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# Impacts of Protected Areas on Local Livelihoods in Cambodia

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**Summary.** — Impact evaluation methods (mixed effects models and matching) were used to investigate the effect of protected areas (PAs) on poverty and livelihoods in Cambodia, comparing households inside PAs with bordering villages and controls. There was no evidence that PAs exacerbated local poverty or reduce agricultural harvests in comparison with controls. Households bordering the PAs were significantly better off due to greater access to markets and services. Non-timber forest product (NTFP) collectors inside PAs were significantly better off than controls and had greater rice harvests, because they had more secure access to land and forest resources. The PAs in Cambodia therefore have some positive impacts on households that use forest and land resources for their livelihoods.


*Key words* — Southeast Asia, conservation, impact evaluation, matching non-timber forest products

## 1. INTRODUCTION

The impacts of protected areas on local poverty—both negative and potentially positive—have been widely debated (Adams & Hutton, 2007; Roe, 2008). Although the global benefits of biodiversity and ecosystem services are well recognized (Balmford *et al.*, 2002; TEEB, 2010), the costs of protected areas (PAs) may be disproportionately borne by local people (Adams & Hutton, 2007; Cernea & Schmidt-Soltau, 2006; West, Igoe, & Brockington, 2006). Debates have focused on whether the environmental goals of protected areas are compatible with poverty alleviation goals, especially in developing countries (Adams *et al.*, 2004). There is now widespread acceptance that conservation policy should, at the very least, do no harm, and where possible should contribute to poverty alleviation (CBD, 2008). Accurate understanding in policy choices is limited by the paucity of information that exists regarding the impacts of current interventions on local poverty (Agrawal & Redford, 2006). For example, high poverty rates have been documented around PAs, but very few studies have attempted to quantify whether this is due to the PA or other factors (Andam, Ferraro, Sims, Healy, & Holland, 2010; Naughton-Treves, Alix-Garcia, & Chapman, 2011; Sims, 2010). The need to better understand the relationship between forest conservation policies and local poverty and the lack of information on impacts has led to repeated calls for the adoption of rigorous impact evaluation methods (Ferraro & Pattanayak, 2006; Pattanayak, Wunder, & Ferraro, 2010; Wilkie, Morelli, Demmer, Starkey, Telfer, & Steil, 2006). Measuring impacts is also necessary during implementation to ensure that interventions do not negatively affect local people (Schreckenberg *et al.*, 2010).

Whether PAs benefit or impose costs on local people depends upon the underlying relationship between local poverty and forest resource use (Angelsen & Wunder, 2003), external drivers, the rules and regulations imposed by the PA and the extent to which these are implemented. The forest-poverty relationship is dynamic and may be different for different groups of people, implying that social impact assessment needs to consider who gains or loses, and when. Forest resources may contribute to local livelihoods through: (*1*) a needs-driven forest reliance, whereby local poor people depend on low-value forest resources to some extent for their livelihoods,

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perhaps in response to shocks ("safety nets"), or (*2*) because they are unable to make the transition out of this resource-dependent mode ("poverty traps"); and (*3*) an opportunity-driven forest reliance, whereby local people use higher-value forest resources as a source of cash products in order to get richer ("pathways out of poverty," Angelsen & Wunder, 2003; Ruiz-Pérez *et al.*, 2004). PA interventions can forcibly influence these relationships by either placing restrictions on forest resource use (Coad, Campbell, Miles, & Humphries, 2008), displacing and resettling people (Brockington & Igoe, 2006), or increasing costs due to wildlife conflicts (Woodroffe, Thirgood, & Rabinowitz, 2005). Alternatively, interventions may encourage and promote local forest resources use, for example through improved marketing or safeguarding access rights, exclusion of outsiders creating local monopolies, and may provide alternative pathways out of poverty through employment and business opportunities (Coad *et al.*, 2008; Scherl *et al.*, 2004; Wunder, 2001).

Rigorous impact evaluation survey designs can be used to untangle the impacts of forest conservation policies from the wider dynamics of the system, by assessing the degree to which changes in poverty can be attributed to policy interventions as opposed to other factors (Ferraro, 2009). Standard approaches use randomized control trials with policy interventions assigned randomly to intervention and control sites in order to eliminate other sources of bias. However placement of forest conservation interventions, such as PAs, is usually non-random (Joppa & Pfaff, 2010a). In these cases, quasi-experimental survey designs such as matching can be used to control for other sources of bias by ensuring that intervention and control groups are comparable in all aspects except that the control groups have not received the intervention (Ferraro & Pattanayak, 2006; Ravallion, 2006; Rosenbaum & Rubin, 1983).

A second methodological problem in social impact assessment concerns how to define and measure poverty in order to assess trends (Ravallion, 2003). Poverty is a multi-faceted concept incorporating social, political, cultural, institutional, and environmental dimensions (McGregor, 2007; Scoones, 1998; Sen, 1999), which can be measured in several aspects: incidence, intensity, inequality, temporality, and spatiality (Agrawal & Redford, 2006). Standard approaches include household consumption and income surveys usually with multiple visits to the same households over the sampling period (Angelsen, Larsen, Lund, Smith-Hall, & Wunder, 2011; Wilkie *et al.*, 2006). These detailed methods can be expensive and time-consuming, and may neglect other non-economic dimensions of poverty. If measuring the impact of environment and development interventions is to become common practice there is a need to develop accurate and cost-effective methods that capture multiple dimensions of poverty and are appropriate for widespread use (Schreckenberg *et al.*, 2010).

This paper uses matching and regression estimators to evaluate the impact of two PAs on the livelihoods of local people in Preah Vihear province, Cambodia. Both PAs contained established villages, and have been the focus of a long-term PA management and development program since 2005. (Clements, John, Nielsen, An, Tan, & Milner-Gulland, 2010). The objective of this study was to investigate impacts due to the PAs since their establishment. It also established a baseline against which the subsequent implementation of three Payments for Environmental Services schemes, which were initiated in 2008, could be evaluated. The principal research questions addressed in this paper are: (*1*) what factors affect household poverty status and agricultural productivity; (2) what has been the overall impact of the PAs on local poverty and agricultural productivity in comparison with bordering villages and controls; and (*3*) have the PAs had different impacts on different types of livelihood strategies in comparison with controls.

## 2. IMPACT EVALUATION FRAMEWORK

### (a) *Background to the study site*

Cambodian PA boundaries were drawn in the 1990s and early 2000s, based primarily upon habitat types, historical records, and very limited fieldwork, due to ongoing conflicts at that time. In general they are located in remote forested areas of Cambodia, where road access is poor and local poverty is higher than the national average (World Bank, 2009). Most PAs contain established villages since the location of settlements was not known when the PA boundaries were drawn, and these villages were not resettled. The impact evaluation focused on the core Management Zones of two PAs—the 1,811 $km^2$ of Kulen Promtep Wildlife Sanctuary (KPWS) and 1,776 $km^2$ of Preah Vihear Protected Forest (PVPF)—in Preah Vihear province (Supplemental materials, Figure S1). KPWS was declared in 1993 as part of the Nature Protected Area network managed by the Ministry of Environment, and PVPF in 2002 as a Protected Forest managed by the Forestry Administration of the Ministry of Agriculture, Forestry and Fisheries. Fifteen villages were located inside KPWS and PVPF, the majority of which had existed since at least the 1960s, although there was considerable disruption in the 1970–90s, due to the civil war and forced resettlement by the Khmer Rouge. Resettled people subsequently returned to their original villages from the 1990s onward. Local people are primarily subsistence farmers, practicing either rain-fed paddy rice cultivation or shifting cultivation, and are dependent upon forest resources as a crucial safety net and for cash income (McKenney & Prom, 2002; McKenney, Yim, Prom, & Evans, 2004). One of the most important sources of cash income is the sale of liquid resins from dipterocarp trees, which makes up 16–23% of household income, with resin-tapping households earning $100–$340/year (Evans, Hout, Phet, & Hang, 2002; McKenney *et al.*, 2004).

Gazettment of the PAs protected those areas from development pressures (such as forestry and agro-industrial concessions). However both PAs remained essentially paper parks until the start of a long-term PA management capacity-building in 2004–05, which provided authorities funding of around $2/ha for the management zones, which is broadly comparable to the budget for other PAs in developing countries (Bruner, Gullison, & Balmford, 2004). PA authorities were charged with enforcement of Cambodian Law, under which local uses of natural resources are legal inside PAs, although land clearance, cutting of timber for sale, and wildlife trade are illegal. Villages were permitted to expand agriculture to a limited extent within agreed land-use plan boundaries, and in-migration by outsiders was prevented. In addition, community development interventions since 2005 included local livelihood assistance, helping villages to gain official status and formalize land-use plans. The impact evaluation took place in 2008, 4 years after the PA management activities were initiated.

### (b) *Village and household matching methods*

Matching methods were used to select appropriate controls for households and villages inside KPWS and PVPF against which to measure the impacts of PA management. A nested survey design was used, with two levels of matching: (*1*)

selecting control villages that were similar to villages inside the PAs in order to measure overall impacts; and (*2*) selecting control households within the control villages that had similar characteristics to households inside the PAs. The first dataset considered overall effects of PAs, whereas the second investigated specific impacts for different livelihood strategies. Prior to matching, a detailed qualitative analysis of the factors influencing the placement of PAs and household livelihood strategies was undertaken to ensure that the appropriate covariates were used to select controls (Ravallion, 2006).

Potential matches to the 15 villages inside the PAs were chosen from a database of all 211 villages in Preah Vihear province. The matching variables selected were factors that influenced PA placement and the main determinants of poverty at the village level, based upon their value in 2005 when the PA interventions started (see Supplemental materials for details). Consequently, the matching covariates were exogenous to the PA intervention, i.e., they were not likely to have been affected by the PA interventions over the timeframe of the analysis. For households, matches were chosen from a database of 504 households from 11 villages within the PAs, and 205 households from the five control villages selected by the village-level matching. The matching variables were the key determinants of household livelihood strategies and poverty status based on previous research (see Supplemental materials for details, Evans *et al.*, 2002; Hansen & Top, 2006; McKenney & Prom, 2002; McKenney *et al.*, 2004; World Bank, 2009). Analyses were carried out in R 2.13.0 using the package "matching" (R Development Core Team, 2011). Nearest-neighbor covariate matching was used (Abadie & Imbens, 2006), allowing matching against multiple variables with equal weighting, which is appropriate when considering complex livelihoods that have multiple dimensions. The Mahalanobis distance (Abadie & Imbens, 2006) was used to measure distance in the multivariate space, as in previous studies (Andam, Ferraro, Pfaff, Sanchez-Azofeifa, & Robalino, 2008; Andam *et al.*, 2010; Joppa & Pfaff, 2010b). Two matches were selected for each village inside the PAs, to ensure an adequate sample of controls, and one match for each household. All matching was with replacement and ties were handled deterministically by weighting the tied matches (Abadie & Imbens, 2006). For household matching, a caliper of 0.5 standard deviation units was used to define an acceptable distance for any match, rejecting households for which matches could not be found. Balancing tests were used to evaluate the results of matching estimators, by comparing the matching variables for the intervention and matched control groups.

### (c) *Matched datasets*

Matching selected 15 possible control villages, and balancing statistics and tests indicated that balance had been achieved in the matched sample (Supplemental materials, Table S1). Two of the villages were within 10 km of the PAs and were excluded from the sample to prevent spillover effects. Random stratified sampling by district was then used to select five controls, ensuring that the control villages were distributed across the landscape, with the controls distributed 20–60 km from the boundaries of the PAs. For households, the matched dataset contained 325 households within PAs (64% of 504 households), matched with 134 households from the control villages outside PAs (65% of 205 households). Households operate as discrete economic units in Cambodia, which is why households were selected as an appropriate sampling unit for the purposes of this analysis. Balancing statistics and tests indicated that balance had been achieved in the matched sample for all eight covariates (Supplemental materials, Table S2).

## 3. SURVEY METHODS

Three survey methods were used: (*1*) household surveys of livelihood strategies and poverty status; (*2*) surveys of village-level characteristics; and (*3*) informal qualitative discussions around livelihoods and poverty and drivers of change. In total 871 households were sample from 20 villages; 504 from 11 villages inside the two PAs (selected randomly from the 15 inside the PAs), 205 from the five matched controls 20–60 km outside the PAs, and 162 from four villages 4–12 km from the border of the PA management zones (Figure S1). Surveys were conducted by trained social researchers, primarily from the Center for Development Oriented Research in Agriculture and Livelihood Systems. Prior to the initiation of data collection, pilot surveys were undertaken in the other four villages inside the PAs for training purposes and to evaluate the survey methods. Full surveys then took place during September–November 2008. Interviews were conducted with 40–45 households in each village, and additional households inside the PAs that had expressed interest in or were engaged in the Payments for Environmental Services program that was being established at the same time. Survey households were selected using random stratified sampling, based on a participatory wealth ranking exercise in each village.

### (a) *Household and village surveys of livelihood strategies and poverty status*

A standard household questionnaire was developed during the pilot surveys, which collected data on key household characteristics, livelihood strategies, and three measures of poverty: (*1*) the Basic Necessities Survey (BNS; Davies & Smith, 1998; Pro-Poor Centre & Davies, 2006); (*2*) a standard basket of assets, as a measure of absolute household wealth (Wilkie, 2007), and (*3*) a participatory wealth ranking exercise. The questionnaire was deliberately kept short, taking 40–60 min to complete, by collecting salient information only. Respondents were household heads or another adult household member if the household head was unavailable. The BNS calculates a relative index of poverty for every household in the sample, relative to a locally derived definition of poverty, and is based on previous methods that have been used in both developed and developing countries (Hallerod, 1994; Mack & Lansley, 1985; Noble, Wright, Magasela, & Ratcliffe, 2008, for further details see Supplemental materials).

Each household was asked which livelihood strategies they engaged in, based on a list compiled during pilot surveys and allowing for free responses. Data on rice harvests (the staple food in Cambodian diet) and yields of liquid resin were collected using standard local units (e.g., sacks of rice, cans of resin collected per trip), which previous work had suggested encouraged accurate responses. The basket of assets list was developed based on the pilot surveys, and the value of the assets was determined using a village-level consumer price index. Village-level variables were collected using a standard questionnaire administered to a group of key individuals (e.g., the village chief, commune officials, shopkeepers, etc.). Qualitative discussions were also undertaken separately around key drivers of changes in livelihood strategies, the impacts of the PAs and external drivers, use of forest resources, and land in order to substantiate the quantitative findings of the models.

### (b) *Analyses*

Three measures of poverty status were calculated for each household: the BNS Score, the value of the basket of assets and the participatory wealth ranking. Correlation coefficients were calculated in order to test the level of consistency between the three methods. Following these tests, the BNS Score results and the household rice harvest in 2007–08 was used as the dependent variables for all further analyses. The impact of PAs on local poverty at the household level was analyzed using two different techniques: mixed effects models and matching estimators. Mixed effects models were undertaken in R 2.13.0 (R Development Core Team, 2011) using package "nlme" (Pinheiro, Bates, DebRoy, Sarkar, & R Development Core Team, 2011), in order to account for the random effect due to repeated surveys of different households from the same village. The models were based on the entire dataset of 871 households from the 20 villages. The initial model included all main effects and 2-way interactions relevant to the research question. Model selection was conservative, using second-order AICc values to compare competing models, as is appropriate when the number of parameters being estimated is <40 (Burnham & Anderson, 2002). All terms with AICc Δ values of >4 ("considerably less" empirical support; Burnham & Anderson, 2002) were removed, with the exception of interactions that were relevant to the research hypotheses (e.g., those involving PA) that had some empirical support. Further details of the model selection procedure and the selected mixed effects models are given in the Supplemental materials. Matching estimators were calculated only for the 325 households from the 11 villages inside PVPF and KPWS, matched with the 134 households from the five control villages. The clustering effect of village was accounted for using the equations developed by Hanson and Sunderam (2012). The matched households were also subsampled to compare specific effects for different types of livelihood strategies: resin-tapping, owning >1 ha, and having a shop or family business.

## 4. RESULTS

All three measures of household poverty status—the BNS Score, basket of assets value, and the participatory wealth ranking—were highly correlated for the 871 households surveyed (Supplemental materials, Table S3 and Figure S3). BNS Score was therefore used as the measure of household poverty status in all subsequent models.

### (a) *Factors affecting household poverty status and rice harvests*

Better-off households (those with higher BNS Scores) were more likely to be larger, with more working adults and a lower dependency ratio (the ratio of the number of working adults to the total household size); they were also more likely to have male household heads that were more educated and older than poorer households (Table 1a). These results affirm the importance for household wellbeing of education and having sufficient labor for farming, collection of forest resources, and other livelihood strategies. 97% of households listed farmer as one of their occupations. Better-off households were more likely to be engaged in more livelihood strategies; were in employment; owned a village shop or provided a service (such as being a carpenter, trader, etc.); or owned larger amounts of land, and had draft livestock or mini-tractors for ploughing, pulling carts, etc. Poorer households were more likely to rent out their labor, perhaps due to lack of other livelihood opportunities, and were more likely to practice shifting cultivation rather than permanent paddyfield rice. Better-off households also collected more resin and had more cattle. The majority of these variables were highly significant determinants of household poverty status, based upon the final selected mixed effects model (Supplemental materials, Table S6a).

Very similar factors predicted household rice harvests (Table 1b), and were supported by the mixed effects model (Supplemental materials, Table S6b). There were some differences; households that were employed or operated a shop or business had significantly lower rice harvests (Table S6b), suggesting that they were diversifying into these nonfarm livelihood strategies.

The two primary development paths were therefore (*1*) intensification of agriculture by adopting permanent paddyfield rice cultivation (rather than practicing shifting cultivation for rice), acquiring greater land holdings, and increased mechanization; and (*2*) diversification into non-agricultural livelihoods such as employment, operating a shop or providing a service. More educated households were more likely to diversify into non-agricultural strategies (Supplemental materials, Table S6a).

Village characteristics had a strong effect on household poverty status and rice harvests. Higher household BNS Scores were found in villages that were closer to the Provincial Capital, were larger, and had more years of schooling available in the village (Table S6a). Similarly, greater rice harvests were found in villages that were closer to the Provincial Capital or secondary schools, and were larger (Table S6b). Villages that were remote from the Provincial Capital were therefore less able to profit from higher agricultural harvests, probably due to restricted market access. The travel time to the Provincial Capital was a suitable proxy for access to major services such as hospitals ($r = 0.908$, $n = 20$, $P < 0.001$), high schools, large markets, and was highly correlated with the distance to all-weather roads ($r = 0.689$, $n = 20$, $P = 0.001$). Travel time to the nearest secondary school was a suitable proxy for access to the nearest major population center, where full-day markets (correlation $r = 0.644$, $n = 20$, $P = 0.002$), shops, and health services were more frequent.

### (b) *Effect of protected areas on household poverty status and agricultural productivity*

Households bordering PAs were considerably better-off than households inside PAs (Table 2 and Figure 1a, Difference = 0.93, $P < 0.001$), using household poverty status measured by BNS Score. Analysis of the livelihood strategies practiced by border households suggests that they are further advanced along the two development pathways identified in comparison with the other village types: (*1*) agricultural intensification, through having greater land holdings and mechanization; and (*2*) diversification, through employment, operating a shop or providing services (Table 2). However, the mixed effects model, which includes the village-level variables, indicated that these differences could be fully explained by the village characteristics (Figure 1a, Model Coefficient = 0.06, $P = 0.408$). Border villages were larger, closer to the Provincial Capital, and had better schools than villages inside PAs (Table 3), which is sufficient to explain the difference between the village types. It is unlikely that these differences can be explained by the PA intervention, because there was no evidence that the presence of PAs had influenced infrastructure development decisions (e.g., on roads, school-building, etc.).

Households inside PAs differed significantly from the control households in terms of the livelihood strategies practiced

Table 1. *Household characteristics, poverty status, livelihood strategies and assets for 871 households in Preah Vihear province, Cambodia, in 2008, showing the poorest and least poor quintiles and the least productive and most productive rice harvest quintiles*

| | All | BNS Score quintiles | | Rice harvests Quintiles | |
|---|---|---|---|---|---|
| | | Bottom | Top | Bottom | Top |
| Households | 871 | 174 | 174 | 174 | 147 |
| Household size (people) | 5.7 | 5.3 | 6.1 | 4.9 | 6.5 |
| Working adults (people) | 3.1 | 2.7 | 3.6 | 2.5 | 3.8 |
| Dependency ratio | 1.0 | 1.2 | 0.8 | 1.1 | 0.8 |
| Female headed households (%) | 9% | 12% | 5% | 14% | 6% |
| Household head education (years) | 2.3 | 1.4 | 3.8 | 2.1 | 3.0 |
| Household head age (years) | 41.1 | 38.3 | 42.7 | 39.8 | 44.9 |
| *Household status* | | | | | |
| BNS Score[a] | 9.3 | 4.9 | 13.9 | 7.0 | 12.0 |
| Rice harvest (kg) | 1732 | 771 | 2857 | 163 | 4295 |
| *Livelihood strategies* | | | | | |
| Resin-tappers (%) | 44% | 30% | 53% | 24% | 60% |
| Rice farmers (%) | 90% | 78% | 97% | 51% | 100% |
| Have > 1 ha (%) | 73% | 36% | 96% | 40% | 100% |
| Shifting cultivation farmers (%) | 39% | 52% | 20% | 39% | 30% |
| Employed (%) | 7% | 3% | 14% | 8% | 8% |
| Provide a service or shop (%) | 17% | 4% | 37% | 19% | 24% |
| Rent out labor (%) | 3% | 8% | 1% | 10% | 0% |
| *Household assets* | | | | | |
| Resin yields (liters) | 501 | 229 | 722 | 182 | 833 |
| Cattle (heads) | 3.9 | 1.5 | 7.2 | 1.5 | 6.1 |
| Draft cattle (%) | 35% | 10% | 64% | 14% | 51% |
| Mini-tractor (%) | 28% | 1% | 60% | 9% | 56% |

[a] Basic Necessities Survey Score (measurement of household poverty status).

(Table 2). In particular, over half of the households inside PAs were resin-tappers, in comparison with only 29% of households in controls, and control households were more likely to practice less intensive agriculture, such as shifting cultivation, with smaller land-holdings. Once village-level variables were taken into account in the mixed effects models, households inside PAs were significantly better-off than households outside PAs (Figure 1a and Table 4a). Very similar results were obtained for the matching estimator, comparing households inside PAs with matched households from the control villages (Figure 1a and Table 4a). Unlike with the border villages, these differences could not be explained by village characteristics, and were more likely to be due to the PA intervention itself.

There were no significant differences between rice harvests for households inside and outside PAs based on the mixed effects model (Figure 1b and Table 4b) and the matching estimators (Figure 1b and Table 4b). PAs therefore had little impact on average household rice harvests.

### (c) *Impacts of protected areas on livelihood strategies*

Resin-tappers benefited most from PAs. Resin-tapping households inside PAs were significantly better-off than resin-tappers outside PAs, based on the mixed effects model and the matching estimator, using BNS Score as the measure of household poverty status (Table 4a). Similarly, resin-tappers inside PAs had significantly greater rice harvests than resin-tappers outside PAs based on the mixed effects model (Table 4b); the equivalent matching estimator is nearly significant (Table 4b). By contrast, for those that did not resin tap there was no difference between households inside and outside PAs in terms of poverty status and rice harvests (Table 4).

Households with larger land holdings had greater agricultural productivity inside PAs than outside. Rice harvests for households inside PAs owning >1 ha were significantly greater than households owning similar amounts of land outside PAs, based on the mixed effects model (Table 4b); the equivalent matching estimator is nearly significant (Table 4b). By contrast, there was no difference in rice harvests between households owning <1 ha inside and outside PAs (Table 4b).

No differences between households inside or outside PAs were observed for other livelihood strategies (such as operating a household business; Table 4) for either household poverty status, as measured by BNS Score, or rice harvests, indicating that the PA intervention had limited impact on these strategies.

## 5. CONCLUSION AND DISCUSSION

### (a) *Measuring the social impacts of protected areas*

A simple comparison of households inside the PAs with bordering villages would come to the conclusion that PAs exacerbate local poverty (Figure 1a). The results of the impact evaluation show that this would be a misleading comparison, because border villages were closer to market centers, other services, and main roads, all of which had positive impacts on local poverty status. This demonstrates the importance of impact evaluation survey designs which ensure that valid comparisons are made. Impact evaluation methods have been criticized as too expensive for widespread use in program evaluation (Richards & Panfil, 2011). The cost of the 2008 surveys analyzed here was US$50,000 (including technical assistance and analysis), which would be affordable in the context of many large

Table 2. *Differences in household status and livelihood strategies between households bordering, inside and controls outside protected areas in the Northern Plains of Cambodia in 2008*

| | Border PA | Inside PA | Controls | Tests of difference[a] (Inside PA *vs* Controls) |
|---|---|---|---|---|
| Villages | 4 | 11 | 5 | |
| Number of households | 162 | 504 | 205 | |
| *Household characteristics* | | | | |
| Household size (people) | 5.5 | 5.7 | 5.9 | |
| Working adults (people) | 3.2 | 3.1 | 3.0 | |
| Dependency ratio | 0.8 | 1.0 | 1.1 | |
| Female-headed households (%) | 12% | 9% | 7% | |
| Household head education (years) | 2.8 | 2.6 | 1.3 | |
| Household head age (years) | 40.9 | 42.2 | 38.6 | |
| *Household status* | | | | |
| BNS Score[b] | 10.4 | 9.4 | 8.0 | * |
| Rice harvest (kg) | 1999 | 1828 | 1286 | ns |
| *Livelihood strategies* | | | | |
| Resin-tappers (%) | 31% | 54% | 29% | *** |
| Rice farmers (%) | 93% | 89% | 92% | ns |
| Have > 1 ha (%) | 88% | 71% | 63% | * |
| Shifting cultivation farmers (%) | 38% | 37% | 45% | * |
| Employed (%) | 14% | 7% | 3% | ns |
| Provide a service or shop (%) | 28% | 15% | 14% | ns |
| *Household assets* | | | | |
| Resin yields (liters) | 357 | 626 | 307 | * |
| Cattle (heads) | 2.8 | 4.5 | 3.5 | ns |
| Draft cattle (%) | 20% | 39% | 37% | ns |
| Mini-tractor (%) | 32% | 28% | 26% | ns |

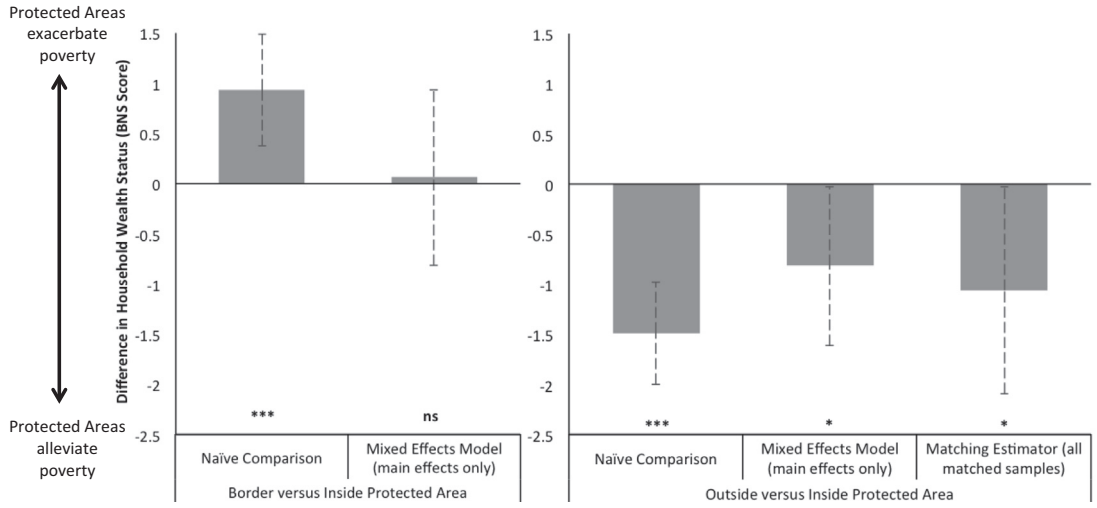
[a] Tests of difference are mixed effects regression models for continuous variables (BNS Score, Rice harvest, Resin yields, Cattle), and chi-squared tests for categorical variables.
[b] Basic Necessities Survey Score (measurement of household poverty status).
*Notes:*
ns = not-significant.
* Significant at $P < 0.05$.
** Significant at $P < 0.01$.
*** Significant at $P < 0.001$.

conservation-development programs. Adoption of impact evaluation methodologies does, however, require access to appropriate technical expertise to design the surveys and analyze the results. Matching methods only give robust results if the matching process controls for the other drivers of change in poverty. Using matching methods for social impact assessment therefore requires a strong prior understanding of the system in order to select appropriate matching variables (Ravallion, 2006). Poor matching designs might identify an effect when in fact none exists or mask effects. The accuracy of estimates can be improved by triangulation of results with other methods (such as regression models and qualitative assessments), and using repeat surveys to calculate difference-in-difference estimators (Ravallion, 2006). In this study, the matching estimators were broadly similar to the results for the mixed effects models on a much larger sample. However, the accuracy of the analysis is dependent upon the validity of the original identification of the matched control villages. This was addressed in the current study by selecting matching variables from 2005 (prior to the commencement of PA management), to ensure that they were exogenous to the PA intervention (see Supplemental materials for details).

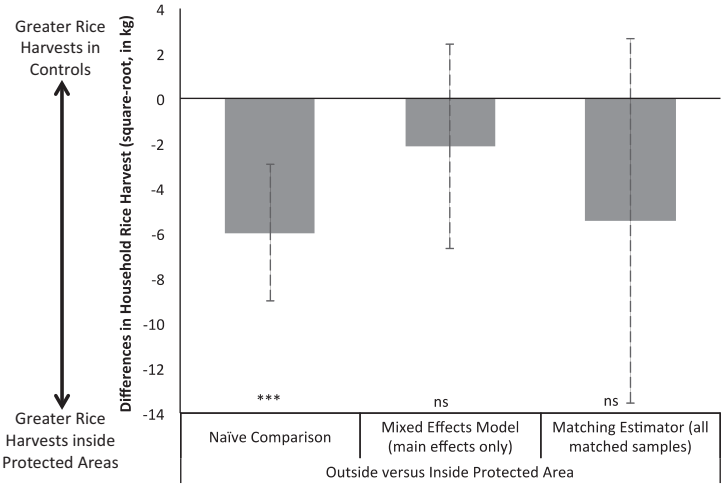
The BNS was a relatively inexpensive and rapid method to assess local perceptions of poverty and to collect data on household poverty status. Again the principal technical hurdles were during the design phase, since the BNS required considerable piloting before a suitable list of items was developed and to train field surveyors in the approach. Considerable prior knowledge of livelihoods in the study area was needed in order to develop an appropriate list. The BNS performed similarly to the two other measures of poverty described here—the basket of assets and the participatory wealth ranking—however its relationship to standard measures of poverty, such as household income or consumption, is unclear. Validating the results of the BNS against income or consumption data would give greater confidence in the survey results. The BNS also captured other salient aspects of wellbeing. For example, Cambodians ranked highly the number of ceremonies in their village as a basic necessity, even if they themselves could not afford to host a ceremony, as a measure of overall social wellbeing.

### (b) *Factors affecting household poverty status and agricultural productivity*

Cambodia underwent rapid economic growth during 1998–2008 with annual GDP increases of 7–13% (World Bank, 2011), leading to a reduction of more than 1% a year in the poverty headcount (World Bank, 2009). Reductions in poverty have been greater for people in urban areas than for the rural poor that make up the majority of the population (78%; World Bank, 2009). The people surveyed in this study would all be categorized as poor subsistence farmers, if the survey results here are compared with national-level indicators of




*(a) Differences in the poverty status of households bordering, inside and outside Protected Areas*




*(b) Differences in the rice harvests of households outside and inside Protected Areas*

Figure 1. *Average differences between households bordering, inside and outside protected areas for (a) for BNS Score, as a measure of household poverty status, and (b) household rice harvests. Notes: Significance values for the null hypothesis of zero impact: ns = not-significant,* $^{*}$ *=* $P < 0.05$*,* $^{**}$ *=* $P < 0.01$*,* $^{***}$ *=* $P < 0.001$*).*

household status (World Bank, 2009). Average household rice harvests were 1,732 kg in 2008, barely sufficient to support a family for a year, suggesting that the majority of households were in rice deficit and dependent on other sources of cash income to buy food.

The most significant source of non-agricultural income in the study area is collection of liquid resin from dipterocarp trees (McKenney *et al.*, 2004). The importance of resin to the household economy of forest communities in Cambodia has been well documented, in particular as a source of cash income to buy food in times of rice deficit (Evans *et al.*, 2002; Hansen & Top, 2006; McKenney & Prom, 2002; McKenney *et al.*, 2004). Income from resin is also invested in livelihood strategies. Resin is therefore an example of a forest resource that is both a "safety net" for vulnerable households and a critical source of cash providing a "pathway out of poverty" (Angelsen & Wunder, 2003; Ruiz-Pérez *et al.*, 2004). Resin is the only forest resource to have local traditional ownership and harvesting rules, indicating its importance to local people (Ostrom, 1990). Under these rules, trees are individually owned, can be inherited, and rights are maintained even if resin-tappers move or live far away. To some extent these rules are acknowledged in Cambodian Law, which recognizes the user rights of tappers and prohibits the clearing of resin trees (Prom & McKenney, 2003).

The usefulness of resin as a development pathway is, however, limited by several factors. Firstly, the majority of useable trees in the area are claimed or tapped (A. John, pers. comm.). New families and immigrants are therefore reliant upon inheriting or buying resin tress. Secondly, the resin trade is monopolized by a small number of traders that pay high formal and informal taxes to transport resin (Prom & McKenney, 2003). This constrains the price that resin tappers can receive; most of the profits are captured higher in the value chain. Finally, large-scale concessions for logging (prior to 2002) or agri-business (since 2005) clear resin trees, often despite strong local opposition, with inadequate compensation (GTZ, 2009; World Bank, 2006). Strengthening resin tree tenure and reforming the trade barriers for resin is likely to have positive impacts on local livelihoods.

Table 3. *Differences between villages bordering PAs, inside and outside the PAs for village-level variables*

| Variable | Border PA | Inside PA | Controls |
|---|---|---|---|
| Village population size (households) | 164.8 | 140.6 | 148.6 |
| Travel time to Provincial Capital (hours), dry season | 3.3 | 5.5 | 4.4 |
| Travel time to secondary school (hours), dry season | 0.8 | 3.1 | 2.7 |
| Distance to nearest all-weather road (km) | 9.9 | 26.9 | 25.7 |
| Number of school years available in the village | 6.3 | 5.4 | 4.0 |

Table 4. *Average differences between households with different livelihood strategies in villages inside PAs and controls outside PAs for (a) household poverty status, measured using BNS Score[a], and (b) household rice harvests. Results are based on mixed effects models and matching estimators*

| Difference test | Matching estimator | | | | Mixed effects models | | |
|---|---|---|---|---|---|---|---|
| | *N* | Coefficient | Standard error | Significance | Coefficient | Standard error | Significance |
| *(a) Difference in household poverty status (BNS Score[a])* | | | | | | | |
| Inside PAs *vs* Controls (all) | 325 | 1.06 | 0.53 | * | 0.82 | 0.37 | * |
| Inside PAs *vs* Controls (resin-tappers) | 150 | 2.19 | 0.41 | *** | 1.05 | 0.37 | ** |
| Inside PAs *vs* Controls (do not resin-tap) | 175 | 0.07 | 0.71 | ns | | | ns |
| Inside PAs *vs* Controls (own > 1 ha) | 240 | 1.01 | 0.53 | † | | | ns |
| Inside PAs *vs* Controls (do not own > 1 ha) | 85 | 1.22 | 0.67 | † | | | ns |
| Inside PAs *vs* Controls (shop/business) | 45 | 1.00 | 0.75 | ns | | | ns |
| *(b) Difference in household rice harvest in 2007–08 (kg, square root transformed)* | | | | | | | |
| Inside PAs *vs* Controls (all) | 325 | 5.45 | 4.13 | ns | 2.12 | 2.11 | ns |
| Inside PAs *vs* Controls (resin-tappers) | 150 | 10.43 | 5.58 | † | 5.50 | 2.60 | * |
| Inside PAs *vs* Controls (do not resin-tap) | 175 | 1.02 | 3.71 | ns | | | ns |
| Inside PAs *vs* Controls (own > 1 ha) | 240 | 7.81 | 4.68 | † | 7.27 | 2.49 | ** |
| Inside PAs *vs* Controls (do not own > 1 ha) | 85 | −1.72 | 3.33 | ns | | | ns |
| Inside PAs *vs* Controls (shop/business) | 45 | 12.68 | 8.88 | ns | | | ns |

*Notes:*
Positive coefficients indicate that protected areas alleviate poverty or increase rice harvests, whereas negative coefficients indicate that protected areas exacerbate poverty or reduce rice harvests.
ns = not-significant.
[a] Basic Necessities Survey Score (measurement of household poverty status).
† Significant a $P < 0.10$.
* Significant at $P < 0.05$.
** Significant at $P < 0.01$.
*** Significant at $P < 0.001$.

There is evidence from this study that rural people are beginning to diversify out of subsistence agriculture and forest resource collection. Two development pathways are indicated by the data: the agricultural path (the traditional rural development model) and the multiple-activity path (rural diversification into nonfarm activities; Wunder, 2001). Some households are investing in improved agriculture, through purchase of mini-tractors and expansion of areas under cultivation. Other households are diversifying into nonfarm livelihoods, such as commercial activities or employment, in a minority of cases leading to households abandoning agriculture all together. Expansion into business activities is heavily related to the availability of education. Both development pathways are strongly related to access to markets and services, through being closer to major towns and roads.

### (c) *Impacts of protected areas on poverty, agriculture, and local livelihoods*

Protected areas cover approximately 12% of the world's terrestrial surface and approximately 27% of tropical forests (Nelson & Chomitz, 2011), with almost every country having some PAs (UNEP-WCMC, 2012). Reviews have suggested that between 56% and 85% of PAs in developing countries have people residing in them (Brockington & Igoe, 2006), including extractive reserves and community conserved areas (Berkes, 2009). Given the controversies about whether PAs exacerbate local poverty or might contribute to poverty alleviation (Roe, 2008), there is a critical need for evidence to inform the debate. Very few well-designed empirical studies have examined PA impacts on local people, and these have generally found limited positive effects (Andam *et al.*, 2010; Naughton-Treves *et al.*, 2011; Sims, 2010). In the current study, there was no evidence that 4 years of PA management had overall negative impacts on local livelihoods, either in terms of household poverty status or harvests of rice, the staple crop that provides the basis of local diets. These results should be seen in context, however. Under Cambodian law, local people are entitled to remain inside PAs and to continue to practice traditional subsistence livelihoods. PA enforcement activities primarily targeted wildlife hunting, logging for commercial purposes, and agricultural expansion. Densities of wildlife in the PAs were also low (O'Kelly *et al.*, 2013), leading to limited human–wildlife conflict. This context is not dissimilar from many other PAs in developing countries, that contain local people and where management budgets are limited (Brockington & Igoe, 2006; Bruner *et al.*, 2004).

The Cambodian PAs did provide some positive impacts for local people, by providing security of land tenure and forest resource access—effectively a "resource pool protection effect"

for villages inside the PA. During the 1990s, forestry concessions were designated covering 7 million hectares (or 70%) of Cambodia's forests, all located outside PAs (Cambodia R-PP, 2011). Resin trees are all dipterocarp species, which are highly valuable timber species and are preferentially targeted by loggers. The subsequent legal and illegal logging led to widespread protests, particularly by resin-tappers, causing all forestry concessions to be suspended by the Royal Government in 2002 (World Bank, 2006). Subsequently, rates of selective illegal logging have continued, particularly for high value species such as dipterocarps. PAs have successfully protected resin trees during this time, both from the commercial companies (since forestry concessions were not declared inside PAs) and from illegal loggers. This explains why resin-tapping was a much more important livelihood strategy inside PAs, and why resin-tappers inside PAs were significantly better off than resin-tappers outside PAs.

In the 2000s, land clearance has replaced logging as the major driver of change. National annual deforestation rates were 0.5% during 2000–10 (Forestry Administration, 2007, 2011), despite the fact that since 2002 most forest clearance has been illegal. Consequently Cambodia has one of the highest rates of land-use change in the region (FAO, 2011). Large-scale resource exploitation and land-use change is primarily driven by economic land concessions, primarily for cash crops and rubber (Cambodia R-PP, 2011), which appropriate and clear large areas of forest. Approved concessions are currently in excess of 1 million hectares (So, 2010), or 6% of Cambodia's area. Concessions are often met with strong local opposition, and are thought to deliver few benefits to local people who lose access to land and forest resources for minimal compensation or development opportunities (GTZ, 2009; UN OHCHR, 2007; So, 2010). Landlessness has risen to 20%, and 40% of rural households have farms less than 0.5 ha, i.e., less than half of the minimum area required to meet nutritional needs (GTZ, 2009). Insecure local tenure over land and forest resources provides little incentive for local people to engage in sustainable resource management (An, 2008). PAs provide some protection to local residents from the risk that land is appropriated for other causes, and this may explain why land-owners inside PAs had greater agricultural productivity than land-owners outside PAs. However, the security of tenure afforded by PAs in Cambodia is currently in doubt. Within the past 2 years, significant forest areas of Cambodia's PA networks have been degazetted for economic land concessions, a trend which seems likely to continue (Cambodia Daily, 2011). The degazetting of PAs has serious implications not just for biodiversity conservation, but also for local people's welfare, due to the importance of the forest and land resources found in PAs for their livelihoods.

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## APPENDIX A. SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.worlddev.2014.03.008.