THE EFFECTS OF PROTECTED FOREST AREAS ON LOCAL ECONOMIC DEVELOPMENT IN VILLAGES OF CHIANG MAI PROVINCE, THAILAND: A REGRESSION DISCONTINUITY APPROACH

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Abstract:

In response to concerns about deforestation and habitat loss, many countries around the globe have set aside large tracts of land with special conservation status. Such lands often contain existing human settlements, which face new legal restrictions on the use of land for agriculture or timber extraction. Is the economic development of communities inside protected areas harmed or helped by these environmental designations? Reasonable theoretical arguments point in both directions, but little is currently known about the sign or magnitude of the actual local effects of protected areas policies on a regional scale, particularly for communities in developing countries where many protected areas have recently been established.

This paper analyzes how protected forest area policies in Chiang Mai Province, Thailand, have affected economic development at the village level, using survey data from the Thai Community Development Department from 1986 to 2005 and GIS data on geographic features. The growth of key household assets shows a pattern of divergence in these years, with slower growth for villages inside of protected forest areas. To estimate policy effects, I use a regression discontinuity approach that relies on increases in the probability of designated status for villages above 500m in elevation. The results suggest that a decrease in wealth of approximately 30 percent is likely attributable to forest protection policies. Several possible specific mechanisms that could explain this divergence and are consistent with the data are hypothesized, including direct restrictions on agricultural land use and indirect effects through reduced access to credit, higher travel costs, fewer educational opportunities, or selective out-migration. Future work should focus on understanding the contribution of these possible policy mechanisms, in order to minimize or overcome tradeoffs between conservation and development goals.

The Effects of Protected Forest Areas on Local Economic Development in Villages of Chiang Mai Province, Thailand:

A Regression Discontinuity Approach

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1. Introduction: Protected Areas and Sustainable Development?

The conservation of tropical forest areas has attracted a great deal of attention from domestic and international policymakers in the past three decades. Such concern is likely warranted, given high rates of deforestation in this time period[1] and the real value that forests provide through ecosystem services, including habitat for millions of species, watershed protection, and prevention of soil erosion. Forests also provide an important "carbon sink," a form of storage for carbon dioxide, which is the main greenhouse gas of concern for global climate change.[2]

In response to these concerns, many countries have set aside large tracts of land as protected areas; in the past three decades, conservation areas worldwide have expanded by more than 10 times.[3] According to the UN and the International Union for Conservation of Forests, by 2003, more than 15% of the world's area of tropical forests was protected to some degree on paper.[4] However, very little is known quantitatively about whether and how such environmental

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[1] For example, in the 1990's, the FAO estimated that 12.3 million hectares per year of natural tropical forest were lost. (FAO, State of the World's Forests, 2001). Other reports have indicated that more than 1/5th of the world's tropical forests have been cleared since 1960 ("Protecting Our Planet, Securing Our Future" UNEP / U.S. NASA / World Bank, 1997)

[2] Deforestation usually involves burning of non-timber species or brush, which releases carbon dioxide into the atmosphere. Conversely, one way to "sequester" carbon is to convert additional land back to forests.

[3] IUCN (World Conservation Union) and WCMC (World Conservation Monitoring Centre) numbers cited by Zimmerer, Galt and Buck (2004).

[4] Includes "Tropical Humid Forests" and "Tropical Dry Forests"; statistics from IUCN/UNEP 2003: http://www.unep-wcmc.org/index.html?http://www.unep-wcmc.org/forest/projects/for-map.htm~main.

protection policies may affect the long-term economic development of populations in or very close to these areas. Do policies to protect forest cover significantly change the pace of economic development for populations inside these areas, compared to similar human settlements that do not have protected status? If so, what is the magnitude of the difference, and what are the mechanisms that seem to explain the differences?

This is an acutely relevant question in many developing countries, where the potential tradeoff between environmental quality and economic development may be keenly felt. It is also a sensitive one because it is usually connected to difficult normative questions about equity and justice. In many places, including Thailand, settlements in protected forest areas are illegal on paper but communities may have existed prior to designation or occupation of lands may have been tacitly permitted or even encouraged by previous national governments. In this paper I seek to explore "positive" questions within the realm of "what" and "how much", rather than the normative questions of equity or justice.

Reasonable theoretical arguments can be offered as to why protecting forest areas might either harm or help local economies, in comparison to a counterfactual "free-market" or "no interference" scenario. Restrictions on land use are likely to impose opportunity costs: lost profits from agriculture or forestry activities that would be undertaken if there were no legal barriers. However, state intervention in the form of protected area designation could also improve local welfare in cases where local forests suffer from a "tragedy of the commons" type over-exploitation of resources. In this case, being given protected status may change the calculus of a community-level common pool resource dilemma in which individually rational strategies lead to a socially sub-optimal outcome, and could result in larger local benefits from environmental services (better functioning watersheds, erosion control, non-timber forest products, etc.) or from increased tourism employment opportunities.

In this paper, I focus on the direction and magnitude of the effect of forest protection policies on economic growth in the context of Northern Thailand.[5] I use data from the Thai

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[5] Previous large-n studies on deforestation in Thailand have focused on understanding the determinants of deforestation, and how protected areas affect deforestation at a large scale. Panayotou and Sungsuwan (1994) first used data from 16 Northeast provinces from 1973-1982 to test a theoretical model of tropical deforestation that includes demand for logging, agricultural land, and fuelwood. They find strong effects on deforestation from population, the price of wood, income, and distance from Bangkok, as well as smaller effects due to rural road

Community Development Department from 1986 to 2005 and show that the growth of key household assets diverges in these years, with slower growth for villages inside of protected forest areas. To estimate the effects of protected forest policy on economic outcomes, I use a regression discontinuity approach that relies on an increase in the probability of designated status for villages above 500 m in elevation that occurred because the initial designation of forest reserve boundaries was based largely on contour maps without careful verification of existing human settlements. By matching data from 2003 with GIS data on the locations of villages and a digital elevation model, I am able to instrument for protected forest status with indicators for being above or below 500 m of elevation and with slope variables. I estimate the difference in assets, employment, and school enrollment outcomes for a subset of villages where the instruments plausibly capture exogenous variation in protected status: villages between 400 and 600 m of elevation and with less than 6 degrees of average slope. The estimates suggest a statistically significant difference, and that a decrease of around 20-35 percent in wealth may be attributable to forest reserve policies. Enrollment in compulsory and secondary school is also estimated to be lower for villages in protected areas.

There are several possible explanations for the mechanism by which being in a protected area might have dampened economic growth, including restricted agricultural development, higher travel costs, less access to credit due to restrictive land rights policies, and fewer educational opportunities which would slow the acquisition of skills and the transition to higher paying non-agricultural jobs. All of these are consistent with the data in this study. Taken together, they suggest that true sustainable development may involve careful attention to alternate employment opportunities and skills as well as environmental protections. However, future research should focus on better understanding the relative importance of these different mechanisms.

Section 2 provides a brief overview of the existing theoretical and empirical evidence on the effects of protected forest areas. Section 3 introduces the history of Thailand's forest reserve policies and describes the divergence in some village characteristics inside and outside of forest reserves between 1986 and 2005. Section 4 presents the ordinary least squares estimates of the association between land in a forest reserve and village outcomes, and discusses the potential

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density. Cropper, Griffiths, and Mani (1999) use an economic land-use framework to examine the causes of deforestation at the province level from 1976-1989.

problems of omitted variables bias and reverse causality inherent in this approach. Section 5 describes the regression discontinuity approach and presents results from this estimation method. Section 6 concludes and discusses possible future extensions of this work.

2. Protected Areas: Trade-off or Win-Win?

The FAO state of the Forests Report in 2003 noted that:

> *"An issue that has attracted renewed attention in recent years is the potential of forests to alleviate poverty, particularly in developing countries. The contribution that they make to poor households is often unrecorded in national statistics, so that much research needs to be done to shed light on the ways in which forests can help rural people avoid, mitigate or rise out of poverty."*

This suggests a cautiously optimistic take on the existence of win-win situations in which both environmental and development goals can be achieved, while highlighting the uncertainty in the state of research knowledge. A recent article in *Science* is not so sanguine:

> *"Globally, it is recognized that the costs of biodiversity conservation are not distributed in proportion to their benefits. Typically, many of the costs of protected areas in poor biodiverse countries are paid by local people" (Adams et al. 2004).*

Most analyses of protected areas from environmental economics, while valuing positively possible regional or global effects, have tended to assume that imposing restrictions on local land use will necessarily lead to large local economic costs. However, some academic studies and many hopeful conservation organizations have argued for the possibility for communities to both protect the environment and grow economically. I argue below that much of the perceived tension between these two perspectives can be explained by their different assumptions about the magnitude of local benefits from environmental protection and the success or failure of local collective action. At heart, both models seem reasonable and we must turn to empirics to gain more traction in the debate.

2.1 Tradeoff?

In the environmental economics literature, most models of land use envision an agent (a landowner) who chooses between potential land uses such as maintaining a forest or growing crops (e.g. Stavins and Jaffe 1990, Stavins 1999). When the present value of expected returns from forestry are higher than agriculture, taking into account conversion costs, a given plot of land will tend to be left in or returned to forest (and vice-versa). If a restriction is imposed on which uses of land are permitted, and if that restriction is binding, then a cost is necessarily imposed because the agent is shifted away from his most productive use of land. Variations on this type of model have frequently been used to estimate the costs of protected areas or forest preservation in terms of the opportunity costs of forgone profits from agriculture or forestry.[6] Taking the conclusions one step further, a simple model of capital accumulation (or common sense) suggests that, given a similar initial wealth and similar savings rates, lower income levels across time will lead to less investment in and accumulation of assets. This leads to the expectation of an observable difference in wealth in the medium and long-term between those who are affected by conservation policies and those who are not.[7]

2.2 Win-Win?

These economic models generally assume, however, that local externalities are small, so that socially optimal land use at the local level is achieved by individual decisions made in response to market signals. In contrast, a well-developed literature in political science has focused on problems of local resource use, where the presence either of common property or of significant externalities between private properties means that individual decisions would lead to socially suboptimal outcomes even at the local level. Much of this literature has concentrated on the calculus of community-based collective action and how communities have developed

[6] Applications in developing countries include a study by Ferraro (2001), who estimates the benefits derived from agriculture and forest products use prior to the establishment of a protected area in Madagascar. Shyamsundar and Kramer (1996) used contingent valuation to measure willingness to accept compensation for the loss of using forest land (mainly for swidden agriculture) by the rural population surrounding a newly-established national park in Madagascar. Similar methodology is used to value the costs of habitat protection policies by Ruitenbeek for the Amazon (1992), Azzoni and Isai (1994) for Brazil, Norton-Griffiths and Southey for Kenya (1995).

[7] More recently, attention has also turned to models analyzing how conservation policies might differentially affect sources of income, including both wages and rents, and to the general equilibrium effects of reducing the availability of land for agriculture. Robalino 2004 presents a model that demonstrates a shift in income distribution in response to protected area status as rents on land increase but real agricultural wages decrease.

institutions to govern common-pool resources, including forests (e.g. Gibson, McKean, and Ostrom 2000, Ganjanapan 2000, Agrawal and Ostrom 2001).[8]

A significant lesson from this literature is that the likely success of community action, in terms of whether communities are able to overcome individual temptation to overuse common-pool resources, depends strongly on the payoffs of different options. In turn, these payoffs depend on various factors including the composition of the community and the relative returns to cooperating with or defecting from community rules. With these types of models in mind, intervention by outsiders such as declaring protected area status and punishing violations could alter the calculus of the collective action problem enough to push the community towards socially beneficial outcomes. (Outside intervention could also destroy communal arrangements, in which case there might be an even larger cost of forest protection policies than predicted by economists.) Sven Wunder (2001) has argued that protection of forest areas could lead to increased income from non-timber forest products if the rules and enforcement levels are such that protection leads to sufficient regeneration of such products.[9]

2.3 A Gap in the Literature: Quantitative, Retrospective Studies

One way to gain further traction in the debate on whether there are net local benefits of forest protection is through quantitative, retrospective analyses of the actual effects of forest protection policies on local economic development. Currently, there are only a few studies touching upon this subject, and large-n studies are available only from developed countries. Lewis, Hunt and Plantinga (2002) test for an effect of public conservation lands on employment

[8] There is a small amount of literature along these lines that intersects with the environmental economics field: Alix-Garcia (2004) finds significant common-property effects in the patterns of deforestation in Mexico. Alix-Garcia, de Janvry, and Sadoulet (2005) find very different deforestation processes at work in communities where forest extraction is for individual profit versus collective use. Antinori and Rausser (2003) find that community involvement in forest management has significant impacts on maintaining forests in Oaxaca, Mexico.

[9] Unfortunately, his assessment is that the amounts are unlikely in most cases to provide enough income to significantly boost development. One other possible mechanism is that tropical forests may serve as “safety nets” for the poor (Wunder 2001, Pattanayak and Sills 2001, Lebel, Garden et al. 2004). Harvest of forest products may provide temporary income or subsistence materials in times of macroeconomic crisis. Pattanayak and Sills (2001) rely on evidence from household surveys in the Brazilian Amazon that shows that higher numbers of trips to collect forest products are correlated with agricultural shocks. Also see Richards (2000) for a discussion of the potential to make sustainable tropical forestry profitable. This literature is also turning towards questions of equity and better understanding how conservation of common forest resources may affect income distribution at the local level (Kerr 2002, Adhikari et al. 2004, Adhikari 2005).

and migration in counties of the Northern Forest Region in the United States (parts of Minnesota, Wisconsin, Maine, New York, Vermont, New Hampshire, and Maine) between 1990 and 1997. They find no significant effects on employment from either a higher share of the land base in public conservation uses or from decreases in public timber harvests that are a result of a change in federal policy.[10] Duffy-Deno (1998) finds no effect on county-level resource-based employment of wilderness area designations in the states of the intermountain western United States. Sullivan et al. (2004) study the possible effects on employment and migration of the U.S. Conservation Reserve Program in counties with high participation rates and find little or no long-term adverse effects on rural employment compared to counties with low participation rates. Clearly, more research is needed along these lines, particularly in developing countries.

3. Differential Development in Protected Areas in Chiang Mai

3.1 Thailand's Protected Forest Area Policies

For most of the 20th century, Thailand's forest policies were largely intended to centralize state control over commercial logging and were focused on control of economically important species (Vandergeest 1996). Logging of teak and other tropical timber species began in Thailand before 1900, and by 1901 the central government had consolidated control of logging concessions under the national Royal Forestry Department (Fujita 2003).[11] Early legislation on forests included the 1938 Protection and Reservation Forests Act and the 1941 Forest Act. These began efforts to plan future land use by designating different types of land status and by regulating the harvest of forest products (Gine 2005, Fujita 2003). However, with the exception of areas of major historical interest or very near to large cities, very few areas received designation in these early years. The demarcation proceeded slowly because the process required local consultation about existing land tenure and compensation for any takings by the state (Fujita 2003, Vandergeest 1996).

In an effort to speed up the process, legislation passed in 1964 dropped the requirements that decisions about protected areas occur with careful mapping and consultation of locals. New

[10] In a separate paper, the same authors (Lewis, Hunt and Plantinga 2003) also find no significant effect on wages.
[11] Thailand was an absolute monarchy until 1932, when it became a constitutional monarchy.

designations of national parks, wildlife sanctuaries, and forest reserves were made by the centrally controlled Royal Forestry Department and approved by ministerial order in the central government. As a result, the designations increased rapidly, but many established villages were included in the official protected areas (Gine 2005, Fujita 2003, Thomas 1996) and initial weak enforcement also encouraged an influx of settlers.[12] The scale was large; according to one source, in 1990, one third of all villages in Northern Thailand were located inside forest reserves.[13] In Chiang Mai Province in 1986, of the 1,341 total villages, 465 villages (or 35%) reported being in the forest reserves. In 2005, 578 villages out of 1,824 (or 32%) reported having more than 5% of their land in forest reserves.

Officially, all unauthorized clearing, farming, burning, and collection of forest products was prohibited in forest reserve lands, national parks, and wildlife sanctuaries. Any of the above activities required permission by the Royal Forestry Department. In addition, land could not be privately owned or occupied without permission and thus full land title could not be given (Gine 2005, Fujita 2003, Chalamwong and Feder 1986, 1988, Sato 2000).[14]

The actual implementation of laws has varied somewhat under different national administrations (see Vandergeest 1996, Thomas 1996) and has been at times contradicted or complemented by the actions of other government departments. Most of the enforcement in the 1960's and 70's was focused on protecting the economic interests of commercial loggers (Fujita 2003), not on restricting agriculture or settlement. However, with the adoption of FAO forest cover goals in 1985 and a nation-wide logging ban in 1989, enforcement priorities shifted towards environmental goals and the Royal Forestry Department sought to re-make itself as the protector of environment and natural resources. In the early 1990's, government policies became stricter, with RFD officials enforcing replanting in some areas and threatening to

[12] For a complete history of the agricultural expansion and political tensions involved with forest settlements, see Hirsch 1993 Chpts. 3 and 4.

[13] Sopin et al. 1990 cited in Walker 2003. Another study by the Thailand Development Research Institute in 1990 found that the value of cash crops grown in villages located inside national forest reserves was 42% of all of the total gross rural income from all upland cropping (Grachangnetara, 1990).

[14] In general, landholders inside forest reserves could not get title to their land because it was officially owned by the state, which meant that they could not use their land for formal bank credit (Fujita 2003, Gine 2005). In 1982, certificates of usufruct (temporary use) were legalized and began to be implemented for landholdings inside the forest reserves throughout the country. The STK certificate allowed for temporary use of land for agriculture but restricted the size of the holding and did not allow for transfer or rental and thus such titles could not be used for formal bank credit (Fujita 2003, Gine 2005). In 1993, additional substantial portions of land were taken out of the forest reserve and established as land reform areas. Landholders could receive a different land document (SPK-4.01), which again entitled them to use but not to sale or mortgage.

relocate forest villages. A small number of villages were in fact forcibly relocated out of wildlife sanctuaries but very few other villages were ever moved (Thomas 1996). Most of the enforcement since that time has focused on limiting the expansion of existing areas and on reclaiming land gradually, particularly when it is being fallowed. Royal Forestry Department officials were particularly reluctant to expropriate or destroy crops (politically and physically dangerous work) and therefore more likely to fine farmers or send them to temporary stays in jail (Fujita 2003).

By law, designations of protected areas were published in the Governmental Gazette, and were supposed to be announced in the district offices and villages. Individual land owners had 90 days to claim prior land occupation at the district office and the possibility to receive compensation for their land if they could prove ownership, but there was no appeals process for later changing the maps if errors had been made. While the designations of protected forest areas in Chiang Mai province were made in the 1960's, 70's, and early 1980's, many villagers did not become aware of the difference between being in a forest reserve or not until land titling programs were introduced on a large scale in the 1980's and villagers discovered that they could not get proper land title (Gine 2005, Fujita 2003, Chalamwong and Feder 1986, 1988, Sato 2000) and until enforcement of the areas was increased in the late 1980's.

This study will include villages that have land in different types of protected areas--forest reserves, national parks, and wildlife sanctuaries. However, the results are dominated by forest reserve villages because they represent a much greater number of villages (the GIS data indicates that in 2003, there were 23 villages inside of wildlife sanctuaries and 66 in national parks, while more than 577 (outside of Chiang Mai district) reported having at least 5% of land in forest reserves). While outside the scope of the current study, future research should explore the difference in effects (possibly at a more qualitative level) across the designation types.

3.2 Chiang Mai Province: Data from the Community Development Department

The first contribution of this paper is to present a new compilation of data from Chiang Mai province[15] which is used to sketch the changes over time for villages that have land inside of protected areas versus those that do not. The data is from a biennial survey[16] by the Thai Community Development Department which collects basic information on village demographics, agricultural practices, development indicators, infrastructure, etc. for all rural administrative villages in Thailand. For this paper I use data from the province of Chiang Mai,[17] which is in the Northern region of Thailand. The earliest year CDD data is available for Chiang Mai is 1986.

The major advantage of the Community Development Department data is that the survey is designed to cover every village within the province,[18] so it contains information even on the more remote villages which are not comprehensively sampled in household surveys by the Thai National Statistics Office. The drawback of the survey is that the data is at the village level, not the household level, and that because of the huge manpower needs involved in collecting data on every village, the survey is filled out in a census style by volunteers--school teachers or village headmen, in combination with officials from the sub-district administrative office. The statistics I use (including assets that are likely to be observable across households, enrollment statistics, and land areas) are of the type considered to be most reliable by those familiar with the surveys:[19] facts about the village that are clearly observable and likely to be known to the village headman, school teachers, or villagers.

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[15] Thailand has 76 provinces, which have historically had relatively little autonomy, although they have gained more since constitutional changes in 1997. Each province is broken down into "amphoes" (districts) and "tambons" (sub-districts), which consist of several "mooban" or villages.

[16]The survey is called "NRD2C" or "Gor-chor-chor-song-kor." I obtained the 1986-1990 data from Charles Griffiths (US EPA) and Jyotsna Puri (University of Maryland); the 2001 data from the Bangkok office of the Community Development Dept., and the 2003-2005 data from the Chiang Mai office of the Community Development Dept. The data from 1986-1996 is used by Jyotsna Puri in her forthcoming dissertation (Puri, 2006).

[17] The survey was conducted in 86, 88, 90, 92, 94, 96, 99, 01, 03, 05. Unfortunately, the data from 1988 has serious coding errors and the data from 1999 has software formatting problems; I do not use these two years in this study. Also, a major problem with the data is that the Community Development Department did not always keep the same codes for villages or tambons (or even districts). In particular there were large changes in coding between 1996 and 2001. I therefore am unable to construct a reliable true panel of the villages across time.

[18] Some villages are made up of more than one "hamlet" or "settlement"; these smaller settlements are supposed to be counted in the survey numbers of the village to which they officially belong. It is likely that the survey may still have missed some very remote or illegal villages or settlements, particularly along less stable border areas near Burma and Laos. However, for Chiang Mai Province this was not believed to be a major problem (personal communication with Ms. U-Tai-Wan, CDD, Wanchat Suankitt, NESDB).

[19] Included: Ms. U-Tai-Wan at Community Development Dept., Chiang Mai Province, who was in charge of data collection for the NRD2C survey for Chiang Mai province and had worked in that office of the Community

3.3 Chiang Mai Province: Tracking Forest Reserve Villages Over Time

Table 1 shows the values of different village characteristics from the CDD survey over time for villages in Chiang Mai Province, excluding those within the (largely urban) district of Chiang Mai. The first three rows in Table 1 show the number of villages in each available year of data that are inside and outside of the forest reserves, and the total number of villages in the survey.[20]

Table 1: Number of Villages Inside and Outside of Protected Areas and Assets

		1986	1990	1992	1994	1996	2001	2003	2005
# villages	Out	839	878	897	926	938	1,081	1,152	1,181
	In	455	525	539	550	571	558	577	572
	Total	1,294	1,403	1,436	1,476	1,509	1,639	1,729	1,753
pick-ups per capita	Out	0.010	0.017	0.023	0.027	0.036	0.057	0.074	0.082
	In	0.007	0.007	0.009	0.012	0.014	0.031	0.044	0.051
motorbikes per capita	Out	0.107	0.156	0.174	0.193	0.204	0.226	0.262	0.273
	In	0.033	0.048	0.051	0.073	0.079	0.134	0.188	0.202
bicycles per capita	Out	0.157	0.143	0.125	0.119	0.101	0.114	0.137	0.143
	In	0.041	0.025	0.020	0.040	0.024	0.031	0.039	0.038
% hh with TV	Out	0.368	0.628	0.732	0.806	0.888	.	.	.
	In	0.150	0.139	0.205	0.326	0.401	.	.	.
cows per capita	Out	0.085	0.071	0.078	0.069	0.060	0.072	0.084	0.085
	In	0.173	0.214	0.212	0.227	0.232	0.177	0.182	0.210
% hh w/ mobile phone	Out	.	.	.	.	.	0.037	0.303	0.487
	In	.	.	.	.	.	0.007	0.090	0.165
% hh w/ TOT phone	Out	.	.	.	.	.	0.273	0.318	0.353
	In	.	.	.	.	.	0.066	0.099	0.112

Table shows median values for all variables. Period indicates questions not asked in that year.

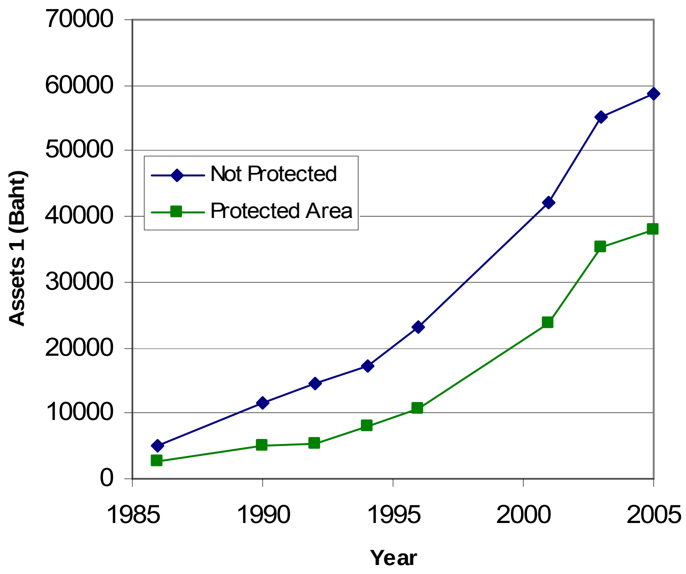
The next set of rows shows measures of central tendency for household assets that are proxies for aggregate village wealth, broken down into villages that report being inside or

Development Dept. for over 10 years. Ms. Siriporn at CDD Bangkok; Dr. Somchai Jitsuchon at the Thailand Development Research Institute (Bangkok). Dr. Benchaphun Ekasingh, head of the Chiang Mai University Agricultural Economics Department. Wanchat Suankitti at the National Economic and Social Development Board, which uses the data for poverty mapping and decisions about economic development programs.

[20] The data from 2001 after reports the actual area of land within forest reserves. For this table, the conservative assumption was made that villages with more than 5% of land in forest reserves are counted as having protected area status.

outside of protected forest areas. The table shows median values of assets per capita for motorbikes, trucks, bicycles, and cows; and the median percentage of households with televisions, TOT phones (land lines) and mobile phones. (Years are missing where survey questions changed over time.) With the exception of cows per capita, villagers in the forest reserves have strikingly fewer of these material assets in all years.

Figure 1: Median Assets1 for Villages Inside and Outside Protected Areas



In addition, there is an apparent pattern of divergence in key assets over time. Figure 1 shows the median levels over time of a price-weighted sum of pickups and motorbikes per capita (units are in Thai Baht), which is denoted as "assets1."[21] These are initially fairly similar across villages inside and outside of reserves, but the gap appears to widen over time. While the "assets1" variable certainly cannot capture all aspects of wealth, researchers who have worked on the ground in rural Thailand agreed that vehicles are an extremely important asset in rural villages and a relatively good measure of household investment.[22] In 2000, the price of a new

[21] Prices for pick-up trucks and motorbikes for each year are from the Thai Ministry of Commerce, Bureau of Trade and Economic Indices, and are for the Northern Region of Thailand.

[22] Personal communication with Louis Lebel and Po Garden, Unit for Social and Economic Research, CMU; Andreas Neef, University of Hohenheim Uplands Project. Using such assets to proxy for wealth is fairly common in the development literature. A well-known paper by Rosenzweig and Wolpin (1993) found that farmers in India use bullocks as both productive assets and as buffer stocks of wealth that can be sold in times of economic trouble. A

pickup truck was around 500,000 Baht, and a new motorbike around 40,000 Baht. Average monthly household income in the Northern region of Thailand in 2000 was 8,650 Baht (National Statistic Office Thailand). In addition, these types of vehicles (in contrast with tractors, for instance) are useful for all types of industries and jobs. They can be used to transport a wide variety of inputs and outputs from agriculture or home industry, or to move people to wage labor jobs.[23] Finally, both can be driven on either city streets or remote mountain roads.

Table 2 shows other characteristics for these villages across time. The first row of Table 2, as well as Figure 2, illustrate the median percentage of village land in agriculture over time. As most land not in agriculture in Chiang Mai will naturally regenerate to forest if left as fallow, the land in agriculture represents a measure of the degree to which enforcement of protected forest area policies discouraged the use of land for agriculture. Figure 2 shows that villages with land in the protected forest areas tend to have much less land in agriculture than those outside. In the first two years of the data, from 1986 to 1990, we see an apparent increase in land in agriculture for villages in protected areas, which likely represents the last few years of the period of logging and agricultural expansion before the shift to stricter policy enforcement. From 1990 to 2001 we see a decreasing trend in agricultural land use inside protected areas. Outside of protected areas over this time we also see a decrease in the total land allotted to agricultural use, which is consistent with Thailand's transition from agriculture to urbanization and skilled labor jobs.

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similar methodology is used by Felkner and Townsend (2005) who combine per capita TVs, motorcycles, pick-up trucks and the percentage of households having flush toilets to create a wealth index from the CDD data for four provinces from the central and northeast regions of Thailand.

[23] For the villages in 2003 with no land in protected areas, there is a negative correlation between the percentage of households engaged primarily in agriculture and the number of pickups and motorbikes per capita. This holds both for all the villages in the rural sample and the villages in the narrow sample.

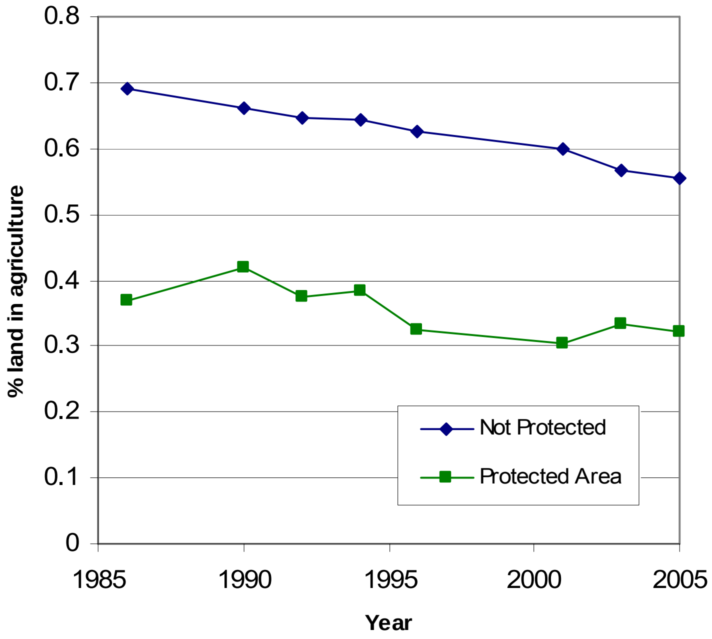
Table 2: Characteristics of Villages Inside and Outside of Protected Areas

		1986	1990	1992	1994	1996	2001	2003	2005
% land in agriculture	Out	0.69	0.66	0.65	0.64	0.63	0.60	0.57	0.56
	In	0.37	0.42	0.38	0.39	0.33	0.30	0.33	0.32
per capita land in agriculture	Out	0.98	0.92	0.94	0.92	0.90	0.93	0.88	0.88
	In	1.07	1.33	1.29	1.36	1.45	1.56	1.94	2.19
# households	Out	150	156	153	156	155	148	128	132
	In	114	116	111	110	106	114	100	102
population density (per rai)	Out	0.67	0.69	0.66	0.66	0.68	0.62	0.54	0.54
	In	0.31	0.26	0.23	0.24	0.20	0.20	0.17	0.15
has electricity	Out	0.93	0.99	0.98	0.98	0.98	0.96	0.96	0.96
	In	0.47	0.69	0.70	0.70	0.69	0.81	0.86	0.86
distance to district (km)	Out	8	7	8	7	8	7	7	7
	In	21	20	23	23	23	18	18	21.5
travel time to district (min)	Out	20	20	20	20	20	15	15	15
	In	45	45	45	45	49	30	30	30
daily wage (Baht)	Out		50	70	80	100	120	120	120
	In		40	50	60	70	100	100	110
out migration for labor	Out	0.94	0.95	0.94	0.96	0.96	0.74	0.70	0.74
	In	0.63	0.68	0.72	0.74	0.78	0.78	0.69	0.71
price of rice (Baht/satang)	Out	2.3	3.0	3.5	3.5	4.0	5.0	5.0	5.0
	In	2.5	3.0	3.0	3.2	3.5	4.5	4.8	5.0
yield: paddy rice (kg/rai)	Out	550	600	560	550	600	540	600	600
	In	450	450	400	400	380	400	420	450
use of BAAC credit	Out	0.82	0.88	0.89	0.90	0.91	.	.	.
	In	0.39	0.48	0.48	0.55	0.62	.	.	.
% hh using BAAC credit	Out	.	.	.	.	.	0.34	0.30	0.30
	In	.	.	.	.	.	0.26	0.21	0.21

Table shows median values for % land in agriculture, per capita land in agriculture, # households, population density, distance to district, travel time to district, daily wage, price of rice, yield, and % hh using BAAC credit. Means are shown for has electricity and use of BAAC credit.

Table 2 also presents differences in other village characteristics. Protected forest area villages tend to have lower wages, less frequent reported out-migration, lower population density, lower reported use of agricultural bank credit, and to be further from the district center as measured by travel time. Over time, both the rates of electrification and the travel time to protected area villages have improved compared to other villages, although they still lag behind.

Figure 2: Median Percent Land in Agriculture for Villages Inside and Outside Protected Areas



This new compilation of data paints a portrait of clear differences between villages inside and outside of protected areas. However, the more difficult policy evaluation question remains unanswered. How much of this difference is attributable to the protected designation and associated policy, and how much is attributable to geographic or other factors? If there were two identical villages in 1960 and one were given protected area status and the other were not, how much would their outcomes differ in 2005? The next two sections will seek to answer this question through a multivariate regression approach and through a regression discontinuity/ instrumental variables design.

4. Explaining Part of the Difference: OLS approach

4.1 Applying OLS to the 2003 Cross-Section

In this section I present results from ordinary least squares regressions where the dependent variables are development outcomes: assets, land in agriculture, employment, and enrollment. I use a cross-section of data from 2003 which I matched with GIS data on the location of villages to construct variables for geographic characteristics of each village including slope, elevation, and distance to the nearest major river.[24] The summary statistics for the villages used in the OLS regressions are given in Table 3.

I narrow the sample used here to villages that are rural and could plausibly have been either included or excluded from protected areas (and therefore we could imagine as having a reasonable counterfactual case). The villages included (612 in total) are those that are 1) good matches with the GIS data based on name and code of village; 2) outside of the largely urban district of Chiang Mai; 3) above 300m in elevation (this excludes the low-lying plains that have been established agricultural areas for centuries); 4) report having at least some village land in agriculture; 5) do not have missing data or inconsistent data on land areas; 6) are below 1000m of elevation (excluding the very high altitude villages which are very different in terms of agriculture and usually ethnic group).

[24] GIS data on rivers is from the Chiang Mai University Geography Department. Location of villages is from the Chiang Mai Community Development Department. Elevation and slope are based on data from the Chiang Mai Geography Department, USGS Shuttle Radar Topography Mission, and a DEM model from Mark Souris, IRD. Only point locations of villages are available; average slope and elevation were taken within a 1.5 km radius of each village. Distance to river measures distance to the closest major river or perennial stream.

Table 3: Summary Statistics Rural Villages above 300m (2003)

variable	mean	median	sd	N
# households	137	121	80.3	612
population	494	436	286	612
% protected area	0.246	0	0.353	612
area of village (rai)	2915	1249	6142	612
average elevation (m)	475	439	187	612
average slope (deg)	4.78	2.37	4.97	612
distance to district (km)	13.3	8	15.4	612
travel time to dist (min)	26.6	20	32.0	612
distance to river (m)	510	252	692	612
pick-ups per capita	0.076	0.065	0.051	612
motorbikes per capita	0.243	0.250	0.093	612
assets1 (Baht)	55268	49766	31540	612
bicycles per capita	0.137	0.112	0.109	612
cows per capita	0.118	0.024	0.261	612
pigs per capita	0.227	0.022	1.28	612
% hh w/ mobile phone	29.5	23.1	25.8	612
assets2 (Baht)	58442	52676	31987	612
daily wage (Baht)	117	120	23	591
% employment	93.7	96.4	9.14	601
% land in agriculture	51.0	52.4	29.2	612
per capita land agriculture	2.04	1.23	2.71	612
enrollment (grades 1-9)	98.8	100	5.52	611
enrollment (1st year hs)	92.2	100	17.0	455

4.2 OLS Results

Table 4 presents the OLS results (with robust standard errors, clustered by district) for outcomes including assets, percent employment, enrollment in compulsory education, and enrollment in the first year of high school. The key explanatory variable of interest is the percent of land in protected forest areas. The specification includes controls for geographic variables that are likely to be correlated with protected status and outcomes related to economic productivity: elevation, distance to nearest major river, slope, soil quality, distance to district center by road, and typical travel time to district. District (amphoe) level fixed effects are included (but the individual intercepts are not shown in the table) in order to control for additional unobserved district-level characteristics such as high quality district infrastructure, district distance from major cities, etc. The inclusion of soil quality and road building variables in the specification may be "over-controlling" since these are influenced by investment, which is in turn likely to be affected by protected area policies. However, the magnitude of the coefficient on percent protected area does not change appreciably when these variables are dropped from the specification.

Table 4: OLS Rural Villages (2003)

	(1)	(2)	(3)	(4)	(5)	(6)
	ln assets1	**ln assets2**	**% employ-ment**	**enroll (Gr 1-9)**	**enroll (Gr 10)**	**% land agriculture**
% protected area	-0.250*	-0.212*	-3.146*	0.420	-3.43	-19.093***
	(0.139)	(0.122)	(1.784)	(1.023)	(4.63)	(6.55)
average elevation	0.434	0.303	0.985	-0.514	8.859	15.299*
(1000 m)	(0.266)	(0.249)	(2.878)	(2.447)	(8.074)	(8.596)
elevation squared	-0.036*	-0.026	-0.044	0.0005	-0.768	-1.094*
(1000 m)^2	(0.020)	(0.018)	(0.199)	(0.172)	(0.588)	(0.608)
distance to river	0.003	0.001	-0.022	-0.01	-0.04	0.055
(meters)	(0.006)	(0.005)	(0.087)	(0.028)	(0.169)	(0.208)
ln average slope	-0.118*	-0.110*	-0.357	-0.702	-2.185	-4.354
	(0.064)	(0.063)	(1.388)	(0.931)	(1.794)	(3.252)
ln distance to district	0.044	0.013	0.542	0.331	-1.599	-0.582
	(0.040)	(0.039)	(0.434)	(0.749)	(2.099)	(2.088)
travel time to district	-0.006***	-0.004***	-0.021	-0.008	-0.003	-0.022
(min)	(0.001)	(0.001)	(0.017)	(0.010)	(0.058)	(0.035)
soil thin	0.077	0.076	-0.715	0.833	-3.286	1.2
	(0.063)	(0.059)	(1.176)	(1.015)	(3.321)	(1.950)
soil hard	0.051	0.016	0.07	-0.277	4.805**	4.247
	(0.052)	(0.048)	(0.978)	(0.294)	(2.195)	(3.253)
soil salty	-0.176**	-0.147*	-0.437	-0.633	-4.576*	0.252
	(0.083)	(0.078)	(0.882)	(0.871)	(2.264)	(3.988)
Constant	10.070***	10.495***	93.678***	101.635***	85.411***	23.392
	(0.609)	(0.569)	(5.73)	(4.57)	(17.24)	(21.01)
District FE	yes	yes	yes	yes	yes	yes
R2	0.48	0.42	0.20	0.16	0.12	0.22
N	612	612	601	611	455	612

The dependent variables are listed in the column heading. Robust, clustered (by district) standard errors are in parentheses. * indicates p ≤ .10, ** p ≤ .05, *** p ≤ .01

The OLS results indicate a negative and marginally significant (significant at the 10% level) association between the percentage of village land in a forest reserve and the assets1 variable (price-weighted aggregation of pick-ups and motorbikes as described in Section 3), controlling for the factors described above. Because of the log specification (chosen because assets1 is close to log-normally distributed), the coefficient on percent protected area indicates that being fully inside a protected area is associated with an estimated 25 percent decrease in vehicle assets. The assets2 variable, which includes a price-weighted aggregation[25] of pick-up trucks, motorbikes, bicycles, cows, mobile phones, and pigs, shows a marginally statistically significant 21 percent decrease associated with being fully protected. Employment levels are negatively and marginally significantly associated with being in protected forest areas, but the magnitude-- a difference of 3.1 percentage points -- is quite small. The difference in the percent of land in agriculture associated with protected area status is estimated at 19.1 percentage points ($p<.001$). (Since the median percent of land in agriculture for the sample as a whole is around 50%, this is a larger difference in percentage terms.) The coefficients on enrollment in compulsory education and enrollment in the first year of high school are not significantly different from zero in this specification; neither are wages (not shown to conserve space).

Without any control variables or district fixed effects, the estimated coefficient of a regression of ln(assets1) on percent protected area in this sample is -.84; meaning that being fully in a protected forest area is associated with an 84% decrease in assets. With only district fixed effects but no additional controls, the estimated coefficient is -.49 (or a 49 % decrease in assets). That the magnitude of the relationship is reduced by the addition of controls for geographic variables suggests that these other included factors (elevation, slope, distance, soil quality) account for much of the differences between these villages. While the OLS specification can improve upon a simple bi-variate relationship by controlling for important geographical and district level factors likely to influence productivity outcomes, there is still considerable worry about possible omitted variables and potential reverse causality (e.g. those villages that were expected to be most productive were excluded from protected areas). The next section will attempt to improve the estimates using an instrumental variables approach that relies on a discontinuity in the probability of being in a protected forest area as a source of exogenous variation in protected area status.

[25] Prices in Baht are: pick-up truck--582,197; motorbike--44,425; cow--14,000; bicycle--2,500; mobile phone--6,000; pig--3,000. Data on prices of pick-ups, motorbikes, bicycles (Northern Region) is from the Thai Ministry of Commerce, Bureau of Trade and Economic Indices. Livestock prices are from the Office of Agricultural Economics, Ministry of Agriculture and Cooperatives. Mobile phone relative value is a back of the envelope estimate (and the results do not change substantially when it is left out).

5. Estimating the Effects of Protected Areas on Assets

5.1 Regression Discontinuity Designs

A regression discontinuity approach is a method for estimating the effects of a treatment that can be used when there is a threshold rule that determines whether some groups receive treatment (Thistlethwaite and Campbell 1960, Campbell 1969). A well-known example from the literature on the effects of financial aid on college enrollment is given by Van der Klaauw (2000). In this example, financial aid is awarded according to a rule where students with test scores above a certain threshold (in fact there are several thresholds in the paper) are much more likely to receive financial aid offers. An estimate of the effect of financial aid on enrollment can be made by comparing the outcomes of those students with test scores just above the threshold with those of students just below the threshold. For this estimate to be unbiased, students on either side of such a threshold must be similar except for the treatment--receiving the financial aid. The estimate is made using a subset of the data that is close to the threshold where there is a discontinuity in treatment. If the rule is followed perfectly, the means of the groups provides an estimate of the treatment effect. When the rule is not followed perfectly, an instrumental variables estimation (e.g. two-stage least squares) can be used to correctly scale the coefficient.[26] In the case of protected forest areas in Thailand, I will take advantage of a discontinuity in the probability of receiving environmental designation for villages higher than 500m in elevation.

5.2 The Process of Protected Designations

As outlined briefly in Section 2, the process of designating protected forest areas in Thailand after 1964 was largely effected through a centrally controlled system with little ground truthing to determine whether existing villages or portions of village lands were being enclosed. This is not surprising given the sheer magnitude of the problem faced by the Royal Forestry Department as a central agency. There are around 70,000 villages in Thailand and it is a country of some 511,770 sq. km of land area.[27] Maps with village level boundaries are still not available for Chiang Mai Province except as hand-drawn versions in each tambon office or in cases where

[26] Duflo 2002. For another well-known example of regression discontinuity design, see Angrist and Lavy 1999.
[27] No. of villages is a 1993 figure from Booranasanti 2001; area is from the CIA World Factbook 2005.

other researchers have digitized them for selected tambons.[28] As mentioned in section 3, the 1964 National Forest Reserve Act streamlined the procedures for declaring reserve forests (Vandergeest 1996) in order to meet central government goals of keeping a large percentage of land in forest (originally a 50% goal) by demarcating reserve forests as quickly as possible. The approval of new protected areas was made by a central government committee with five voting members. According to Vandergeest (1996), the composition of this committee likely meant that three out of the five members would be closely linked to the Forestry Department, giving them essential jurisdiction over the choices (previously the process had more input from local Ministry of Interior officials). By 1985, 42% of national territory was declared to be reserve forest, and was under the jurisdiction of the Forestry Department (Vandergeest 1996).

There was no precise, written criterion for the designations, but several sources indicated that it was done largely on the basis of maps, probably from the 1960's and 70's, including those from the military, the Thai Royal Geological Survey, and the Department of Lands. Boundaries are thought to have been drawn mainly on the basis of contours, with some departures where there was already documented land ownership (titled land or large villages). Area most likely to be included in the forest reserves in Chiang Mai Province (which has many areas of higher elevation than the central provinces of Thailand) were those that were above 500m in elevation, had steep slope, were close to significant watersheds, or were classified as forested on rough vegetation maps.[29]

5.3 Regression Discontinuity Applied to Chiang Mai Province

The centralized process of protected area designation on the basis of elevation and slope without careful regard to existing settlements makes it likely that some villages of initially similar character around the 500m contour lines received different protected area designations. I use this variation to estimate the effect of being in a protected forest area on wealth and other

[28] With the help of a Thai assistant I could not locate any such maps through local or national government offices and was told by GIS experts at Chiang Mai University that they are not available.

[29] Sources include: Vandergeest 1996 and personal communication, Dr. Benchaphun Ekasingh, head of the Chiang Mai University Agricultural Economics Department, Louie Lebel and Po Garden, Unit for Social and Economic Research, Chiang Mai University, Dr. Pornchai, Chiang Mai University and former RFD official. A current Chiang Mai Province RFD official, however, disputed this story, saying that the borders had been drawn carefully to exclude existing villages and that the problem was that villages had expanded illegally into the protected areas.

outcomes. However, since large differences in slope and elevation are also associated with different agricultural regimes, the approach taken here is to restrict the sample used for the estimates to a subset in which the differences in elevation and slope are plausibly small enough to not directly influence outcomes (this is discussed in more detail below, and see robustness checks in the discussion section). In particular, I use only villages between 400 and 600 m of elevation, which is on either side of the 500 m discontinuity in the probability of receiving protected area status, and villages with average slope less than 6 degrees. I will also include a control for a non-linear trend in elevation over this range.

Table 5: Summary Stats: villages 400-600m elevation & < 6 degrees slope

variable	mean	median	sd	N
# households	154	133	100.9	155
population	536	471	350	155
% protected area	0.123	0	0.233	155
area of village (rai)	2075	1375	2513	155
average elevation (m)	5	5	0	155
average slope (deg)	2.33	1.79	1.52	155
distance to district (km)	9.5	7	9.7	155
travel time to dist (min)	18.4	15	18.4	155
distance to river (m)	6	4	7	155
pickups per capita	0.061	0.055	0.038	155
motorbikes per capita	0.241	0.244	0.073	155
assets1 (Baht)	46464	42730	23277	155
bicycles per capita	0.148	0.128	0.106	155
cows per capita	0.079	0	0.167	155
pigs per capita	0.223	0.066	0.89	155
% hh w/ mobile phone	26.0	20.8	20.7	155
assets2 (Baht)	49063	45456	23668	155
daily wage (Baht)	105	100	15	152
% employment	92.2	95.55	10.4	154
% land in agriculture	59.7	64.2	27.3	155
per capita land agriculture	2.17	1.565	1.97	155
enrollment (grades 1-9)	99.0	100	3.69	155
enrollment (1st year hs)	92.6	100	17.1	126

Table 5 shows summary statistics for the smaller number of observations used for the instrumental variables/ regression discontinuity approach. Comparing these 155 villages with the 612 shown in Table 3 shows that they are fairly similar on average. The smaller subset has less land in the protected areas on average, and has a slightly higher percentage of land in agriculture.

Table 6: First Stage LPM Estimation

	protected area
elevation above 500 m	0.334**
	(0.167)
ln average slope	0.425***
	(0.077)
average elevation	20.48
(1000 m)	(32.38)
elevation squared	-4.55
(1000 m)^2	(6.56)
elevation cubed	0.325
(1000 m)^3	(0.439)
distance to river	-0.0054
(meters)	(0.0049)
soil thin	-0.109
	(0.090)
soil hard	-0.061
	(0.082)
soil salty	0.196
	(0.147)
ln distance to district	0.005
	(0.053)
constant	-30.21
	(52.83)
District FE	yes
R^2	41.1
N	155
F-stat for excluded instruments	21.6

Robust, clustered standard errors are in parentheses.
* p ≤ .10, ** p ≤ .05, *** p ≤ .01

Table 6 presents the results of the first stage of the IV approach.[30] Villages with average elevation above 500m and with steeper slopes are significantly more likely to be in a protected

[30] In this estimation the dependent variable is 0 or 1. Villages with more than 5% of land in the forest reserve are classified as "treated." Since this counts as treated villages which received only partial treatment, it should tend to bias the effects towards zero. Very similar results are found using a probit in the first stage and the IV method described by Wooldridge (2002) p. 623-625.

area, conditional on a cubic trend for average elevation,[31] soil quality dummies, distance to nearest major river, log of distance to district, travel time in minutes to district and district dummies (district fixed effects). The F-statistic for the excluded instruments--elevation above 500 m and log slope--in the first stage is 21.6, indicating the instruments are relevant.

To produce an unbiased estimate of the effect of protected area policies, the instruments also need to be exogenous with respect to the outcome variables. That is, that being above or below 500 m in average elevation or having a steeper slope, conditional on the control variables given above (an elevation trend, soil quality, distance to major river, distance to district, travel time in minutes to district, and district dummies) should not directly affect productivity. A characterization of agricultural regimes put together by researchers at the International Center for Research in Agroforestry at Chiang Mai University (Thomas 2003) suggests that agricultural possibilities are likely to be similar within the range of 400-600m. They describe elevations of 300-600m as the zone which would naturally be dry dipterocarp forest, in which traditional human land use would be short cultivation/ short fallow, and where current land use is mainly continuous field crops or tree crops. Since steeper slope has the potential to affect the outcomes directly, the sample is restricted to villages with an average slope of less than 6 degrees, which is plausibly small enough to not greatly affect productivity (also see note below about robustness checks).

5.4 Regression Discontinuity Results

The results from the second stage of the IV/regression discontinuity approach are presented in table 7. I find a slightly larger effect on asset levels than was estimated using OLS: a 33 percent decrease in the assets1 variable and a 31 percent decrease in the assets 2 variable (both are significant at the 5% level). These estimates are not that different from the OLS estimates. As with the OLS specification, the magnitude of the coefficients doesn't change substantially when the controls for soil quality or distance to district are dropped, or when controls for travel time to district are included.

[31] A simple linear trend for elevation or a squared trend give very similar results, however the signs of the cubic trend best match the expected trend in probability of being in a forest reserve.

Table 7: IV Estimates for villages 400-600m & < 6 deg slope

	(1)	(2)	(3)	(4)	(5)	(6)
	ln assets1	**ln assets2**	**% employ-ment**	**enroll (Gr 1-9)**	**enroll (Gr 10)**	**% land agriculture**
protected area	-0.327**	-0.311**	-0.816	-3.991*	-13.38*	-6.814
	(0.132)	(0.120)	(3.921)	(1.749)	(6.68)	(16.647)
average elevation	35.3*	29.8	700.0	-257.8	1112.3	2424.3
(1000 m)	(17.8)	(17.8)	(398.5)	(338.3)	(1014.2)	(2043.2)
elevation squared	-7.54*	-6.44*	-147.10	55.93	-215.11	-512.47
(1000 m)^2	(3.47)	(3.50)	(81.14)	(70.61)	(200.92)	(405.50)
elevation cubed	0.529**	0.456*	10.199	-4.041	13.83	35.76
(1000 m)^3	(0.225)	(0.228)	(5.50)	(4.89)	(13.14)	(26.61)
distance to river	-0.001	-0.001	-0.123	-0.006	-0.212	0.652
(meters)	(0.007)	(0.007)	(0.118)	(0.029)	(0.452)	(0.356)
ln distance to district	0.064	0.054	0.509	0.437	2.733	-2.834
	(0.043)	(0.043)	(1.965)	(0.314)	(3.404)	(1.704)
soil thin	0.027	0.019	1.099	0.441	0.633	-6.312**
	(0.090)	(0.098)	(1.94)	(0.614)	(8.443)	(2.266)
soil hard	0.005	0.007	-3.539*	-0.353	-0.576	8.894*
	(0.080)	(0.071)	(1.834)	(0.688)	(3.416)	(4.299)
soil salty	-0.162	-0.155	1.83	-0.071	1.875	1.379
	(0.25)	(0.25)	(2.059)	(0.971)	(6.223)	(10.902)
Constant	-44.168	-35.107	-1024.9	493.8	-1850.0	-3709.0
	(30.326)	(30.268)	(650.2)	(538.0)	(1702.3)	(3403.3)
District FE	yes	yes	yes	yes	yes	yes
R^2	0.147	0.148	0.265	0.148	0.084	0.184
N	155	155	154	155	126	155

The dependent variables are listed in the column heading. Robust, clustered (by district) standard errors are in parentheses. * indicates p ≤ .10, ** p ≤ .05, *** p ≤ .01

The results are also fairly robust to changing the width of the window around 500 m and the slope cut-off of less than 6 degrees. Varying the window up to 800 m or down to 300 m produces estimates of the effect on lnassets1 between -21% and -32%. Varying the slope cut off between 4 and 8 degrees produces estimates from -20% to -30%. Adding a restriction for minimum slope above 1 degree produces estimates around -32% to -35%. Taken together, these suggest that the particular choices of the window around the discontinuity or restriction on the slope is not driving the results, although we should be cautious about the precise magnitude. In addition, the results are robust (coefficient is -29%) to the addition of a variable for the average area of rice fields per household (constructed from other variables on the number of households falling in to different categories of land ownership size). A final robustness check concerns the distribution of wealth among households. Villages are a shifting composition of households and both protected area villages and other villages lost population density in the past 20 years as Thailand became more urban. We may be concerned that well-off families inside of protected areas would be likely to move. Using a constructed Gini coefficient representing the equality of distribution of paddy rice land per household as the dependent variable, I find no significant effect of being in a protected area on the distribution of land being farmed by households.

It is a bit surprising that the IV/regression discontinuity gives larger point estimates than the OLS approach. There are several possible reasons, the most obvious of which is sampling error, which is quite likely since the number of observations is fairly small and the standard errors are large; the confidence intervals of the coefficients from IV vs. OLS overlap. A second possibility is that the treatment effect is slightly larger for this sub-sample of villages than for the whole sample. This seems unlikely as the villages used for the discontinuity approach were fairly close to the mean villages of the larger sample. A more likely reason is measurement error in the variable for land in protected areas: this would cause attenuation bias in the OLS estimates, biasing them towards zero. If the instrument is not correlated with the measurement error, it will correct this bias in the IV estimates. Finally, there is the possibility of omitted variables in the OLS estimates, such as Royal Projects, community institutions, or NGO involvement, that are positively correlated with protected forest villages and positively correlated with outcomes. These would also bias the OLS estimates upwards (towards zero) in this case.

From the IV estimates, there is no statistically significant effect on employment or on wages (not shown), which may reflect equilibrium in the district labor markets. However, there are marginally significant negative effects on enrollment in compulsory education (- 4.0 percentage points) and enrollment in the first year of high school (- 13.4 percentage points). These are (unfortunately) consistent with negative effects on wealth from forest protection policies if educational enrollment is influenced by whether households can afford to invest in educational opportunities for children. They may also reflect associated government policies that directed resources more to schools outside of protected forest areas. The estimated effect on percent of land in agriculture of being in the forest reserve is 6.8 percentage points (less than the OLS estimates) and is not statistically significant. This suggests either that there was relatively little enforcement, or that the restriction of agricultural land is not currently binding.

Given the overall downward trend in land in agriculture seen in the data in recent years, this is plausible, but it is difficult to draw conclusions given the large standard error.

6. Discussion and Conclusion

The results presented above are more consistent with a theoretical story in which protected area policy has a net negative local impact than one in which state intervention stops sub-optimal resource use and communities benefit both environmentally and economically. This study found significant negative effects (on the order of 20-35%) on assets which proxy for household wealth and marginally significant negative effects on educational enrollment. By taking a quantitative, retrospective look at the outcomes of protected forest designations, this study makes a first step towards filling an important gap in the empirical literature on conservation and development.

However, from a policy perspective, interesting questions remain about which policies and mechanisms may have driven these results. Are the observed differences in wealth due to direct restrictions on land or to the result of policies concomitant with protected areas such as less access to credit, poor roads, fewer educational opportunities, selective migration, or tenure insecurity? Several correlations in the sample (across both protected and regular villages) match current development theories: travel time to district (controlling for distance to district) and elevation are negatively and significantly correlated with assets. Credit from the main agricultural bank (BAAC), higher percentages of titled land, high school enrollment, and the percentage of households engaged only in labor are positively and significantly correlated with assets. However, the percentage of households engaged in tourism, the size or presence of community forests, and a village level Gini coefficient indicating the equality of distribution of paddy rice land are not significantly correlated with wealth.

These questions and puzzles suggest that one avenue for future work might be a "residuals analysis" following methods proposed by Agrawal and Chhatre (2005). This would involve using qualitative, small-n analysis to further investigate the mechanisms for a subset of the observations that are outliers of the regression models above. In particular, much might be gained from comparing districts or sub-districts with positive outliers--where protected area villages are doing relatively well compared to nearby villages--to other districts or sub-districts where protected area villages are negative outliers-- they have been left behind in developmental indicators. What distinguishes success from failure at the micro level? Such an analysis might reveal the importance of other mechanisms at work such as NGO involvement, Thai Royal Projects, successful village micro-credit programs, differential opportunities for tourism in National Parks vs. Forest Reserves, lower transportation costs, or well-managed collective institutions. Identifying such positive mechanisms is key to the possibility of improving trade-offs between development and environment and moving towards true sustainable development win-win solutions.

While the data seem to tell a cautionary tale about the possible local tradeoffs between environmental goals and local development goals, without knowing the regional or global environmental benefits it is impossible to say whether (from an efficiency perspective) the costs were justifiable. Furthermore, while this study highlights the need for compensation schemes to communities when use of land is restricted for the public good and when development goals are also important, the amount or form of compensation is a very difficult separate question involving ethical issues of rights and distributional justice. It is likely to be particularly tricky in a case like Thailand where the original ownership of the land is disputed and tense politics surrounds the debate over whether settlements in protected areas should be encouraged or discouraged. This type of problem is mirrored in many protected area situations across the globe and likely has no easy solution. However, more information about the magnitude of the trade-offs at stake and how local communities have responded to policy changes in other countries or regions would help as future polices are debated.

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