exogenous.

nearby state forest stocks on a state forest polygon is higher than the effect of nearby council forest stocks on a council forest polygon, then across the board transfers could result in lower crown cover even if marginal transfers would not. However, we see from Table 7 (and confirm with an F-test) that the coefficients on D*Nearby CF Stock and Nearby SF Stock are not significantly different ($p > 0.2$) in both broadleaved and pine regressions, so this hypothesis is not true either. All of these results hold in the sample that excludes the Gori valley. Thus there is no evidence to indicate that the cross-border sample is non-representative.

Propensity score matching Next, we use propensity scores to match state forest ('treatment group') polygons in the valley data with comparable council forest ('control group') polygons and then test for a difference in crown cover. The propensity score for a polygon is the probability that it is in the treatment group (in our case, a state forest) conditional on the values of the explanatory variables. Rosenbaum and Rubin (1983) showed that if there is no selection bias conditional on the n-dimensional vector of explanatory variables, then there is no selection bias conditional on the one-dimensional propensity score. In our case, this means that if there is no variable that affects crown cover and is correlated with assignment to state forest other than the ones used in the computation of the propensity score, then by computing the mean difference in crown cover between state and council forests with the same propensity scores, we get an unbiased estimate of the effect of state forest management on crown cover relative to council forest management.

The average differences are reported in Table 8.[24] The first row reports

[24] We use Leuven and Sianesi's (2003) Stata program psmatch2. The unbiasedness of the estimate depends on the use of the correct propensity score function. Rosenbaum and Rubin's (1985) necessary 'balancing' condition that the expectation of the vector of explanatory variables conditional on the propensity score be the same for the treatment and control groups offers a way to check for an incorrectly estimated propensity score function. We use Hotelling mean-squared tests to check that the expectations are equal for each of the five quintiles of the propensity score functions. After including the higher order terms mentioned in the note to Table 8, the hypothesis of equal means in all five

the mean difference by matching each state forest polygon with the council forest polygon that has the nearest propensity score. Those state forest polygons with a propensity score higher than that of any council forest polygon are excluded so as to avoid comparisons between polygons with propensity scores that are far apart. The third row also excludes such polygons and matches each state forest polygon with a weighted average of council forest polygons using the Epanichnikov kernel with a bandwidth of 0.6. The second row matches state forest polygons with an average of council forest polygons with propensity scores within 0.01 of their propensity scores.

Table 8: Mean difference in percent crown cover between council and state forests matched by propensity score.

Matching method	Broadleaved	Pine
Nearest neighbor	1.8 (3.0) 75%	14.6 (4.7) 75%
Radius =0.01	0.5 (2.7) 79%	12.0 (4.0) 74%
Kernel	1.1 (2.2) 75%	9.2 (3.5) 75%
Treated observations	355	318
All observations	582	504

Note: Percentages refer to the percentage of treated observations (state forest polygons) used in the calculation of the mean difference. Figures in parentheses are standard errors estimated from 1000 bootstrap replications. In broadleaved forests, the variables used in the estimation of the propensity score functions were the first three powers of population density, the neighboring forest stock, broadleaved aspect, and time to the nearest road. In pine forests, the square of the time to the nearest road was used in addition. The number of treated observations and the percentage of treated observations refer only to the point estimates since the propensity score function is re-estimated in each bootstrap sample and accordingly, the region of common support changes.

Table 8 indicates that council and state forests have virtually the same broadleaved crown cover since the differences are small and not statistically significant. In fact, the estimates using propensity scores are remarkably

quintiles could not be rejected at the 10 percent level.

close to the point estimate from Table 6 that used the cross-border data controlling for differences in the relevant variables. In pine forests, on the other hand, council forests are seen to have higher crown cover and the differences are large and statistically significant.[25]

These results pertain only to the state forests that had close enough matches in terms of the propensity score to be used in the comparison. However, it may be remarked that more than 95% of those excluded have a population density below 0.3 persons per hectare with a mean of less than 0.07 persons per hectare as compared to a mean of 0.67 for all state forests and of 1.41 for all council forests. Therefore, it appears quite unlikely that anthropogenic pressure would result in lower crown cover if these were transferred to council forests.

Results for the sample excluding the Gori valley were similar, with the exception of the pine regression. Here, instead of finding a positive and significant effect of council management, we find a positive (4.4 percentage points) but insignificant effect.

We conclude this section by noting that the parametric analysis of the valley data provide no support for the hypothesis that the cross-border data understate crown cover in state forests relative to council forests because of edge effects, while propensity score matching analysis of the valley data provide additional evidence that council management results in crown cover no lower, and in the case of pines, possibly higher, than state management.

5.3 Costs

Table 9 compares the costs per hectare of administering council and state forests in 2002-03. A comparison of the totals in the last row shows that state forests cost about 13 times as much per unit area to administer as did

[25] It may appear odd that councils do better than the state in pine forests in which they may have less of a stake than in broadleaved forests. It could be that (pine) state forests suffer more from the conflict between grass production and resin-tapping because there is more resin-tapping in state forests and because villagers are less willing to render assistance in putting out fires in the state forests. This may not show up in the cross-border data because villagers are more motivated to control fires close to their own council forests. Other explanations are, of course, possible.

council forests. In our sample, 70% of councils appointed watchmen for all or part of the year and this constituted the bulk of councils' expenditures. A few councils are known to have all villagers patrol the forest by rotation, but this seems to be rare.[26] We have not attempted to calculate the opportunity cost of time involved in council meetings or other activities by members. However, these are probably quite small since meetings are held not oftener than once a month and mostly less often. They are probably held during slack times and involve only the 5 to 9 members of the council.

Apart from the councils' own expenditures, the Uttaranchal government's Revenue department spent 7 rupees per hectare on the offices of the forest council Inspectors in the Kumaun Division, most of this being wage costs, while the Uttaranchal Forest department spent 9 rupees per hectare on its Forestry and forest council training school. We have assumed that all of the training school's money is spent on councils thus probably overstating actual expenditure on councils. It is also doubtful, given what is known about the functioning of councils and the Forest Department, that the tranining school would actually contribute to forest conservation by councils. Moreover, the Forest department's Forestry and council training school was set up only in the mid 1990's. So for most of the years preceding 1998, the year in which we measure crown cover, expenditures on council forests would have been lower.

[26] If we make the extreme assumption that in all councils with an annual frequency of meetings greater than 2, rotational guarding substituted for watchmen, and the value of time was same as for watchmen, then the cost per hectare for councils increases to 75 and the ratio of state to council cost per hectare costs falls to 11.5.

Table 9: Expenditure in Rupees per hectare on forest administration in 2002-03.

council forests		state forests	
Watchman's wages	43	Wage payments	398
Other exp by councils	6	Other exp	464
Govt exp on councils	16		
Total	65	Total	862

Sources: Data on expenditure on state forests by forest division and areas of forest divisions, as well as data on Government expenditure on councils and the area under council forests in Kumaun were provided by the Government of Uttaranchal and pertain to the forest divisions in the Garhwal, Almora, Bageshwar, Pithoragarh, Champawat and Nainital districts. The data on expenditure per unit area by councils are from our survey.

Salaries also dominate the Forest department's expenditure on state forests. 2002–03 was the only financial year for which we could get data for all the components of expenditure on administration. Using data from 1995-96, we found that state forests cost 403 rupees per hectare in 2002 rupees to administer (Government of Uttar Pradesh, 1999). This is about 6 times the 2002-03 figure for the cost of council forests indicating that there has been a sharp rise in real expenditure on state forests in the last few years. On the other hand, between 1970-71 (the earliest year for which we could find the data) and 1994-95, real expenditure by the Forest department on the region that later became Uttaranchal fell by 43%. This latter figure includes all expenditure, although expenditure on state forests constituted the bulk of the Forest department's spending.

Thus, we may conclude that over the roughly three decades preceding the year we measured crown cover, the cost of administering the state forests was several times that of administering the council forests. A rough calculation shows that the annual savings that would have accrued if all state forests in the area were council forests are about 60% of the value of annual domestic consumption of firewood in the area in 2002. Since state forests constitute not more than 60% of the forest area and are less accessible than unmanaged village and council forests, this means that the savings from council control would be of the same order of magnitude as the entire annual firewood production from the state forests.[27]

6 Conclusions

This research is the first to directly examine the long-run effects of decentralization of management and control on forest stocks. We studied the effects of having a formal institution, the village forest council, to manage village commons (using geographic, historical and ecological information for identification) and find that it positively affects forest density as measured by crown cover in broadleaved forests although not in pine forests. We also examined the effects of village council versus state control of forests using propensity score matching in addition to a geographic identification method and find that council control was no worse and possibly better in terms of crown cover. In other words, decentralized management was as good and perhaps better at forest conservation than centralized management. Moreover, decentralized management by forest councils cost an order of magnitude less per unit area than centralized forest management by the state government.

It is likely that flow benefits from council forests are of greater value than from comparable state-managed forests even though they have the same crown cover on average, since the former are managed locally by villagers for their own benefit. The harvesting of fodder, fuelwood, and other products from state forests, on the other hand, is more likely to involve conflicts, illegalities, and the costs associated with improper timing and lack of coordination of harvests. Given the much higher cost of administering state forests, we conclude that there is a strong case for reversing the 1972 change in the council rules that disallowed the extension and formation of council forests out of state forests.

[27] This assumes that the savings calculated from Table 9 are distributed to all 2.263 million residents of the districts containing the Reserved forests in question. Figures for annual per capita consumption expenditure (7437 in 2002 rupees) and the value of firewood consumption as a proportion of domestic consumption (0.030) are computed from the National Sample Survey of 1999-2000 (55th round) and the Consumer Price Index for agricultural labourers.

This study has shown that state control has been very expensive because of the cost of supporting a large hierarchical bureaucracy while not doing any better and possibly worse than community management on the resource-conservation front. It also highlights the importance of putting in place an appropriate institution which facilitates community regulation of resource use. However, it does not offer much solace to those hoping that devolution will lead to large reversals of forest degradation. It does not appear that the system actually in place did very much more for conservation than did the state administration. However, it should be kept in mind that the same centralizing rule change that prohibited extension of council management into state forests also took away the councils' powers to raise revenue by selling timber and other forest products. This may well have had the effect of reducing the village councils' incentive to conserve forests as well as their ability to do so by making it more difficult for them to pay watchmen. Reforming the forest council system to this extent is a matter of a simple rule change, and may be easier than reforming the state forest deparment.

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