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Conservation and development: Evidence from Thai protected areas

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ABSTRACT

Protected areas are a key tool for conservation policy but their economic impacts are not well understood. This paper presents new evidence about the local effects of strictly protected areas in Thailand, combining data on socioeconomic outcomes from a poverty mapping study with satellite-based estimates of forest cover. The selective placement of protected areas is addressed by controlling for characteristics which drove both protection and development and by instrumenting for protection with priority watershed status. The estimates indicate that protected areas increased average consumption and lowered poverty rates, despite imposing binding constraints on agricultural land availability. Socioeconomic gains are likely explained by increased tourism in and around protected areas. However, net impacts are largest at intermediate distances from major cities, highlighting that the spatial patterns of both costs and benefits are important for efforts to minimize conservation-development tradeoffs.

1. Introduction

Protected areas now cover more than 12% of global land area [1] and are a critical environmental policy tool. These areas provide important environmental benefits including carbon sequestration, watershed protection, and wildlife habitat [2–4]. However, the global conservation community is increasingly concerned about the local socioeconomic impacts of protected areas [5–8]. Critics argue that protected areas restrict community development opportunities and increase poverty [9–11].

Economic models of protected areas predict both negative and positive local economic effects, leaving the net impact ambiguous [12–19]. By definition, protected areas impose constraints on resource use, and if these constraints bind, should reduce local incomes. Protected areas might also generate new income by attracting tourism, inducing infrastructure development, or increasing the flows of economically significant environmental services. Unfortunately, there is little rigorous empirical evidence on the socioeconomic impacts of protected areas in developing countries to inform this debate.

The evaluation of protected area economic effects in developing countries has been hindered by two problems. The first is the scarcity of reliable data on socioeconomic outcomes at the appropriate spatial scale. To measure local outcomes, this paper takes advantage of new poverty-mapping techniques [20], which estimate socioeconomic indicators for small geographic areas. Poverty mapping combines data from household consumption or expenditure surveys, which are detailed but accurate only for large areas, and census surveys, which have comprehensive geographic scope but contain only basic information on household characteristics. I use locality-level measures of average household consumption,

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poverty, and inequality from a 2000 poverty mapping study based on Thai census and household survey data from Healy and Jitsuchon [21].

The second problem in this literature is the highly non-random placement of protected areas. Protected areas in Thailand and elsewhere were sited on the basis of conservation goals including watershed management, habitat conservation, and recreation opportunities. Clearly, locations with attractive conservation characteristics might also differ on other characteristics which would drive subsequent economic development, such as terrain, distance to cities, and historical forest cover.

I use two regression frameworks to account for this selective placement. The first is a standard ordinary least squares regression model which controls for relevant geographic and pre-protection characteristics. Given the historical context, I argue that this model reasonably captures the set of characteristics which determined selection and influenced development. To the extent that there are omitted characteristics in the OLS, they are most likely to bias the estimates against a positive socioeconomic finding. The second regression framework addresses the possibility of omitted characteristics by instrumenting for protection with priority watershed status. Priority status, which is measured by proximity to the headwaters of major rivers, is correlated with protection, but should not affect locality outcomes because it is determined by the downstream destination of waterways, not local characteristics.

The results from both empirical strategies indicate that protected areas increased locality average consumption and decreased poverty rates. The OLS estimates suggest that an increase in the share of locality land protected from zero to the median share among those protected (one-third) corresponds to a 4.5% increase in monthly household consumption and a 10.3% decrease in the poverty headcount ratio. The IV estimates confirm that protection increased household consumption and decreased poverty but are larger in magnitude. Although the OLS and IV estimates are not significantly different, the direction of the difference is consistent with the argument that OLS may underestimate beneficial economic impacts of protection.

That protected areas could improve development outcomes is surprising only if they also substantially constrained local resource use. I construct and analyze both cross-sectional data on forest cover from 2000 and panel data from 1967 to 2000. The results show that protected areas did significantly constrain forest clearing, reducing the amount of land available for agriculture by approximately 11% for a change from no protection to the median share protected (one-third).

How did strictly protected areas in Thailand improve socioeconomic outcomes while also reducing land available for production? The most likely explanation is that they generated enough local tourism income to offset opportunity costs. Back of the envelope calculations based on visitor statistics suggest that the results could be explained if each visitor generated approximately 1.20 US$ in local net income. The case for tourism as the likely explanation is also bolstered by differences in impact by park type. Localities with a high share of land in national parks, where tourism was actively promoted, benefited more than those with a high share of land in wildlife sanctuaries, which allowed only research and small-scale tourism.

However, the largest positive socioeconomic impacts are not simply where there are the most tourists. Although tourist visits are most numerous close to major cities, net socioeconomic impacts are greatest at intermediate distances, where the opportunity costs of protection are also likely to be lower. The success of protected areas at intermediate distances highlights the importance of the spatial distribution of both costs and benefits. As suggested in the conservation targeting literature (e.g. [22–24]), better understanding of spatial patterns can help to minimize tradeoffs between environmental protection and economic development.

The analysis here contributes to the environmental economics literature in several ways. First, the results provide new evidence that protected areas could improve socioeconomic outcomes in developing countries. This has been debated theoretically [12–15,19] but not shown empirically in a developing country. Second, the paper demonstrates the application of poverty mapping in the environmental literature. There is great potential for a broader use of poverty mapping estimates in combination with environmental data to study environment–development relationships. Third, the paper adds to the small but growing literature exploiting spatial variation to examine the joint impacts of policies affecting the environment and economic growth (e.g. [25,26]). Finally, the paper supports the conclusions of previous researchers that protected areas have been moderately effective in reducing deforestation in middle-income countries [27–29].

2. Protected areas and local socioeconomic impacts

2.1. Theoretical insights

The conventional wisdom is that protected areas will reduce local economic welfare by restricting land use choices. This can be illustrated by a very simple von Thünen style model (e.g. [27,30–32]). Assume that there is a set of landholders, varying in distance from a central market. Each landholder seeks to maximize rents from land based activities (agriculture or forestry) but can freely choose land use allocation and inputs such as labor. Suppose that a new protected area is then imposed that overlaps with land currently in production and restricts land clearing or production of forest products. Intuitively, if free exchange has already ensured that factors are being put to their most productive uses and if there are no significant positive externalities from forested land, these restrictions will constrain local production possibilities and reduce local welfare. Although land rents just outside of the protected area might increase, total rent within the locality must decrease due to diminishing marginal productivity of inputs. Workers previously employed on land now devoted to conservation will seek other work within the locality and wages will fall.

Although the framework here is a static one, the logic should also hold for a dynamic framework. Protected areas will constrain future development opportunities even if they do not overlap with productive lands when they are first established. Restrictions on resource use will eventually slow local economic growth and decrease the accumulation of wealth over time.

This negative portrait of protection assumes that conservation merely constrains production and does not generate any significant local benefits. Such an assumption may be reasonable in cases where the environmental benefits accrue to others at a regional or global scale (e.g. carbon sequestration, biodiversity conservation). Modeling of protected area establishment that demonstrates negative effects for nearby households can be found in papers by Robalino [13] and Robinson et al. [12].[1]

However, in some cases local environmental benefits might be large enough to matter. Protected areas might safeguard ecosystem services on which local economies depend, such as water supplies, non-timber forest products, or the regeneration of fish stocks [19,33]. Alternately, protected areas might increase local incomes more directly. Protected areas might generate a new tourism sector, direct employment in protected areas, or new infrastructure investment by central governments.[2]

2.2. Empirical evidence

Given these theoretical reasons why protected areas might have both positive and negative effects on local economies, empirical evidence about the net socioeconomic effects is clearly important. Unfortunately, there is a dearth of retrospective quantitative evidence about the socioeconomic impacts of protected areas [36–38].

To date, the literature includes several studies that evaluate protected areas but focus on environmental outcomes. These studies generally find that protected forest areas can achieve environmental benefits, although studies that account for selection by controlling for land characteristics find only moderate decreases in deforestation rates. Deininger and Minten [28] find that protected areas in Mexico decreased deforestation probabilities by 10–21 percentage points; Chomitz and Gray [27] find that national parks and private reserves in Belize had 4.5 percentage points less deforestation; and Andam et al. [29] find that protected areas in Costa Rica slowed deforestation by 10% or less. Pfaff et al. [39] finds significant heterogeneity in the Costa Rica impacts depending on location. Several other studies that do not employ econometric comparisons also conclude that protected areas are moderately environmentally effective (see [40–43]). However, several studies in contexts where there are weak institutions or low enforcement find little or no environmental impact of protected areas (see [44–47]).

In addition to the literature retrospectively assessing the environmental impacts of protected areas, there are several studies that prospectively estimate the costs and benefits of protected areas [48–51]. Related studies seek to estimate local economic benefits from sustainable forestry schemes or flows of non-timber forest products (see review by Sunderlin et al. [52]). Note that whether or not communities which depend on non-timber forest products would benefit from protected areas depends on how protection affects the flow of those products, the community's ability to access those products, and the magnitude of income from those products (for different views see [33,52–54]).[3]

To date, retrospective evidence about protected area impacts comes mainly from case studies of specific protected areas, which document both positive and negative impacts.[4] Previous studies with regional scope using direct measures of socioeconomic well-being[5] and accounting for the non-random placement of protected areas have been limited to the United States [16–18]. Lewis et al. [16,17] find no significant effects on employment or wages from a higher share of the land base in public conservation uses or from decreases in public timber harvests. Duffy-Deno [18] finds no effect on county-level resource-based employment of wilderness area designations. Other retrospective studies of protected areas in developing countries are currently in progress.[6] A newly published study by Bandyopadhyay and Tembo [71]

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[1] Robalino models the case where the prices of goods are endogenously determined and labor can move between agricultural and manufacturing sectors. Protection has a net positive effect on aggregate rents but agricultural workers are harmed. Robinson et al. demonstrate negative welfare effects for local households around protected areas in a model where households have a fixed resource requirement from the park.

[2] In theory, if there are significant local benefits of protection, we might expect to see localities establish their own community protected areas. Does the absence of community protection then imply that protected areas are not locally beneficial? Not necessarily, because communities must overcome collective action problems to establish protected areas. This requires both institutional capacity and local control over resources, neither of which can be taken for granted in developing country contexts. National governments would have significant scale advantages in solving resource dilemmas and promoting tourism. For counter-arguments that community protected areas are more effective and efficient than state imposed areas, see [34,35].

[3] Even when forest products do not regularly contribute to local incomes, they may still serve as "safety nets," providing temporary income or subsistence materials in times of crisis [54,55].

[4] See [56–64]. See also additional references in [36,65,66].

[5] For instance, Wittemyer et al. [67] finds that population growth rates have been higher near parks, but this is not a direct measure of well-being and the methodology has been criticized (see [68]).

[6] Wilkie et al. [8] discusses plans for evaluation in Gabon; Andam et al. [69] (unpublished) compares socioeconomic impacts of protected areas in Costa Rica and Thailand using matching estimators; Robalino and Villalobos-Fiatt [70] (unpublished) looks at labor market effects around protected areas in Costa Rica.

indicates positive gains to some households near four game management areas in Zambia but does not find that poor households gain.

As highlighted above, there is a gap in the literature with respect to empirical evidence on the socioeconomic impacts of protected area systems in developing countries. Thailand provides an interesting case study. It was one of the first developing countries to implement an ambitious system of protected areas, so it is possible to study long term impacts. In addition, although protected areas were not sited at random, the selection process is relatively well-documented and thus can plausibly be accounted for using the empirical strategies described below.

3. Data

3.1. Protected areas

This paper considers two categories of strictly protected areas in Thailand: wildlife sanctuaries and national parks. These correspond to categories I and II – strictly protected areas – as defined by the International Union for the Conservation of Nature (IUCN).[7] By the year 2000, the North and Northeast regions of Thailand included 31 wildlife sanctuaries and 57 national parks, covering 15.6% of land area. Protected areas boundaries come are from the IUCN World Database of Protected Areas. Years of establishment for protected areas from this database were cross-checked with information from Thailand's Department of National Parks.

Both national parks and wildlife sanctuaries officially prohibit agricultural use and the extraction of forest products or mineral resources. However, these legal regulations and definitions conflict significantly with reality on the ground. Protected areas overlap with and enclose large areas of agricultural land. According to a 2003 report by the International Center for Environmental Management [72] more than 500,000 people live inside national parks and wildlife sanctuaries. This incongruity is the result of rapid protected area designation, initial weak enforcement which encouraged in-migration, and population growth of communities inside protected areas [73–75].[8] Such dissonance between legal definitions and de-facto use is not unique to Thailand but is a common problem for protected areas in many developing countries [42].

3.2. Socioeconomic outcomes

The unit of analysis for this study is a locality (also called a sub-district or *tambon*). The analysis includes 4113 localities in the North and Northeast regions of Thailand. These regions were chosen for this study because they contain the majority of protected forest areas. (The boundaries of the regions are defined by the Thai National Statistical Organization.) The average size of a locality in these regions is 82 km^2 and the average population is approximately 5000 people. Localities are grouped into districts, provinces, and regions. Table 1 lists the set of variables collected for each locality and the data sources. Covariates were constructed for this analysis using spatial overlay of geographic layers.

Socioeconomic measures at the locality level come from a poverty mapping analysis for the year 2000 by Healy and Jitsuchon [21]. Their analysis applies the poverty mapping methodology developed by Elbers et al. [20] to Thailand. Healy and Jitsuchon first model household income and consumption for households in the 2000 Thai Socioeconomic Survey (SES) as a function of household characteristics and assets. These relationships are then used to predict household income and consumption for the census households (20% of all households). By running simulations and aggregating across households, Healy and Jitsuchon generate estimates of poverty and inequality at the district and locality level. They demonstrate that the standard errors on their poverty estimates at the locality level are actually smaller than the standard errors at the province level which would be obtained using only the SES data.[9]

I use estimates from the poverty mapping study's rural consumption approach. Nearly all protected areas are in rural locations, and consumption measures are generally preferred by economists to income measures, which are more susceptible to fluctuations and reporting inconsistencies. In this case, the consumption measures may also be more robust to possible error due to household consumption of non-market forest products.[10]

[7] Thailand also has significant areas designated as national forest reserves which were less strictly protected [72], and small areas designated as non-hunting areas and forest parks.

[8] Enforcement primarily limited community use of protected areas. Limitations included prohibitions on hunting, forest product collection and the amount of land allowed for cultivation (e.g. [74,76–81]. Enforcement was relatively more lax in the 1960s and 1970s but increased in the 1980s and 1990s [75,82–84]. There are only a few documented cases of forced resettlement of villages from inside of protected areas to areas in the lowlands outside the park boundaries. Two large proposed resettlement schemes – the "Green Northeast" program and the "Khor Jor Kor" program – failed due to overwhelming political opposition [76].

[9] Poverty mapping techniques have been demonstrated with reasonable accuracy by comparison to known true small-area values [20,85]. Concerns about precision (see report by Banerjee et al. [86] and response by Lanjouw and Ravallion [87]) are not a major concern here given that poverty is the outcome variable.

[10] If forest products constitute a source of food or items for household use (e.g. firewood), those items should be measured in household consumption surveys, although some non-standard items might be missed. Forest product use should also appear indirectly in measures of wealth based on assets because forest products could substitute for cash income. For example, households who acquire firewood locally rather than buying it in markets would have additional cash for the purchase of the household assets which are measured in the census data.

Table 1
Locality data.

Variable	Description	Source
Socioeconomic outcomes		
Consumption	Estimated avg. monthly household consumption (Baht)	Year 2000 poverty mapping analysis [21]
Poverty headcount	Share of population with consumption below poverty line	
Poverty gap	Mean distance consumption to poverty line	
Squared poverty gap	Mean squared distance consumption to poverty line	
Inequality	Gini coefficient: Dispersion of estimated consumption	
Population density	People per square km	
Protection variables		
Share protected	Share of locality land strictly protected (NP or WLS)	IUCN World Database on Protected Areas (2007)
Share NP	Share of locality land protected as national park	
Share WLS	Share of locality protected as wildlife sanctuary	
Share FR	Share of locality land in forest reserves	Thailand Environment Research Institute (1996)
Locality fixed characteristics and pre-treatment controls		
Avg. slope	Average slope of land (deg)	National Geospatial Intelligence Agency-Digital Terrain Elevation Data from USGS Global GIS (1999)
Avg. elevation	Average elevation (m)	
Max. slope	Maximum slope (deg)	
Max. elevation	Maximum elevation (m)	
Distance major city	Distance to nearest major city (pop $>100{,}000$)	ESRI World Cities (2000)
Dist. 1962 major road	Distance to 1962 major road (km)	Digitized East Asia Road Map, US Map Service (1964); data from 1962
Dist. 1962 any road	Distance to 1962 minor road (km)	
Distance rail	Distance to railroad line (km)	Vector Map Level 0/USGS Global GIS (1997)
Distance major river	Distance to major river (km) (flow accumulation >5000)	USGS EROS Data Center, Hydro 1k dataset
Watershed boundary	Less than 1 km from the boundary of a major watershed	
Distance minerals	Distance to mineral deposit (km)	Mineral Resource Data System (MRDS)/USGS
Distance border	Distance to Thai national border (km)	Vector Map Level 0/USGS Global GIS (1997)
Temperature	Average monthly temperature in (C)	Ministry of Transp. of Thailand/Marc Souris (IRD)
Rainfall	Average monthly rainfall in mm	
Ecoregion 2	Share tropical and sub-tropical coniferous forest	WWF Conservation Science Program/USGS Global GIS
Ecoregion 3	Share tropical and sub-tropical dry broadleaf forest	
Waterfall	One or more waterfall points in locality	Mapguide Thailand (2009)
Northeast	Northeast region (dummy)	Thai NSO (2000)
Max flow	Maximum flow accumulation (area draining into each grid cell; cells $\sim$1 sq km)	Calculated from Hydro 1k dataset
Stream density	Stream density (km/sq km), calculated from rivers and streams layer	Thailand GIS data, courtesy of Marc Souris (2007)
Instruments		
Intersects tributary	Intersects a major tributary (dummy)	Major rivers of Thailand, courtesy of Marc Souris (2007)
Distance to tributary	Distance to nearest major tributary (km)	
Within 1 km tributary	Within 1 km of a major tributary (dummy)	

The socioeconomic variables used are average household consumption, poverty headcount, poverty gap, squared poverty gap and the Gini coefficient for consumption inequality. The poverty headcount ratio, poverty gap and squared poverty gap are part of the Foster–Greer–Thorbecke (FGT) family of poverty measures [88]. This family can be summarized as below [89]:

$$FGT(\alpha)=\left(\frac{1}{n}\right)\sum_{y_i<p}\left(\frac{p-y_i}{p}\right)^{\alpha} \qquad (1)$$

where n is the number of people (in the Thai data, in each locality), y_i is the per capita consumption of each individual, p is the poverty line, and α is a choice parameter that reflects distributional concerns. The expression $[(p-y_i)/p]$ is the poverty gap for each individual as a fraction of the poverty line. Therefore, when $\alpha=0$, the index simplifies to be the poverty headcount ratio (FGT0) which is the share of the population with consumption below the poverty line. When $\alpha=1$, the index measures the average poverty gap (FGT1), which indicates the extent of resources needed to lift people out of poverty. With $\alpha=2$, the index measures the squared poverty gap (FGT2). The squared poverty gap gives additional weight

Table 2
Summary statistics.

	(1) All localities	(2) High share protected[a]	(3) Low share protected[a]	(4) Difference in means (2)−(3)
Consumption	1528.1	1458.6	1538.2	−79.6***
Poverty headcount	0.214	0.233	0.211	0.022***
Poverty gap	0.049	0.057	0.048	0.009***
Squared poverty gap	0.017	0.021	0.017	0.004***
Gini coefficient	0.277	0.285	0.276	0.009***
Population density	107.3	49.2	115.8	−66.6***
Avg. slope	1.334	4.842	0.822	4.02***
Avg. elevation	242.0	503.9	203.8	300.1***
Max. slope	5.14	17.8	3.30	14.5***
Max. elevation	372.2	961.9	286.3	675.6***
Distance major city	86.7	108.6	83.5	25.1***
Dist. 1962 major road	10.77	16.70	9.91	6.79***
Dist. 1962 any road	5.64	10.98	4.86	6.12***
1973 forest cover	0.233	0.682	0.168	0.514***
Distance rail	57.06	82.54	53.35	29.19***
Distance major river	22.44	32.22	21.02	11.20***
Watershed boundary	0.487	0.776	0.445	0.331***
Distance minerals	115.9	86.4	120.2	−33.8***
Distance border	89.45	68.63	92.48	−23.85***
Temperature	25.17	23.19	25.46	−2.27***
Rainfall	1059.8	1033.7	1063.6	−29.9***
Ecoregion 2	0.004	0.014	0.003	0.011***
Ecoregion 3	0.714	0.584	0.733	−0.149***
Waterfall	0.033	0.178	0.012	0.166***

N total=4113, *N* high share=523, *N* low share=3590.
Columns 1, 2, and 3 give the mean values of variables. Column 4 gives the difference in means between localities with high and low share protected and the significance of a two-tailed *t*-test of the difference in means. The directions of the differences in means are all consistent with the qualitative designation priorities described in Section 4.2; localities with a higher share protected are more rugged and remote and had high initial shares of forest cover.
[a] High share protected defined as share protected $\geq 5\%$; low share protected as $< 5\%$.
*** $p < 0.01$.

to people far below the poverty line and so is higher both if average poverty is greater and if there is more inequality among the poor. In addition to the poverty indices, the Gini coefficient is included as a measure of income inequality among all households. A larger Gini coefficient implies a more unequal distribution of consumption within localities.

4. Did Thai protected areas exacerbate poverty?

The primary question of this paper is whether localities which had a high share of land protected have higher or lower socioeconomic outcomes by 2000 as a result of those conservation set-asides. A simple comparison of outcomes between localities with a high share protected and a low share protected demonstrates that there is a strong positive correlation between protection and poverty. This is illustrated in Table 2, which shows summary statistics by share of land protected.

Differences in means indicate that localities with a high share of land protected had significantly lower household consumption and higher poverty measures than those with a low share protected (Table 2, column 4). It would clearly be a mistake to jump from this association to the conclusion that protected areas cause poverty, because protected areas in Thailand were selectively located in areas with lower potential for economic development. Localities with a high share of land protected were also significantly more rugged (steeper slopes, higher elevation), farther from major rivers, less developed in the past (higher historical forest cover), and farther from pre-existing roads, rail lines, and cities (Table 2).

I employ two empirical strategies to account for this non-random placement of protected areas. First, standard OLS regressions are used to control for historically relevant variables that determined selection and could affect outcomes. I argue that remaining unobservable factors are most likely to bias socioeconomic results against a conclusion that protected areas improved economic development, given the historical context. Second, since sources of upward bias cannot be ruled out, I use priority watershed status to instrument for protection among the sample of upper watershed localities.

4.1. Ordinary least squares model

The OLS regressions estimate the following simple model of the relationship between share protected and socioeconomic outcomes:

$$y_{ij} = \beta_1 PA_{ij} + \beta_2' G_{ij} + \beta_3' X_{ij} + \alpha_j + \varepsilon_{ij} \quad (2)$$

where y_{ij} is the socioeconomic outcome for locality i, in district j, as measured in the year 2000. PA_{ij} measures the share of locality land designated as a protected area prior to the year 2000. G_{ij} is a vector of fixed geographic controls, X_{ij} is a vector of time-varying characteristics which are measured pre-treatment for each sub-district, and α_j is a district fixed-effect.

For β_1 to be an unbiased estimate of average protected area impacts, the model must include any determinants of y that are also correlated with the share of land protected. Based on a review of the history of the designation process, G_{ij} includes the following fixed characteristics: average and maximum slope, average and maximum elevation, distance to Thai national boundary, distance to large river, distance to mineral deposits, ecoregion, average temperature and rainfall, distance to nearest major railroad line, and dummies for whether the locality overlaps with an upper watershed and whether the locality has a touristic waterfall. X_{ij} includes the following pre-treatment characteristics: historical forest cover (1973), distance to major and minor roads (1962), and distance to nearest major city (established in the 1960s). District fixed effects (α_j) are included in all specifications to control for unobserved fixed factors at the district level such as political power or institutional strength.[11]

This model essentially identifies impacts on the basis of residual variation in the share protected between localities in the same district, conditional on fixed geographic characteristics and proxies for pre-protection development potential. Whether or not this variation is a good source of identification depends on whether the regression in fact captures all factors that are correlated with protection and might determine socioeconomic development. This in turn depends on how protected areas were actually designated in North and Northeast Thailand. A brief review of the historical context of protected area designation follows.

4.2. Protected area selection and the OLS model

Qualitative historical research[12] supports the assertion that selection decisions were made largely on the basis of physical and geographical characteristics which are controlled for in the above model. To the extent that other characteristics which are correlated with both selection and outcomes are omitted, they are most likely to bias the results against a positive socioeconomic finding.

4.2.1. Selecting protected areas

Much of the initial pressure for protection and the initial site selection is credited to Dr. Boonsong Lekagul, a Thai doctor and conservationist [75,90–92]. Lekagul campaigned for protected areas throughout the 1950s but had little success until the late 1950s, when a new general came to power in a coup. Lekagul apparently used personal political connections to this military leader and a helicopter tour of forest destruction to advocate for conservation set-asides [75,77,92]. His campaigning led to passage of the Wild Animals Reservation and Protection Act in 1960 and the National Parks Act in 1961. This legislation, which defined protected areas and established the process for their designation, remained in force without major changes throughout the period of this study. Protected area sites were designated mainly in the 1970s and 1980s, but sites were still being added in the 1990s and continue to be designated [93].

In 1959 and 1960, Lekagul toured Thailand with a representative from the US National Park Service, George Ruhle, to select initial protected area sites. A review of Ruhle's initial 1964 report and subsequent publications shows that protected areas were selected primarily on the basis of expected environmental benefits [14,72,90,93]. Sites were supposed to protect important watersheds, preserve scenic natural features, and maintain biological diversity by saving habitat for endemic and rare species. However, since planners did not have budget and personnel for extensive field surveys, in practice "environmental benefits" were usually defined with respect to geographic proxies such as terrain, hydrological features, distance to roads, and past forest cover.[13]

Lands with clear official land title were generally excluded from consideration [14,95]. In practice, this meant a very low probability of protection for flat lands that were not initially forested. Lands with existing timber and mining concessions were also less likely to be protected [14,76]. Finally, protected areas were more likely to be located near national borders due to security concerns. Locating parks near borders meant that nationally loyal personnel and resources could be deployed to areas threatened by neighboring countries or internal communist uprisings [75–77,82,83,96].

The history of designation suggests that locations were more likely to be protected if they had higher historical forest cover, were important for watershed protection, were further from high quality agricultural land, further from mineral and

[11] Another approach to account for time-invariant unobserved influences at the locality level would be to use panel data. Prior census data at the locality level was sought repeatedly by the author from the Thai National Statistical Organization and the author was informed that it cannot be shared with the public.

[12] In addition to the secondary sources cited, information is from personal communication with individuals including Jeff McNeely, IUCN, Louie Lebel and Po Garden, Unit for Social and Economic Research, Chiang Mai University, Dr. Benchaphun Ekasingh, Chiang Mai University, Dr. Pornchai (former RFD official), Mr. Veerasak (current RFD official, Chiang Mai Province) and from undated articles by the Bird Conservation Society of Thailand and Wildlife Fund Thailand.

[13] Vandergeest [94] describes a case in which the borders of a park appeared to be drawn along the contour lines from 1:50,000 military topographic maps, with some adjustments for existing forest cover. Aerial photographs available to central planners would have allowed them to distinguish between paddy rice and forested areas, but not the fruit trees, rubber trees, or the fallow areas which would mark agricultural uses of sloping and upland areas. Jeff McNeely also confirmed that this type of military map and some photos were the main tools used in laying out protected areas; forest cover often served as a proxy for more intact habitats. The GIS data shows that many of the protected area boundaries follow contour lines or rivers and streams.

timber resources, and were closer to national borders. Measures of or proxies for each of these characteristics were collected and are included in the OLS model above to control for these selection priorities. The differences in means for these covariates between localities with high and low share protected show the expected signs (Table 2). Regressions of the share protected on each of these characteristics also have the expected signs and the full set of geographic and pre-protection characteristics (G and X) predict more than 38% of the variation in share protected across localities (results available from author).

4.2.2. Potential omitted characteristics

Although the characteristics described above explain much about the selection process, OLS estimates could still be biased if there are additional characteristics that were correlated with selection and influenced development outcomes and that are not included in the regressions. The three most likely possibilities are political variables, initial levels of development, and tourist attractions.

In many situations, omitting local political power or institutional capacity would bias estimates of protected area impacts. In the Thai case, however, the historical context makes it highly unlikely that local political variables actually influenced selection. Protected areas were chosen and designated through a central political process that by all accounts largely ignored local communities' wishes or characteristics. There is repeated documentation of failure to consult local communities and the enclosure of community agricultural and forestry lands in protected areas [72,74,75,77,78,81,94,97].

The bypassing of local preferences stems from the administrative structure of government in Thailand and the history of land ownership. The division of the Royal Forestry Department that administered the parks system was nationally controlled [75], as was the approval process for protected areas [14]. In general, provincial governors and district officers for all ministries were appointed by the national government [98,99]. Even minor staffing and budget decisions were made at a national level. Localities had virtually no independent political power [100]. Locality development plans and budgets, including items related to environmental management, required central approval [101].

Much of the land that later became national parks and wildlife sanctuaries was already designated as "national forest reserves."[14] Since this land already belonged officially to the government, local settlements inside the parks or overlapping with the parks were illegal from the government's perspective.

Given this centralized selection process, it is unlikely that local institutional capacity or political power drove selection decisions. However, to the extent that localities did have enough political capacity to influence the process, they would most likely have lobbied against protection. Environmental protection was (and largely still is) assumed to have restricted local development [77,78,81,94] and the obvious correlation between protected areas and poverty makes this conventional wisdom easy to believe. Assuming that communities with more institutional capacity lobbied against protection and that institutional capacity is correlated with economic development, the OLS model would be biased against a positive socioeconomic finding.

A second potential omitted characteristic is initial development level. Due to data availability problems, initial development level is proxied for with historical land use[15] and distance to roads and cities, but cannot be directly measured. As described above, the available evidence indicates that central planners selected sites primarily on the basis of geographic characteristics. To the extent that socioeconomic factors influenced selection, it is likely that the planners reporting to the development-oriented military regimes in power during this period [96] would have located protected areas in order to minimize opportunity costs. If protected areas are negatively correlated with unobserved development potential, this would again bias the results against positive socioeconomic conclusions. For example, protected areas may have disproportionately included land occupied by ethnic minority groups who had lower initial development levels and often lacked formal land title; these areas would be likely to remain less developed in 2000.[16]

A final omitted characteristic to be considered is tourism potential, which could potentially bias the OLS results in favor of the conclusions. Protected areas were deliberately selected to include attractions such as rare wildlife, waterfalls, caves, limestone and sandstone cliffs, and the country's highest mountain tops [90,107]. The OLS specifications include some of these characteristics (slope, elevation, major rivers, waterfalls) but omit other characteristics which might have attracted tourists even in the absence of state protection and promotion. For communities to have captured the economic benefits from tourism potential in the absence of state protection would have required them to overcome local collective action problems in preserving and promoting these assets (also see discussion in Footnote 2). This is relatively unlikely in the Thai case given that there was no legal basis allowing communities to create private forest reserves or local protected areas [75,108,109]. Efforts to recognize community management in Thailand through a "Social Forestry Bill" stalled and failed in the late 1990s [75,109].

[14] The forest reserves designation process also ignored local realities and relied heavily on maps and images indicating historical forest cover [80,82,102–105].

[15] Specifications shown in the tables use forest cover in 1973; the results are robust to including forest cover from 1985 or 1992.

[16] An overlay of protected area boundaries with a map showing the location of ethnic minority villages [106] does not clearly show this pattern—major ethnic groups are represented both inside and outside of the protected areas.

Table 3
Socioeconomic outcomes and share protected (OLS estimates).

	Outcomes				
	(1)	(2)	(3)	(4)	(5)
	Log consumption (Baht/month)	Poverty headcount ratio	Poverty gap	Squared poverty gap	Gini coefficient
Share protected	0.135***	−0.066***	−0.017***	−0.006**	0.017**
	(0.033)	(0.017)	(0.006)	(0.002)	(0.008)
R^2	0.593	0.702	0.627	0.563	0.503
N localities	4113	4113	4113	4113	4113

Standard errors are robust, clustered at the district level. All specifications include the following controls: district fixed effects, 1973 forest cover, average slope, average elevation, max slope, max elevation, distance to major city, distance to rail line, distance to mineral deposits, distance to 1962 major and minor roads, distance to national boundary, distance to navigable river, average temperature, average rainfall, ecoregion 2, ecoregion 3, near watershed, waterfall. Average slope and elevation are controlled for flexibly by including dummies for six categories of equal sample size. Standard errors are similar if calculated using Conley's [121] method for correcting for spatial correlation, assuming cut-off values of 25 and 50 km.

*** $p < 0.01$.

** $p < 0.05$.

4.3. OLS results: share protected and poverty impacts

The OLS estimates indicate that protected areas have boosted household consumption and reduced poverty. Table 3 presents the estimates of the impact of share protected on socioeconomic outcomes. To interpret the coefficients, recall that protection is measured as the share of locality protected, ranging from zero to one. Consumption is measured in logs, so the coefficient in Table 3, column 1 indicates that a change from no land protected to all land protected, holding other controls constant, corresponds to an increase of approximately 13.5% in average monthly household consumption.[17] However, only a small number of localities actually have the full share of locality land protected—the median share for localities with some land protected is just one-third. A better sense of typical impacts can thus be gained by comparing expected outcomes for localities with no land protected versus one-third of land protected (i.e. divide coefficients by three). For this policy change, the expected increase in average monthly household consumption associated with protection is 4.5%, which is approximately 66 Baht per month or 1.70US$.[18] In terms of daily wages, 66 Baht per month represents less than one day of additional labor income.[19]

With respect to the poverty headcount ratio, an increase in the share of land protected from zero to one corresponds to a decrease in the ratio of households under the poverty line by 0.066 (Table 3, column 2). Converting this to the more realistic policy change from zero protection to one-third share protected implies a reduction in the poverty headcount ratio of 0.022. This is approximately 10.3% of the mean poverty headcount ratio. In a locality with 250 households (close to the median number of households) this would correspond to roughly five households changing status from below to above the poverty line.

The results indicate that protected areas also reduced the poverty gap and squared poverty gap. This means that protection reduced the depth of poverty and the inequality of poverty in addition to the number of households in poverty (Table 3, columns 3 and 4). At the same time, the Gini coefficient of income inequality among all households increased (Table 3, column 5). This suggests that households higher in the income distribution gained relatively more from protection than households lower in the income distribution.

As described in the previous section, the OLS estimates are most likely to be biased against results showing that protected areas improved socioeconomic development. It is therefore likely that they represent conservative estimates of the benefits of protected areas for local communities.[20] Since bias in favor of positive impacts cannot be dismissed, this motivates the use of the instrumental variables strategy described below, which can be applied to a sub-sample of localities.

[17] The estimated relationship between share protected and consumption measures, conditional on covariates, is best described by a linear relationship: second and third order terms for share protected are not significant. The results are also very similar if consumption is measured in levels rather than logs; logs are preferred because of the skewed distribution of average consumption.

[18] Average exchange rates in Baht/USD were 37.8 in 1999 and 40.1 in 2000 (Economist Intelligence Unit). 66 Baht is 4.5% of the average monthly consumption in localities with a high share protected (1458 Baht).

[19] The mean daily wage reported in the 1999 Village Survey (Thai NSO) ranges from 44 to 150 Baht/day; the average is 109 Baht.

[20] A comparison of the OLS regression results with and without the waterfalls variable (a major source of tourism potential) shows only a small change in the coefficient on consumption (13.8 vs. 13.5). This suggests that the potential bias from omitting tourism potential might be small. Another comparison takes advantage of the fact that some protected areas were designated after the year 2000. These areas are also likely to have tourist potential, but have not yet been protected. Restricting the sample to include only these areas gives similar results.

Table 4
Share protected and instruments (IV first stage).

	Dependent variable: Share protected area		
	(A)	(B)	(C)
Intersects with tributary	0.0606*** (0.0108)		0.0295** (0.0132)
Distance to nearest tributary		−0.0038*** (0.0007)	−0.0025*** (0.0008)
F-statistic: excluded instruments	31.44***	32.49***	17.31***
N localities	1595	1595	1595

Robust standard errors. The sample includes localities with total flow accumulation less than 10,000, within 1 km of a watershed boundary, and not overlapping with any major rivers. Regressions include district fixed effects and controls for 1973 forest cover, average slope, average elevation, max slope, max elevation, distance to major city, distance to rail line, distance to mineral deposits, distance to 1962 major and minor roads, distance to national boundary, distance to navigable river, average temperature, average rainfall, ecoregion 2, ecoregion 3, waterfall, density of streams and rivers, presence of any streams and rivers, presence of water bodies, maximum flow accumulation, and an interaction of maximum flow accumulation and northeast region.

*** $p<0.01$.

** $p<0.05$.

4.4. Instrumental variables model: priority watersheds

The IV approach instruments for protection with priority watershed status and is appropriate for the sample of upper watershed localities. In general, the protection of upper watersheds was a major conservation goal: national planners perceived that water supplies were vital for economic growth and believed that upstream forest cover determined downstream water quality and quantity [72,94,110,111].

The instrument takes advantage of the fact that among upper watersheds, those which supplied the tributaries of major rivers were more likely to be protected. According to conventional wisdom, protection of the ''head watersheds'' (or ''headwaters'') areas would improve downstream water quantity and quality.[21] Ruhle's initial protected area planning report, for instance, identifies several upper watersheds flowing into major rivers as important sites for protection.[22] In order to locate the headwaters areas, planners would have traced waterways back to their sources using maps of the major rivers and their major tributaries. This means that localities which are close to the upper reaches of major rivers were more likely to be protected.

The instruments therefore measure (a) whether a locality overlaps with a major tributary river and (b) distance to the nearest major tributary river. Impact estimates are obtained using standard two stage least squares. The first stage is

$$PA_{ij} = \pi_1' Z_{ij} + \pi_2' G_{ij} + \pi_3' X_{ij} + \pi_4' W_{ij} + \delta_j + u_{ij} \tag{3}$$

where PA_{ij} is the share protected of locality i in district j and Z_{ij} is the vector of excluded instruments. The vectors G and X are the same geographic and pre-treatment characteristics described in the OLS model above. W is a vector of additional controls for irrigation potential and δ_j is the district fixed effect.

As shown in Table 4, the instruments do significantly predict protection. The *F*-statistics for each of the instruments separately are 31.4 and 32.5 and the joint *F*-statistic is 17.3 (Table 4, columns (A)–(C)). Fig. 1 also visually illustrates the correlation between protected areas and major tributaries in upper watersheds. In the top panel (a), large rivers are shown as thick black lines and their major tributaries as thin black lines. Minor tributaries and other rivers and streams are shown as thin gray lines. Protected areas, which are shaded in gray, can be seen to overlap with the upper reaches of several of the river systems.

Good instruments must be correlated with the endogenous regressor (share protected) but should not directly affect the outcomes or be correlated with other variables that affect outcomes. This assumption is likely to hold among the sample of localities in upper watersheds (N=1595).[23] Among this sample, both ''major'' and ''minor'' tributaries appear within the

[21] For instance the 2003 ICEM [72] report notes that ''a water yield study recommended that 38% of the country, specifically the head watersheds should be under forest to maintain the required annual flow'' (p. 81).

[22] Ruhle [90]: "This area is a vital watershed as well, and should be fully protected as such" (referring to Thung Salaeng Luang, p. 5); "This uplift is part of the rim of the Khorat Basin, which has the most precarious water reserves of the entire country. Any use that may possibly affect the delicate water supply adversely should be scrutinized with caution" (p. 6 referring to Khao Yai).

[23] The sample includes only localities which are within 1 km of the boundary of a major watershed and have only small waterways. Small waterways is defined by excluding any localities which intersect with major rivers or which have a flow accumulation greater than 10,000 (this measures the upstream catchment area and was generated using a DEM to calculate the area above each cell that drains into that cell, where grid cells were approximately 1 km^2). The results are robust to using a cut-off of 5000 or 15,000 for flow accumulation.

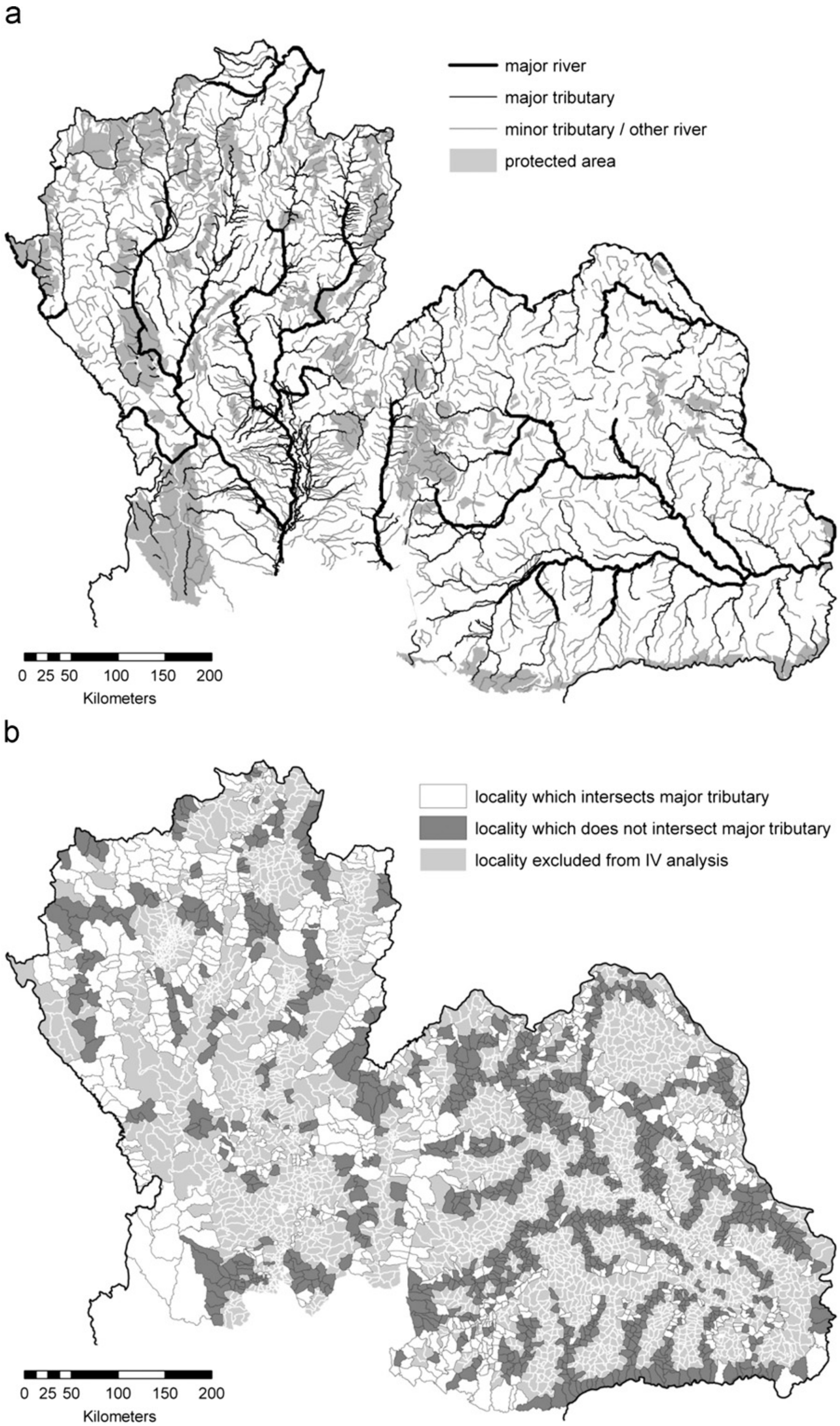

Fig. 1. Map of North and Northeast Thailand showing proximity to major tributaries as an instrument for protection: (a) locations of major rivers, major tributaries, other rivers and streams and protected areas and (b) localities with priority watershed status among upper watersheds.

locality only as small, non-navigable rivers and streams. Therefore, the instrument essentially picks up differences in the downstream destination of water, differences which should be uncorrelated with locality-specific characteristics.

Although it is not possible to test the exogeneity of the instrument directly, balance tests reveal that localities overlapping with major tributaries and other localities are not significantly different with respect to observable

Table 5
Socioeconomic outcomes and share protected (IV estimates).

	Outcomes				
	(1) Log consumption (Baht/month)	(2) Poverty headcount ratio	(3) Poverty gap	(4) Squared poverty gap	(5) Gini coefficient
IV estimates					
A. Intersects with tributary					
Share protected	0.372**	−0.183**	−0.063*	−0.030*	0.035
	(0.184)	(0.092)	(0.034)	(0.017)	(0.050)
B. Distance to major tributary					
Share protected	0.358**	−0.187**	−0.069**	−0.033*	0.020
	(0.172)	(0.093)	(0.035)	(0.017)	(0.048)
C. Both instruments					
Share protected	0.365**	−0.185**	−0.066**	−0.031*	0.028
	(0.170)	(0.088)	(0.033)	(0.016)	(0.046)
Overidentification test[a]	0.018	0.004	0.094	0.091	0.263
(p-value)	(0.893)	(0.950)	(0.760)	(0.763)	(0.608)
OLS estimates					
Share protected	0.151***	−0.082***	−0.021***	−0.008**	0.019**
	(0.033)	(0.019)	(0.007)	(0.004)	(0.009)

Robust standard errors. The sample and controls are the same as in Table 4 (N=1595). The OLS estimates are for the same localities as the IV estimates and include the same controls except for the excluded instruments.

[a] As there are two instruments and one endogenous regressor, Hansen's J-statistic [122] is reported as a test of overidentifying restrictions. The p-values indicate that in all cases we fail to reject the null hypothesis that the instruments are valid.

*** $p<0.01$.

** $p<0.05$.

* $p<0.10$.

characteristics such as distance to cities, climate, and average slope and elevation.[24] This suggests that the instrument is likely to be exogenous among upper watersheds, given that confounders would have to be orthogonal to these observable characteristics. In addition, as shown in Fig. 1b (bottom panel), the localities overlapping with major tributaries are well-mixed spatially in the sample of upper watershed localities. Localities overlapping with major tributaries are shown in white and other upper watershed localities in dark gray.

Finally, the IV regressions include controls that may help to alleviate potential concerns that the instrument could be correlated with factors such as trade routes or with better irrigation resources. Both stages of the regressions include controls that proxy for potential trade routes—distance to large rivers, distance to major cities, and distance to historical roads and rail lines.[25] With respect to irrigation resources, the regressions also include the density of local streams and rivers, the density of other water bodies, waterfalls, and maximum flow accumulation (denoted above as W). All regressions also include controls for slope, elevation, pre-treatment land clearing, distance to Thai boundary, distance to mineral deposits, temperature, rainfall, ecoregion and district fixed effects.

Falsification tests for the instrument are difficult to come by since nearly all outcomes could conceivably be affected by protection, which is correlated with the instrument. As a plausible but imperfect test, I regress per-area rice yield in 2003 on the instrument. Significant differences in per-area yield could indicate that the instrument is correlated in an undesirable way with unobserved land quality or irrigation potential. I do not find evidence for such differences.[26]

4.5. IV estimates: share protected and poverty impacts

The results of the IV estimation are given in Table 5. The rows show results for different combinations of the instruments[27] as well as the OLS estimates for the sample of upper watershed localities. Like the OLS results, the IV

[24] Two-tailed t-tests were run to compare differences between localities overlapping with a major tributary and not overlapping with a major tributary (variables were first demeaned by district because the appropriate comparisons are within-district). There were no significant differences (10% level) for distance to major river, average slope, average elevation, temperature, rainfall, distance to major city, distance to railroad, maximum elevation, percent forest cover 1973, distance to mineral deposits or distance to major or minor road in 1962. The group that is close to major tributaries has slightly higher maximum slope (significant at the 5% level but not the 1% level) and a slightly lower percent in ecoregion 3 (dry broadleaf forest).

[25] The results are also robust to controlling for current road density (layer from the late 1990s).

[26] The instruments are not significant predictors (10% level) of average rice yields. Yields are from a separate data source and are averages of estimated village-level rice yields reported to the Thai Community Development Department in the NRD2C survey (year 2003).

[27] Since there are two available instruments, a formal test of overidentifying restrictions based on Hansen's J-statistic is reported in Table 5. This test fails to reject the null hypothesis that the instruments are valid.

estimates suggest that protected areas have significantly increased consumption and decreased poverty. An increase in the share of land protected from zero to one corresponds to an increase in average household consumption of approximately 36–37% (Table 5, column 1) and a reduction in the poverty headcount ratio of approximately 0.18–0.19 (Table 5, column 2). The IV estimates also show significant decreases in the poverty gap and squared poverty gap and positive but not significant increases in the Gini coefficient.

Although the signs agree, the magnitudes of the impacts estimated using IV are more than twice as large as those found in the OLS regressions. The direction of the difference is consistent with the argument based on historical context that the OLS estimates could be biased against positive socioeconomic impacts. However, the Durbin–Wu–Hausman test for endogeneity suggests that the OLS and IV estimates are not significantly different.[28] Given that, we may prefer the results from the OLS estimation since they are more conservative estimates of potential socioeconomic gains from protection.

I have argued that the IV strategy is most appropriate among the sample of upper watershed localities ($N=1595$), for which the downstream destination of waterways is least likely to be correlated with local characteristics. The strategy does work on the full sample of localities ($N=4113$) although the instrument is weaker in the first stage ($F=11.48$). These regressions also indicate positive and marginally significant increases in consumption and reductions in poverty (results available from author).

5. Were protected areas environmentally effective?

An improvement in the socioeconomic status of localities due to environmental protection is surprising only if protection also imposed a binding constraint on land use. To test whether protected areas have significantly reduced land clearing, I construct cross-sectional and panel data on forest cover at the locality level. The sources of map and satellite data on forest cover for each of the available years (1967, 1973, 1985, 1992, and 2000) are given in Table 6.

The means across time in Table 6 agree with the many accounts of rapid forest clearing in Thailand over this time period.[29] For instance, the Royal Forestry Department estimated that forests covered 53% of Thailand's land area in 1961 and only 27% of total area by 2000 [79]. The panel data gathered here shows that forest cover decreased rapidly in the 1970s and 1980s. During that period, land clearing was encouraged by a variety of government programs including agricultural subsidies, land laws which rewarded clearing, and lax enforcement. Encouragement to clear by some agencies conflicted with attempts to control the extraction of timber and forest products or to slow permanent conversion to agriculture [82,104,109]. In the late 1980s and 1990s, the pace of new deforestation slowed and some of the new deforestation in the North was offset by reforestation of areas in the Northeast.[30]

5.1. Panel estimation of protected area impacts on forest cover

Protected areas are clearly associated with higher levels of forest cover: the mean among localities with a high share protected is 55% while the mean among localities with a low share protected is 12%. Again, these statistics are misleading with respect to the actual impact of protection on forest cover, which must account for the selection of protected areas.

The most basic strategy to account for selection is to repeat the OLS and IV estimation described in the previous section, using the cross-section of forest cover from 2000 (Table 7, columns 1 and 2). Given the panel data constructed for forest cover, it is also possible to control more directly for time-invariant unobservable characteristics such as land quality, which might determine both the share of locality protected and subsequent forest cover. I therefore also estimate the following model:

$$pctforest_{ijt} = \lambda_1 PA_{ijt} + \alpha_i + \alpha_{jt} + \varepsilon_{ijt} \tag{4}$$

where $pctforest_{ijt}$ is the forest cover (in percent) for locality i in district j at time t. PA_{ijt} is the share of locality i in district j protected at time t and α_i is a locality fixed effect. I also include a set of district-year fixed effects (denoted as α_{jt}) to control for regional deforestation trends.

5.2. Estimated impacts of protected areas on forest cover

As shown in Table 7, the results demonstrate that protected areas did significantly increase forest cover, preventing clearing that otherwise would have taken place and imposing a binding constraint on land use. The estimated magnitude of the effect of protection on forest cover is moderate. The regressions that use only the cross-sectional data (columns 1 and 2) indicate that a change from zero to the full share of a locality protected results in an additional 16–18 percentage points of forest cover. Comparing the OLS and IV estimates on forest cover (columns 1 and 2), we see that the IV estimates are slightly smaller although we fail to reject the null hypothesis that the OLS and IV estimates are equal using

[28] See [112] for a description of this test. The test was run for each of the IV specifications in Table 5, paired with the OLS estimates for the sample. In all cases this test fails to reject the null hypothesis that the OLS estimates are equal to the IV estimates for the upper watersheds sample.

[29] Additional literature on drivers of deforestation in Thailand includes [113–115].

[30] Since 1989, a nation-wide logging ban has officially prohibited large scale logging in all areas but has been difficult to enforce.

Table 6
Forest cover panel data summary.

Year	1967	1973	1985	1992	2000
Source	Royal Forestry Dept.	Tropical Rain Forest Information Center (TRFIC), Michigan State University			Royal Forestry Dept. courtesy of Marc Souris
Type of data	Digitized map	Landsat MSS	Landsat MSS	Landsat TM	Landsat TM
Scale/resolution	1: 2,500,000	60 m	60 m	30 m	30 m
Mean percent forest cover by locality: all localities	51.8	23.3	16.9	15.3	17.1
Mean percent forest cover: $>50\%$ initial	84.5	40.9	29.9	26.9	28.7

The author thanks the Harvard Map Library and Anjali Lohani for digitizing and geo-referencing the 1967 map; all other geo-referencing and processing was done by the author. All maps were geo-referenced to match the 2000 layer, which was geo-referenced by the Thai Royal Forestry Department. The last row indicates means among localities which had at least 50% forest cover according to the 1967 map.

Table 7
Effectiveness of protected areas in reducing clearing.

	Forest cover (%)				
	Cross-section (2000)		Panel (1967–2000)		
	(1) OLS (all localities)	(2) IV (Panel A)	(3) Locality FE (all localities)	(4) Locality FE ($>10\%$ initial forest cover)	(5) Locality FE ($>50\%$ initial forest cover)
Share protected	18.20***	16.38	7.09**	11.47***	19.42***
	(3.99)	(12.13)	(2.85)	(2.70)	(3.06)
R^2	0.867	0.895	0.593	0.695	0.816
N localities	4113	1595	20565	16430	10495

Column 1 repeats the OLS specification in Table 3 with forest cover measured in 2000 as the outcome variable. Column 2 repeats the IV specification from Table 5, Panel A. Columns 3–5 are panel estimations including locality fixed effects and time by district specific fixed effects. Standard errors are clustered by district. Column 3 includes all years and all localities; Column 4 includes only localities which began with at least 10% forest cover in 1967, and Column 5 includes only localities with at least 50% of forest cover in 1967.
*** $p<0.01$.
** $p<0.05$.

the Durbin–Wu–Hausman test described above. The direction of the difference between the OLS and IV results is consistent with potential sources of bias in the OLS estimates (assuming that variables which would be positively correlated with socioeconomic outcomes would be negatively correlated with forest cover outcomes).

In order to compare the constraint on land use imposed by protection to the consumption benefits generated by protected areas, it is again useful to think of a change from zero to the median share protected (divide coefficients by three). Using the OLS estimates, this change would correspond to an expected increase in forest cover of 6 percentage points. This corresponds to a reduction in available cleared land of approximately 11%.[31]

The panel data estimates also indicate that protected areas increased forest cover. The magnitudes vary somewhat depending on whether we include all localities or those which had significant forest cover in the 1960s. The regressions using all localities indicate that a change from zero to the full share of a locality protected is associated with an additional 7 percentage points of forest cover (Table 7, column 3). Regressions restricting the sample to localities which originally had 10% (column 4) or 50% (column 5) of forest cover in the 1960s indicate larger estimated effects. Protection may have been substantially more effective in slowing clearing where initial levels of forest cover were high.

Interestingly, the estimated impacts of protected areas on forest cover are similar to previous estimates from other middle income countries (as described in Section 2.2), but larger than the estimates from an earlier study in Thailand by Cropper et al. [44]. The previous study in Thailand did not find that national parks and wildlife sanctuaries together significantly reduced the probability of clearing in the North region. The difference in conclusions may be explained by the

[31] The mean percent forest cover for localities with land in protected areas is approximately 54%. The overall sample mean in this case (17%) is not a good reflection of the typical locality because localities with a high likelihood of protection had much higher forest cover.

Table 8
Socioeconomic outcomes and share protected by IUCN category.

	Outcomes					
	(1) Log consumption (Baht/mo)	(2) Poverty headcount ratio	(3) Poverty gap	(4) Squared poverty gap	(5) Gini coefficient	(6) % Forest cover
Share WLS (I)	0.054	−0.019	−0.008	−0.004	0.004	26.6***
	(0.050)	(0.032)	(0.013)	(0.006)	(0.012)	(5.3)
Share NP (II)	0.086**	−0.057***	−0.015***	−0.005**	0.007	22.2***
	(0.038)	(0.018)	(0.005)	(0.002)	(0.009)	(3.9)
Share FR (IV)	−0.062***	0.022***	0.005*	0.002	−0.011***	5.7***
	(0.016)	(0.008)	(0.003)	(0.001)	(0.004)	(1.3)
R^2	0.870	0.596	0.703	0.628	0.563	0.505
N localities	4113	4113	4113	4113	4113	4113

Standard errors are robust, clustered at the district level. All controls from Table 3 (OLS model) are included here.
*** $p<0.01$.
** $p<0.05$.
* $p<0.10$.

fact that Cropper et al. use forest cover data from 1986, which coincided with a period of relatively lax enforcement of Thailand's protected areas [75].[32]

6. Discussion: tourism as a potential channel

The regressions above suggest that protected areas have had a positive socioeconomic impact despite reducing the amount of land available to communities for agricultural use. The most likely explanation is that protected areas attracted sufficient tourism benefits to offset the opportunity costs of reduced agricultural production or natural resource extraction. A discussion of the evidence for this mechanism and possible alternate explanations follows.

6.1. Impacts by category of protection

If protected areas reduced poverty because of tourism income, we should expect to see greater impacts for the national parks than for the wildlife sanctuaries. National parks (IUCN category II) allow for and encourage recreational use, while wildlife sanctuaries (IUCN category I) permit only small-scale ecotourism or research activities [14,72,95].[33]

As shown in Table 8, national parks are indeed associated with larger increases in consumption and reductions in poverty than wildlife sanctuaries. For instance, the reduction in the poverty headcount ratio for a change from zero to full protection is 0.057 for national parks but 0.019 for wildlife sanctuaries. The differences in coefficients are not significant but are consistent with the tourism explanation.

Although localities with land in national parks have fared better than localities with land in the more strictly protected wildlife sanctuaries, both have done better than localities with land in the weakly protected national forest reserves.[34] The forest reserves, which are comparable to IUCN category IV, have a long and complicated history of restrictions on forest use and extraction but generally very weak enforcement [103,105]. Table 8 shows that having more land in the national forest reserves is significantly associated with increased poverty headcounts (column 2) and reduced consumption (column 1). The national forest reserves also appear to have had smaller effects on forest cover than the national parks or wildlife sanctuaries (column 6).

Evidence that strict protection actually promoted economic development while weak protection did not runs counter to the conventional wisdom (e.g. [116]). In general we expect that strictly protected areas are more likely to harm local communities while weak protection might balance environment and development goals by allowing more resource use. The Thai case suggests the opposite, possibly because strictly protected areas have attracted enough tourism or infrastructure benefits to offset opportunity costs while weakly protected areas have not.

[32] Methodological differences may also explain the divergence in results. Cropper et al. [44] instruments for protection in a bivariate probit model with distance to major river. That instrument inspired the watershed status instrument used here, but as previously mentioned, this study controls for distance to major river under the assumption that it has important direct effects on forest clearing and development.

[33] The two types of strictly protected areas are similar with respect to geographic and pre-treatment characteristics.

[34] Note that including the share of land in forest reserves changes the interpretation of the coefficients and so they cannot be directly compared to Table 3. In Table 3 the omitted reference group is localities with zero share in strictly protected areas (national parks or wildlife sanctuaries) whereas in Table 8 it is localities with zero share in national parks, wildlife sanctuaries or forest reserves.

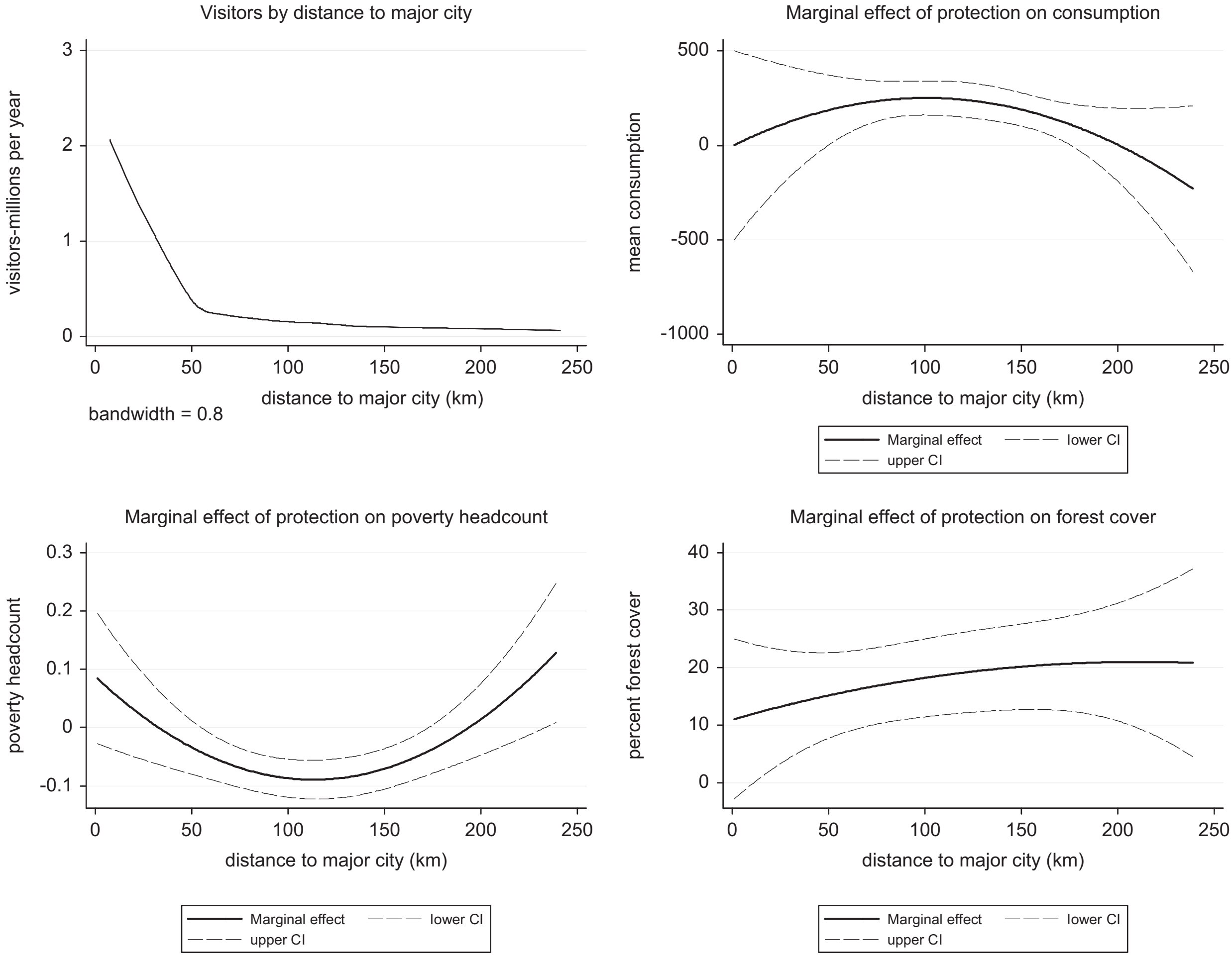

Fig. 2. Tourist visits and marginal effects by distance to nearest major city. Visitor statistics from the National Park, Wildlife, and Plant Conservation Department Statistics. Data courtesy of Nipaphorn Paisarn and Surachet Chettamart, Faculty of Forestry, Kasetsart University, Bangkok. The visitor numbers are calculated as millions per year to the first and second largest parks in the locality.

6.2. Tourist visits and net impacts by distance from major cities

Data on actual visits to protected areas indicates that the volume of tourists is large, compared to the population of the relevant localities, and that the magnitude of the results could be explained by increased tourism. Official statistics indicate that there were 10.47, 10.36, and 10.81 million visitors to parks in the study area in 1998, 1999, and 2000. These visitor statistics include both foreign and domestic tourists. Foreign tourists are approximately 10–15% of the overall total although this varies by protected area.[35]

Previous sections indicated that the estimated positive effect on consumption (for a change from zero to the median share protected) was approximately 4.5%, while the estimated negative effect on land availability was approximately 11%. A back of the envelope calculation suggests that if each tourist visit generated approximately $1.20 (46 Baht) in net income, this would be enough to explain the net increase in average household consumption.[36] This is a very rough calculation, but the order of magnitude of net income that would need to be generated to explain the results seems reasonable.

[35] Surachet Chettamart, Faculty of Forestry, Kasetsart University, Bangkok, personal communication (2007).

[36] Calculation: assume that household income is entirely agricultural and that income is reduced in proportion to lost land availability. Assume that households are not saving significantly, so income losses translate directly into consumption losses. Therefore, the consumption cost of protection is approximately 11% of household consumption. To achieve a net increase of approximately 5% consumption, tourism would have to generate increases equal to 16% of household consumption, or approximately 233 Baht per month (2796 Baht per year). The total number of households in localities with a protected share of land greater than 1% is 172,978. The annual number of visitors per household (if visitors were evenly distributed) would be approximately 61 per year. Each tourist would need to contribute 2796/61 = 46 Baht of net income to generate the observed increases in household consumption.

Anecdotally, there is evidence of institutional mechanisms which may have helped local communities to benefit from tourism. Government agencies including the Royal Forest Department have attempted to help locals by supporting training courses in touristic guiding or providing lodging [79,95,117]. In addition, a provision passed in 1996 required parks to give localities a small portion of collected revenue from entrance fees [118].

We might expect that net benefits would be highest where there are the most tourists. As illustrated in Fig. 2 (upper left panel), park statistics show that tourists are most numerous close to major cities. However, the marginal effect of protection on consumption (Fig. 2, upper right) is highest at *intermediate* distances from major cities. The marginal effect of protection on the poverty headcount ratio is also highest at intermediate distances. These patterns cannot be explained by enforcement, because the marginal effect of protection on forest cover is relatively flat or increases slightly as protected areas are further away from major cities (Fig. 2, lower right).

Instead, a likely explanation is that while tourist visits are highest near urban areas, the opportunity cost of forgone agricultural land is also highest near major cities. As famously noted by von Thünen, agricultural land will be most valuable where transport costs are low. Therefore, close to cities, the additional income from tourism may barely be enough to make up for the high opportunity cost. Conversely, far from cities, opportunity costs are low but so are tourism prospects. This heterogeneity in impacts by distance highlights the importance of understanding the spatial patterns of both costs and benefits of protection. Spatial patterns may be the key to future attempts to minimize conservation-development tradeoffs, a point that has been made in the conservation targeting literature [22–24].[37]

6.3. Alternate explanations: migration and spatial spillovers

Although tourism is a plausible explanation for the observed effects, migration is often raised as an alternate possible mechanism. If poorer households selectively moved out of localities in response to protection, average wealth would increase. If this mechanism held, we should then see significantly lower population density for sub-districts with protected land. This pattern is not found in the data—population densities in 2000 are not significantly different. Robustness checks also indicate that changes in population density between 1990 and 2000 are not significantly different even though this period coincided with stricter enforcement and therefore the greatest likelihood of migration away from protected areas.[38] In summary, migration could explain the results only if out-migration of poor households were matched equally by in-migration of wealthier households.

Spatial spillovers are another suggested alternate mechanism. Restrictions on land use in protected localities may increase agricultural prices or drive down wages in nearby communities. Such price spillovers would tend to increase deforestation in neighboring communities, increase the rents to agricultural land use for land-owning households and reduce the incomes of landless households. Spillovers were tested for in the regression framework using spatial lags measuring distance to the nearest protected area. The results indicate that deforestation spillovers are negligible and that socioeconomic spillovers are small and positive.[39] This suggests that neighboring localities may have gained from protection—perhaps by catering to tourists traveling to and from protected areas or because of increased agricultural rents. Because economic spillovers are positive, they are unlikely to explain the result: higher socioeconomic outcomes among control communities will make the positive socioeconomic effects of protection appear smaller rather than larger. The results are also robust to excluding from the set of controls any localities within 20 km of a protected area (i.e. removing neighbors from the set of controls), again suggesting that spillovers do not explain the results.[40]

Although migration and spillovers are unlikely to explain the results, they could be explained by other sources of income (besides tourism) or by the mitigation of open access problems. Protected areas do directly employ some local workers and could have attracted additional infrastructure projects. For instance, ''Royal Projects'' initiated by the Thai royalty to promote local development might have been differentially targeted to communities near protected areas. International environmental organizations have sponsored integrated conservation and development projects around protected areas which could have boosted incomes. Finally, income from forest products could have increased. Although the extraction of most products is officially prohibited, local communities who do collect forest products may have benefitted because protection has restricted access to these resources by outsiders, mitigating open access problems and maintaining income sources for locals.

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[37] The results of positive socioeconomic gains from protection in both the IV and OLS specifications are robust to dropping any parks within 10 km of a major city (Doi Suthep) and to dropping the ''flagship'' parks with the most visitors (Khao Yai, Doi Suthep, Doi Inthanon). Specifications that include controls for the length of time since establishment indicate that older parks on average are associated with larger socioeconomic gains. This is consistent with a story where it takes time to promote and develop tourism but cannot be distinguished from a story where older parks have more tourism potential.

[38] Population density is not significantly related to share protected, conditional on controls (same specification as Table 4). If both share protected as national parks and share protected as wildlife sanctuaries are included, there is a marginally significant (10%) level increase in population density for wildlife sanctuaries. Changes in population density from 1990 to 2000 are not significantly related to the share protected, based on data from the Center for International Earth Science Information Network [119].

[39] The spatial lags are included in the same specification as Table 3 (OLS); results available from author.

[40] Both magnitudes and significance of the OLS results are robust; IV results are robust in terms of magnitude but lose significance because of the smaller sample.

7. Conclusion

Strictly protected areas in Thailand are clearly associated with high levels of poverty. However, after accounting for the selective placement of protected areas in locations with dramatically lower development potential, this paper finds that protected areas have contributed to economic development and reduced poverty. The most likely explanation is that economic benefits from increased tourism have been large enough to offset the costs of restrictions on land use.

This result is interesting, since it provides evidence for net positive economic outcomes due to protected areas in a developing country, but we should be careful not to extrapolate from Thailand's experience to other countries with very different social and political situations or to draw overly positive conclusions about protected areas in general. Thailand had rapid economic growth and a relatively stable political situation during the study period and its government invested considerable resources in the protected areas system and in promoting tourism generally. In other countries and situations the local benefits of parks may not outweigh local costs. Future work is needed to understand how institutional structure and infrastructure development might play a role in mitigating the opportunity cost of land restrictions and helping local communities to capture tourism benefits.

Even where protected areas positively contribute to local development, these improvements may be unevenly distributed. This study suggests that protected areas reduced local poverty but may have increased overall local inequality. In addition, the bulk of environmental benefits from watershed protection and biodiversity conservation may still accrue to larger regions or the global community. Future work should therefore focus on understanding how redistributive policies or payments for environmental services schemes might mitigate distributional concerns. This is particularly important in light of ongoing efforts to expand protected area systems under agreements to reduce greenhouse gas emissions from deforestation and forest degradation [4,120].

Finally, it would be valuable to understand how protected areas in developing countries have affected a broader set of environmental and social outcomes, including biodiversity, water quality, and health. The limitations of current data to shed light on these questions suggests the need for additional long term monitoring efforts to track the effects of protected areas on both the environment and economic development.

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