

Participatory Protection in Theory and Application: Paper Tigers, Fences & Fines, or Negotiated Co-Management?

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Participatory Protection in Theory and Application: **paper tigers, fences & fines, or negotiated co-management?**

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Abstract

Forest protection can imply binding constraints on communities ('fences & fines') yet some attempts to protect forest by blocking local land use are fruitless ('paper tigers'). Participatory protection, i.e. involving a local community in forest 'co-management', is a relatively recent forest policy innovation that falls between these two endpoints. We model the emergence of negotiated agreements that can share management of and benefits from forest between actors with different objectives, a state and forest users. Going beyond models of user-user interactions involving common-property resources, our state-user model addresses the question of *when rights are devolved* to such users. Next we compare our derived hypotheses about de facto rights, negotiated agreement, and within-agreement transfers -- all endogenous -- with unique community-level data describing a large protected area in Indonesia. The results broadly support this model.

Keywords

forest, protected area, park, co-management, endogenous property rights, participation

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1. Introduction

Protected areas are a leading instrument for the conservation of biodiversity and other forest eco-services. In developing countries, they may be established and maintained at the expense of the local community (Kiss 1990; Swanson and Barbier 1992; Tisdell 1995) and conserve through effective ‘fences & fines’, i.e. exclusion. But some attempts to block land uses are fruitless. Thus, parks may be ‘paper tigers’. Conflicts over natural resources and property rights are reasons why protected areas may not fully conserve forests (see Albers and Ferraro 2007; Bulte and Engel 2007).

Yet these do not exhaust the set of institutions. In particular, another option is to involve the local community in protected-area management.¹ Such collaboration or ‘co-management’ involves relevant state authorities negotiating with communities to share both the management of and the benefits from the forest resources (see, e.g., Borrini-Feyerabend et al. 2000, Carlsson and Berkes 2005). For example, locals with longstanding resource claims may be responsible for the protection and management of forest while receiving rights to forest products and other benefits (see Sims 2009).²

Thus co-management schemes, through the devolution of resource rights, can permit direct use value from resources, e.g. harvesting of non-timber forest products (Baland and Platteau 1996; Knox and Meinzen-Dick 2000; Bulte and Engel 2007). Such participatory protection could help people and resources, as local actors have an incentive to preserve resources while addressing their income and consumption needs.

Initiatives of this kind are widespread and not only in forest (Edmonds 2002) but also in coastal fisheries and irrigation (Ostrom 1990; Baland and Platteau 1996).³ Related research has focused on intra-community processes or user-user interactions. Our focus is *state-user interaction* and, specifically, *when co-management will occur*.

¹ Rationales include successful management by users (Ostrom 1990), failures of state management perhaps due to the high costs of monitoring and enforcement, shrinking government budgets, equity, and promotion by international donors. While over 70% of the natural forests in developing countries are still formally owned by the state (White and Martin 2002), Scherr et al. (2004) estimate that around 25% of forests currently are owned or are controlled in some way by resource-dependent communities.

² This can be in ‘integrated conservation and development projects’ (ICDPs) with varied benefits and responsibilities (Brandon and Wells 1992) or after devolution reforms allowing greater involvement of communities in management of natural resources (Ligon and Narain, 1999; Meinzen-Dick et al. 2001).

³ They do not always ‘work’ so empirical study is critical. Preconditions include secure rights, transfer of sufficient powers, and downwardly accountable institutions (see Larson and Ribot 2004). Bulte and Engel (2007) review evidence that devolution has often transferred more responsibilities than rights, e.g. outsourcing costs while government maintains control. Rights may be weakly defined and rarely enforced by extensive bureaucratic procedures that withhold information and do not build capacity.

When co-management will occur is relevant for an evaluation of the impact of co-management. Evaluation efforts highlight multiple possible definitions of success, which vary by setting and by stakeholder group, although resource conservation and local livelihoods often are central. For either objective, inferences about impacts of co-management can be confounded by non-random occurrence of co-management.

For example, if co-management occurs only within situations where relevant authorities were able to maintain pristine forest via ‘fences & fines’, co-management may be highly correlated with, but yet not responsible for, a positive forest outcome. Then comparison of its outcomes with other cases overestimates its effectiveness in promoting forest conservation. Similarly, if such co-management agreements arise only where parks are ‘paper tigers’ unable to constrain local land use, livelihoods can be positively correlated with co-management despite not in fact being increased by it, since within such settings local consumption is high with or without co-management.

More generally, if the occurrence of co-management is correlated with factors that themselves directly affect forests and livelihoods, its evaluation could be biased. As a step towards understanding the likely biases of this type, this paper first predicts and second studies empirically the emergence of forest co-management agreements. First, we develop a conceptual framework for understanding roles of co-management interventions. Second, we bring our derived hypotheses to unique panel data collected from a co-management policy implemented in Lore Lindu National Park, Indonesia.

We develop a game-theoretic model of an interaction between a protected area authority and a local community on the periphery of a park. The key interaction is that the park—by preventing extraction—limits community benefits from park resources.⁴ The critical feature of the model, and we think many real cases, is that property rights over a park’s natural resources are endogenous to parameters that vary across settings. Thus, the *de facto* property rights are an outcome of the park-community interaction.

In contrast, previous studies of resource users playing a role within resource management assume exogenous resource rights (be that in fisheries, water or forest).⁵

⁴ The model is adapted from Engel et al. (2006) and Engel and Lopez (2008) who consider interactions between resource-dependent communities and resource-extraction firms, given weak property rights. In their models, the firm—by extracting the resource—limits community benefit from the standing forest.

⁵ While many studies on the co-management of renewable resources are concerned with how intra-community processes affect resource outcomes, some also look at the role of the state. In particular, there is a rich case-study literature on the co-management of coastal fisheries, e.g. Pinkerton (1989), Pomeroy and Berkes (1997), where formal modelling of the state-community interaction is absent.

Focusing on forests, Robinson et al. (2008) examine interactions between the spatial and intertemporal aspects of resource extraction and between those and effectiveness of community resource management. Rights vary exogenously for studying the impact of property rights upon patterns of resource extraction and stocks. Also, community management is not modelled as the outcome of any interaction with another actor.

Other models concerned with protected area policy, e.g., look more explicitly at co-management between local actors and a state agency. Barrett and Arcese (1998) and Skonhoft and Solstad (1996, 1998) consider the impact of co-management upon both illegal hunting and wildlife conservation. Either the local households or the park, respectively in each paper, control the wildlife stock. A model by Johannesen and Skonhoft (2005) assumes that both the park agency and local people control wildlife yet still rights are exogenous even though the actors are strategically interdependent.

Gjertsen and Barratt (2004) offer a contracting model of conservation design, in which tasks such as financing and management are efficiently allocated between a community and a government according to biophysical, economic and socio-political conditions. Co-management is one outcome of the model yet property rights are still given exogenously and there is no potential for a non-conservation outcome in which a park fails to have any influence on forest outcomes (as in our ‘paper tiger’ scenario).

Muller and Albers (2004) model a protected-area manager interacting with the local households in varied market settings. Their model has significant commonalities with ours yet we assume no external, third-party enforcement. Everything is self-enforced. In addition, corner solutions are important options within our results.

Finally, Ligon and Narain (1999) study the effects of the state’s policies upon community forest management where the community can potentially self-enforce collective agreements. While not explicitly focused on protected area policy per se, they find that the state’s policy preference will partially depend on the community’s ability to enforce collective agreements, a theme taken up in our model and empirics.

Our model features three possible outcomes. First is complete forest protection where a park possesses *de facto* property rights and creates a ‘Fences-&-Fines Park’. Second is open access, where the property rights are *de facto* held by the community, which implies ‘Paper Tiger Parks’. Third is the ‘Co-Management’ outcome negotiated between the park and the community, in which the park authorities effectively hold *de facto* rights but still the relevant local communities can benefit from direct-use values from the resource in exchange for taking on management responsibilities in the park.

Our predictions about when various outcomes arise are compared to observed outcomes in Sulawesi, Indonesia. After decentralization in natural-resource sectors at the end of the 1990s, and given local demand for a share of resource rents, the head of Lore Lindu National Park pioneered new ‘Community Conservation Agreements’ (or KKM for *Kesepakatan Konservasi Masyarakat*). Promoted by NGOs, the agreements were negotiated between communities’ representatives and the park, within an effort to balance conservation with communities’ development needs (Mappatoba 2004).⁶

The data from repeated visits to Lore Lindu provide the first opportunity in the study of co-management, so far as we are aware, to directly examine the question of *when such agreements emerge*. These data, from about 50 villages where roughly half negotiated KKM, permit measurements of differences across these settings that are hypothesized in our model to be critical. We can compare measures with predictions.

Following the sequence of our modelling, we first examine our predictors for which actor wins *de facto* rights (park for Fences-&-Fines, or locals for Paper Tigers). We relate these measurements to the deforestation outcomes (observed by satellite). Among settings where the park appears to have *de facto* rights, we then compare the characteristics of communities with a KKM to those without. Finally, among those with KKM, we compare to our predictions when transfers to the community occur.

We find, as predicted, that the places where the park appears to have *de facto* property rights are those where conservation benefits are higher, enforcement cost is lower, and community benefit from extraction is lower. Next, among settings where the park appears to have *de facto* rights, our proxies for community ability to enforce a KKM (all of which are motivated by the extensive collective-action literature) do in fact predict the emergence of KKM co-management. For within-agreements transfers among those with agreements, though, our predictors have little explanatory power.

Below, Section 2 presents our model of bargaining, in which *de facto* property rights arise based on other parameters, and derives hypotheses concerning where one might expect agreements. Section 3 provides background on the Indonesian setting. Section 4 then provides our comparison of the unique KKM data set with the model-based hypotheses. Finally, Section 5 discusses and points to potential further work.

⁶ Links between resource outcomes and degree of community participation in negotiating rules are explored in Bardhan (2000), for example, in which the degree of participation is assumed exogenous. We focus on the conditions under which an agreement with any degree of participation will emerge. Understanding of differences in underlying setting under which more or less community participation may be expected to emerge could, as noted, matter for assessing the impact of degree of participation.

2. Model

We present a game-theoretic model of community-park interaction within a context of weak formalized property rights. This model is adapted from Engel et al. (2006) and Engel and López (2008). The model integrates conflict and bargaining theories. Below, the conflict-and-rights component of the model is discussed first.

2.1 Conflict Determines Endogenous Property Rights

In Engel et al. (2006), *de facto* property rights are modeled as the outcome of a war of attrition between a commercial actor (e.g., a logging company) and a resource owner (the community). We adapt their model to co-management of protected areas. Our two actors are ‘park authority’ (or P or ‘Park’) and ‘Community’ (C). The resource is ‘forest’. In Engel et al. (2006), the possibility of bargaining is developed in a context of resource exploitation, logging. In our context, bargaining occurs over the environmental benefits of ‘forest conservation’ (see next sub-section).

Park has *de jure* property rights over the forest but may only be able to enforce these weakly, e.g. due to a lack of funds and manpower to monitor large remote areas. These rights are challenged by local people with long-standing claims to the resource. Each actor could obtain *de facto* forest-control rights. Community may unilaterally exploit the forest if it has the power to win a war of attrition. Park may prevent that completely if it is more powerful. If Park cannot effectively enforce its legal property rights, it cannot exclude Community from using park resources. If, on the other hand, Community is unable to win a potential conflict, i.e. if Park can effectively prevent exploitation, then bargaining between Community and Park may take place over a co-management agreement to share conservation benefits and management costs. For simplicity, we assume that each actor is risk neutral and has perfect information about the other’s parameters.⁷

Let $v(\bar{L} - L)$ denote the per-period environmental benefits to the Park from some forest conservation given forest extraction L , with \bar{L} denoting the initial level of forest. We assume that v is increasing and concave in $\bar{L} - L$, ($v' > 0, v'' < 0$).

⁷ This setup implies that the actor that would lose the conflict withdraws immediately. With imperfect information actual conflict is possible, yet the outcome will generally depend on the same parameters listed here (see Burton (2004) for a related model with imperfect information). Introducing imperfect information would make the model considerably more complex and is beyond the scope of this paper.

Community attempts to break park rules through, for example, collection of fuelwood, hunting, small-scale logging and the harvesting of rattan. These yield direct use values (and likely require little capital investment).⁸ Let $b(L)$ denote per-period net benefits of forest exploitation to Community, e.g. from timber and rattan sales (which reduce the forest level by L). We assume that b is increasing and concave in L , ($b' > 0, b'' < 0$) and $b(0) = 0$. The discount rate of actor i is denoted r^i ($i \in \{C, P\}$).

In general, a conflict game is won by the party able to stay in the potential conflict longer. The conflict game between Community and Park is seen in Figure 1. In each period, Community can attempt to exploit park resources by investing effort in extraction of forest products. Park, in turn, can attempt to enforce control over the forest by setting up monitoring and enforcement to prevent resource extraction. If the Park loses this conflict and withdraws, we characterize a ‘Paper Tiger’ (PT) park. If Community loses the conflict, Park can enforce a ‘Fences and Fines’ (FF) situation.

FIGURE 1 HERE

With perfect information, both actors can perfectly predict conflict outcomes. Hence, the actor who would lose the conflict withdraws immediately. A PT outcome has no monitoring or enforcement and high Community forest extraction (denoted below by $L = \tilde{L}$). A FF outcome has no extraction by Community ($L = 0$) and high monitoring and enforcement by Park. Staying in conflict one more period means that both actors incur costs and benefits. Park incurs costs of monitoring and enforcement, K , and receives per-period conservation benefit $\bar{v} \equiv v(\bar{L})$. For Community, there is a cost of attempting to withdraw forest products, denoted as $e(L)$, which is given by the value of the effort (opportunity cost of time) spent in the attempt. We assume that e is convex in L ($e' > 0, e'' > 0$). Without Park enforcement, Community will chose \tilde{L} to maximize per-period net benefits of extraction, i.e., to satisfy

$$b'(\tilde{L}) = e'(\tilde{L}). \tag{1}$$

Let $\tilde{v} \equiv v(\bar{L} - \tilde{L})$, $\tilde{b} \equiv b(\tilde{L})$, and $\tilde{e} \equiv e(\tilde{L})$. If Community wins the conflict, it

obtains the present value of the stream of forest benefits, $\frac{\tilde{b}}{r^c}$.

⁸ The Community may also consider ecological services from the standing forest (e.g., erosion prevention, water retention) as well as non-use values (e.g., the cultural value of living near a forest). For simplicity, we assume a zero value of non-use values to the Community.

Three cases can be distinguished. First, where $\tilde{e} > \frac{\tilde{b}}{r^C}$ the Community never enters into a conflict because the cost of extraction for a single period exceeds the value of exploiting park resources forever. So long as the Park's net benefits from forest conservation remain positive, i.e., $\frac{\bar{v}}{r^P} > K$, Park will always win the conflict and will establish *de facto* property rights over the forest.

Second, if $\tilde{e} < \tilde{b}$, Community will always extract because the benefits from doing so exceed the costs even in the same period. Third, for $\frac{\tilde{b}}{r^C} > \tilde{e} > \tilde{b}$, or equivalently, $\tilde{e} > \tilde{b} > \tilde{e}r^C$, the conflict is won by the actor that can stay in conflict longer. The conflict outcome in this case is obtained by computing for each actor the maximum length of time that this actor can stay in conflict while still receiving a non-negative expected payoff. Let these be denoted by t^C and t^P for the community and the Park, respectively. Setting $t^C > (<) t^P$, the condition for the Community (respectively the Park) to win the conflict can be obtained.

In analogy to Engel et al. (2006), who provide a formal proof of these results for their model of community-firm conflicts, it can be said that Park is more likely to win the conflict (thus obtaining *de facto* property rights over the forest and being able to enforce a fences-and-fines situation) when the following conditions prevail:

- Park's conservation benefits from the resources (\bar{v}) are high
- Park's costs (K) of monitoring and enforcing FF are low
- Community's costs of forest extraction (\tilde{e}) are high
- Community's benefits from extraction (\tilde{b}) are low
- Park's discount rate (r^P) is low and/or Community's (r^C) is high.

These results of the conflict model are intuitive. An actor is likely to be able to stay in conflict longer the higher are the actor's benefits and the lower are its costs from doing so. Moreover, since benefits are received over time, while fighting costs are immediate, each actor is likely to stay in conflict longer the lower its discount rate.

If Park wins the conflict game, it can enforce a FF situation. In this case Park payoffs per period are given by $\bar{v} - K$, while the community's benefits from the park are zero. However, in this case, Park and Community may negotiate a co-management agreement (see section 2.2 below) where Park delegates monitoring and enforcement of park rules to Community and allows some limited extraction of park resources.

If the Community wins the conflict game, a PT situation results and the community's per-period net benefits from forest extraction are $\tilde{b} - \tilde{e}$, while Park receives reduced conservation benefits of \tilde{v} . We assume co-management is not an option in this case. Although Park might prefer an agreement that reduces extraction, it would not be enforceable by Park. The only exception would be if co-management could take the form of an ex-post payment conditional on reduced extraction levels. Such conditional payments were not observed. We therefore reduce our analysis of co-management agreements below to the case where Park can enforce a FF situation.

Table 1 shows the payoff matrix for all three outcomes.

TABLE 1 HERE

2.2 Community-Park Negotiation Under *De Facto* Park Rights

Here we focus on cases where the Park is able to self-enforce property rights, imposing FF, yet bargaining may lead to a co-management agreement. We refer to a co-management agreement as KKM, using terminology from our Indonesian example presented in the following section. The negotiated transfer from Park to Community under an agreement is denoted Π^C , while s denotes Community's costs of setting up an internal monitoring and sanctioning system that substitutes for Park's efforts.

An important argument for co-management agreements or, more generally decentralized natural resource management, is that it may be less costly for local communities to monitor and enforce resource use rules because they can rely on local knowledge and traditional monitoring and enforcement mechanisms (e.g., ostracism). Thus, it may well be that $s < K$, giving an incentive for Park authorities to consider a co-management agreement, in which it trades reduced monitoring and enforcement costs (by devolving some of the management responsibilities to the Community) for some (limited) resource extraction rights (denoted by forest extraction level $\hat{L} > 0$).

Following Engel et al. (2006), we model negotiation over a co-management agreement between the Park and the Community as Nash bargaining. As shown in Muthoo (1999), the Nash bargaining solution implies that each actor receives his reservation utility and a share of the remainder of 'the cake' that is inversely related to his bargaining power. We let τ denote the Community's bargaining power and $1-\tau$ the Firm's bargaining power. Moreover, let $\hat{v} \equiv v(\bar{L} - \hat{L})$, $\hat{b} \equiv b(\hat{L})$, and $\hat{e} \equiv e(\hat{L})$.

Community payoffs under the agreement are given by $\hat{b} - \hat{e} - s + \Pi^C$.

Community's reservation utility is zero, as we focus on when Park would win a potential conflict. Park's reservation utility is $\bar{v} - K$. Total benefits to divide under a co-management agreement are $\hat{v} + \hat{b} - \hat{e} - s$. The Nash bargaining solution is given by

$$\begin{aligned} \hat{b} - \hat{e} - s + \Pi^C &= 0 + \tau [\hat{v} + \hat{b} - \hat{e} - s - 0 - (\bar{v} - K)] \\ \Rightarrow \Pi^C &= \tau [K - (\bar{v} - \hat{v})] - (1 - \tau) [\hat{b} - \hat{e} - s] \end{aligned} \quad (2)$$

Furthermore, note negotiations over a co-management agreement will succeed only if the size of the cake exceeds the sum of both actors' reservation utility, i.e., if

$$\hat{v} + \hat{b} - \hat{e} - s - (\bar{v} - K) > 0. \quad (3)$$

Thus, a KKM is more likely to result when the loss in the conservation benefits from forest extraction ($\bar{v} - \hat{v}$) and/or the Community's costs of monitoring and enforcement (s) are low, or when Community's net benefits from resource extraction ($\hat{b} - \hat{e}$) and/or the Park's costs of enforcing a Fences-and-Fines outcome (K) are relatively high.

The allowed forest extraction level under a co-management agreement, \hat{L} , would be chosen by the two parties in order to maximize the 'size of the cake'.

$$\max_{\hat{L}} v(\bar{L} - \hat{L}) + b(\hat{L}) - e(\hat{L}) - s \Rightarrow v'(\bar{L} - \hat{L}) + e'(\hat{L}) = b'(\hat{L}) \quad (4)$$

Comparing conditions (1) and (4) yields that

$$0 < \hat{L} < \tilde{L}, \quad (5)$$

i.e. forest extraction will be lower under a co-management agreement than under PT. This is so because a co-management agreement takes the reduction in conservation benefits into account. A formal proof of inequality (5) is given in Appendix A.

Intuitively, starting from the default outcome of FF, the total 'agreement cake' to divide in negotiations for co-management are the net benefits from allowing some level of extraction while reducing the monitoring and enforcement effort by Park from what was required to enforce FF. As the marginal enforcement costs to fully prevent extraction could be high and the marginal benefits of the first units of extraction could also be high, agreement may be desirable. In agreeing, Park would allow Community to capture limited direct use values (timber, NTFP, etc). In return, Community would take on limited management and enforcement responsibilities for Park.

There may also be a transfer involved. Examining (2) shows that the transfer to the Community (Π^C) rises with Community bargaining power (τ^C), Park costs of enforcement (K), and Community enforcement costs (s). It falls with the conservation benefits lost under a KKM ($\bar{v} - \hat{v}$) and Community net benefits from extraction ($\hat{b} - \hat{e}$).

In principle, the transfer (Π^C) may be positive or negative. Coasian thinking could have Community pay Park to desert the FF result that the Park has the (*de facto*) right to impose. That would be a negative transfer, which could take the form of Park keeping part of the benefits of extraction, e.g. retaining some of the NTFPs collected by the Community. While not observed in our field setting, transfers from Community to Park have been observed in other settings, such as India's Joint Forest Management programme and a Participatory Forest Management program in Ethiopia.⁹

In the model, specifically transfer $\Pi^C < 0$ if $\tau[K - (\bar{v} - \hat{v})] < (1 - \tau)[\hat{b} - \hat{e} - s]$. This is more likely for small K (i.e., when monitoring costs are less of the 'agreement cake'), or for $\bar{v} - \hat{v}$ or $\hat{b} - \hat{e}$ large (i.e., when the Community really would like to extract some of the natural resources, but this induces a high loss in conservation value), or if s is small (i.e., when Community monitoring is very cost effective).

2.3 Hypotheses

We summarize results from sections 2.1 and 2.2 in three sets of hypotheses.

DE FACTO RIGHTS

	Park has <i>de facto</i> rights (yielding FF or KKM)	Community has <i>de facto</i> rights (yielding PT)
\bar{v}	High	Low
K	Low	High
\tilde{e}	High	Low
\tilde{b}	Low	High
r^C	High	Low
r^P	Low	High

Empirically, as attempted in Section 4 below, these predictions from the model can be examined for our case by comparing values of parameters listed in the table between a group of observations consisting of those where Park appears to have *de facto* rights (FF and KKM together, where the FF designation is not observed but rather inferred) with the group where Community appears to have rights (PT, which also is inferred).

⁹ For example, see Behera and Engel (2006) and Rustagi et al. (2009).

INSTITUTION GIVEN DE FACTO PARK RIGHTS

	FF	KKM
$\hat{b} - \hat{e}$	Relatively lower	Relatively higher
K	Relatively lower	Relatively higher
S	Relatively higher	Relatively lower
$\bar{v} - \hat{v}$	Relatively higher	Relatively lower

These predictions from the model can be examined by comparing the means of these parameters across the group of observed FF and the group of observed KKM.

TRANSFERS WITHIN KKM INSTITUTION

	KKM transfer to community predicted to be higher when:
τ	Higher
K	Higher
$\bar{v} - \hat{v}$	Lower
$\hat{b} - \hat{e}$	Lower
s	Higher

These predictions from the model can be examined by comparing listed parameters between subgroups of the group of observed KKM, specifically those communities receiving agricultural/development benefits in agreements and those which did not.

3. Data

We present background about Lore Lindu National Park in Indonesia, including information about the surveys and methods used to gather data in the area. In addition, we provide some more context for better understanding of the negotiated KKM agreements, along with some basic statistics related to the observed agreements.

3.1 Lore Lindu National Park (LLNP)

LLNP covers a mountainous area of over 200,000 ha dominated by primary and secondary forest, in the province of Central Sulawesi. The region is renowned for its unique biodiversity. LLNP is an identified core area for protection of the Wallacea biodiversity hotspot (Myers et al. 2000; Achard et al. 2002) with over 200 bird species observed, of which 77 are endemic to Sulawesi (Waltert et al. 2004; 2005).

Combining three protected areas established during 1973-1981, Indonesia's government officially founded LLNP in 1993 (Birner and Mappatoba 2003). Land customarily used by local communities was designated Park. A few communities moved out of the park to its borders (Mappotoba 2004). Despite decentralization after the fall of Suharto in 1998, all National Parks are still run by the central government (Ministry of Forestry). It holds *de jure* property rights to all natural resources, with strict rules prohibiting community forest use in the Park. In contrast, land use rights in the local communities tend to be based on traditional *adat* rights (customary law).

There are 60 communities at LLNP's borders and seven more in two enclaves inside the park (Figure 2). The provincial capital, Palu, is close to the northern end, with relatively good roads to many communities. Agriculture is the primary source of income, with paddy rice the principal food crop and cocoa and coffee the most important cash crops (Maertens et al. 2006).¹⁰ Agricultural expansion has been said to be one of the primary drivers of past deforestation within LLNP (Maertens 2003).

FIGURE 2 HERE

Beginning in 1999, and on the initiative of the head of the LLNP at that time, Community Conservation Agreements (*Kesepakatan Konservasi Masyarakat* (KKM)) were established as a strategy for Park authorities and local communities to jointly co-manage forest inside Park borders. Mediated by local and international NGOs, KKM were negotiated to resolve conflicts between communities' needs and conservation's demands (Mappatoba 2004). Overall, the aim of the KKM is to overcome the major threats to LLNP, i.e. forest conversion inside the Park for agricultural land, rattan extraction, logging, hunting of protected endemic animals, and the collection of eggs of the protected maleo bird (ANZDEC 1997). Long-standing community claims to

¹⁰ Average percentages of community-level production that goes to market for the most important crops grown are: 30% for rice, 68% for corn, 74% for coffee, and 92% for cocoa.

Park forest resources were recognized in exchange for communities undertaking responsibilities towards Park protection and management. While *de jure* property rights to forest land continue to be held by the Indonesian government, limited forest use rights for communities were tacitly institutionalized within these KKM.¹¹

3.2 Data (including KKM)

As part of an interdisciplinary research programme known as Stability of Rainforest Margins in Indonesia (STORMA),¹² 80 out of a total of 119 communities in the Lore Lindu region were surveyed using stratified random sampling in 2001 (Zeller et al. 2002). Data were collected on community characteristics including demography, household livelihoods, land use and social institutions. In 2006 and 2007, this survey was repeated with the same sample, although the number of communities surveyed dropped to 72 due to funding and time constraints.¹³

One major difference was the inclusion of detailed questions on the KKM in the 2006-07 survey. Before then, it was not known which communities had negotiated agreements with the exception of six surveyed previously by Mappatoba (2004).

Remote sensing data were collected by STORMA for 2001-02 and 2006-07. Based on 30x30 m pixels, they convey land-use classes including 'broadleaved (closed) forest' and 'mosaic' (degraded forest and agriculture) as well as a number of agricultural land uses. A map of community land claims was overlaid upon a land-use map using the data that were collected within a comprehensive, five-year participatory mapping project that was undertaken between 1998 and 2003 (Mappatoba 2004).¹⁴

A total of 50 communities claim forest inside LLNP. All claim forest outside as well. Of these, 28 negotiated KKM with the Park, with local and/or international NGOs as facilitators. These NGOs have differing policy objectives with many having operated in the community prior to negotiation of the KKM (Mappatoba, 2004). The

¹¹ This institutionalization was implemented via a new interpretation of Indonesia's 1999 Forestry Law by the head of LLNP (Mappatoba 2004). The law gave substantial decision-making powers to local governments, and formalized community use rights to forest resources (Palmer and Engel 2007).

¹² STORMA is a collaborative research programme between Indonesian and German universities - the Agricultural Institute Bogor (Bogor, Java), Tadulako University (Palu, Sulawesi), University of Kassel and Georg-August-University Goettingen. Since 2000, research has focused on processes and factors of the stability and dynamics of rainforest margins.

¹³ All those dropped from the survey in 2006 were ones located furthest away from the Park, with little or no dependence on Park resources and no territorial claims within the borders of LLNP.

¹⁴ Coordinated by the provincial authorities of Central Sulawesi, the project was funded by the Asian Development Bank.

first KKM was piloted in 1998 by a local NGO known as the Free Earth Foundation (YTM) that emphasized indigenous land- and forest-use rights. YTM is involved in agreements in a further six communities, four facilitated with other NGOs. Another local NGO, JAMBATA, has a more environmental focus as well as strong links to the international development NGO CARE. It also works in a relatively small number of communities in this area, in this case six in total, of which three were co-facilitated.

The NGO responsible for facilitating the majority of agreements is the Nature Conservancy (TNC), an international conservation NGO. It has worked with LLNP on conservation management plans since 1992. The 21 agreements promoted by TNC, and sometimes co-facilitated with JAMBATA or YTM, had a high level of detail on resource-use regulations and were adapted to a village's conditions. Negotiations were typically concluded and agreements acknowledged by the Park within the same year.

We note that park authorities deliberately maintained a low profile in KKM negotiations. For political reasons, the park had to at least maintain the pretence of upholding strict *de jure* no-extraction regulations within LLNP borders. Yet while the NGOs were more visible during negotiations, the park was the negotiating partner for communities and the park had the final say on KKM rules and management systems.

The typical KKM process involved facilitators and communities working together to map and to plan as well as to draft the KKM. Mapping was undertaken in 24 (86 %) of cases. The park authority was usually in attendance during this process; local government was present in fewer cases. By 2006, 24 KKM (86 %) had been formally recognized by the park authorities. In general, KKM agreements allowed communities the 'right' to remain settled within LLNP (for those yet to be resettled outside) and the authority to manage natural resources in LLNP (following traditional village institutions and customary use rights) in exchange for community commitment to implement a forest management plan and to enforce this effectively.

Traditional forest rights were agreed upon within 22 KKM (79 %), while the permission to remain in a community's current location was granted within 16 KKM (57 %). Agricultural assistance was agreed upon in 13 cases (46 %). Common rules agreed upon include: limits on the amount of timber harvested (56 %); restrictions on forest conversion (64 %); restrictions on plantation development (57 %); restrictions on the harvesting, use, and sale of rattan (57 %); and, restrictions on the use and sale of timber (50 %). All communities with a KKM established an enforcement system.

4. Empirical Results

Our model examined endogenous emergence of three institutional outcomes. Ranking from the Community actor's perspective in terms of increasing land uses: a fences-and-fines (FF) result in which Park can block forest extraction; a negotiated agreement (KKM) outcome in which Park could block extraction but negotiates a deal with Community to allow some extraction and save on monitoring and enforcement; and a paper-tiger (PT) result in which Park is unable to block forest extraction.

The great strength of our data is the observation and description of the KKM. However, an immediate challenge is how to distinguish among the non-KKM settings or institutions in the data. Local actors might be confident they can identify *de facto* property rights, e.g. FF versus PT settings, on the basis of their personal experience or others' anecdotes. We, however, do not observe this distinction in the non-KKM data.

We use the observed rates of deforestation to identify *de facto* property rights within the 22 non-KKM communities, i.e. to distinguish FFs from PTs. Thus if forest increased from 2001 to 2006 for a non-KKM observation, we assign FF. If it fell, we assign PT. Table 2 shows the significant deforestation differences not only across the two groups labeled in this way but also between each of the two and observed KKM. KKM observations are in the middle, with deforestation above 'FF' and below 'PT'.

TABLE 2 HERE

4.1 Who Wins De Facto Rights?

Our conflict model predicted which actor can impose, be that full conservation or full extraction. Higher conservation benefits raise the gains of fighting to the park and thus both the chance that the park simply imposes FF and the chance of a KKM negotiated from an FF default. Higher Community gains from extraction, in contrast, make PT more likely. PT is more likely also when there is a higher cost of excluding the Community, while high Community discounting and high Community extraction costs support FF. As we observe when a KKM exists and we have distinguished the non-KKM institutions in Table 2, Table 3 can describe relevant patterns in the data using our proxies (the rationales for which are in Appendix B, for all of our results).

TABLE 3 HERE

Table 3 begins with the conservation benefits of the Park (v). Communities in close proximity to an important bird-watching site feature forests with higher gains

from conservation and this should lead to willingness of park authorities to fight for property rights. Consistent with this prediction from our model, 44% of communities are proximate to bird sites for the institutions in the *de facto* Park rights settings, FF and KKM. That is significantly higher than the 18% proximate to bird sites for PT.¹⁵

Table 3's proxies for Park enforcement costs (K) are the proximity to a park ranger office (from survey data), the distance to the provincial capital Palu and thus also the Park headquarters and provincial government, and finally also the proportion of Community land characterised as hilly terrain (over 20° in GIS data). While the result for hilly terrain supports the model hypothesis, we are less than fully clear that this variable always best proxies for enforcement costs alone.¹⁶ We certainly expect in contrast that greater distance to the location of those who undertake enforcement, i.e. to park rangers' and government offices, could significantly raise K . We see in Table 3 that the values across groups for both of these proxies support the hypothesis that higher enforcement costs (K) raise the probability of observing PT.

Considering next the Community benefits from extraction, five of our ten proxies variables for b presented in Table 3 exhibit significant differences between the groups. Just as for v and K above, all support the model's predictions. Greater food shortages (across two prior decades), within the first column, are consistent with the relevance of higher expected benefits to the Community from using forested land for food production, thus lowering the probability of observing a PT outcome. When a higher share of the Community migrates temporarily there is relatively less value in extracting, which gives the Park a greater chance of claiming *de facto* rights. Finally, the prices for rice and coffee and timber are found to be significantly lower in those places where it seems that the Park could exclude Community, consistent with the logic that lower Community's incentives to use forest permit an FF default.¹⁷

¹⁵ On the other hand, along the lines of Sims (2009) birdwatchers may spend money in and around the villages close to these sites (that said, they may well not depend on how tourism is structured). This could lower communities' net benefits from degrading forest (lower b), which has the opposite prediction. That a proxy might correlate with multiple parameters is a recurring feature of our data.

¹⁶ Continuing the theme of other parameters potentially being correlated with the same proxies, here we might imagine that if agriculture is more difficult on hilly terrain then community benefits from using forest (b) will be lower where terrain is hilly. That would predict less PT for hilly areas, not more. However, even if that were the case, our results in Table 3 might simply indicate that this is outweighed by the enforcement effect of hills. We also note significant agriculture on slopes, particularly rice (Maertens et al., 2006).

¹⁷ The numbers of households dependent on timber harvesting are relatively small. We include this in our analysis anyway as they could have a large influence on the small deforestation rates in our sample.

Next we consider a Community's expected (opportunity) cost of extraction, e . Differences for our two proxies, households with off-farm wage labor and where the proportion of children ages 13 to 18 is higher, are not statistically significant. Still we will note that their values are higher in the first column, consistent with our model.

Finally, we predicted that communities with higher discount rates value less the gain from winning *de facto* rights relative to the costs of early actions to win them. This predicts more PT, i.e. extraction gains due to patience, for lower discount rates. Robust proxies for Community discount rate are difficult to isolate. Credit is one reasonable option but at first glance the data for government and NGO credit do not support our model since more credit in the first column would imply lower discount. However, as noted under Table 3, the allocation of credit is not random with respect to other measures relevant for observed institutions. In particular, communities closer to the park headquarters are more likely to get such credit. That predicts less PT.¹⁸

TABLE 4 HERE

4.2 When Do KKM's Arise Under Park Rights?

Here we compare communities that have negotiated a KKM (28 communities) with those where a park could negotiate a KKM but instead simply excludes, FF (11). Put another way, we examine *de facto* Park rights, no longer examining PT cases, and our second set of hypotheses from the model predict when KKM's will be observed.

The novelty introduced here (and in Table 4) affects Park's choice to exclude versus to negotiate a KKM institution and it is the Community's capacity to organize and implement a KKM in such a way that the Park believes the agreement will work. Park benefits matter but almost surely Park perceives sufficient conservation benefits to be concerned about forest implications of delegating enforcement within a KKM. Community surely perceives sufficient benefits from the use of the forest such that household forest use remains a threat under a KKM (though Park can revert to FF).

Thus, we might even expect that the central issue here would be whether the park believes that such a KKM can be carried out. To examine this, Table 4 presents group values for our proxies for s , Community cost of setting up internal monitoring. Overall, we find that our proxies for s strongly support the theoretical predictions.

¹⁸ Adding to the note under Table 3, we observe also that access to government credit and other credit are highly correlated with distance to Palu (0.01 level). This can confound the inference about credit.

The collective action literature (Agrawal 2001) suggests that smaller and more homogenous communities self-monitor at lower cost. In Table 4, we see that KKM arise for smaller communities, although the difference is not statistically significant. Per homogeneity, we see a significant difference in that KKMs arise in locations with on average 85% native households, whereas non-KKM observations average 72%.

Land ownership differences might also not only comment on homogeneity but also independently indicate potential for conflict of interest (or even conflict as we examine directly just below). While the difference in the land Gini coefficient does support our hypothesis it is too small to be significant. On the other hand, both the fraction of households who sold all their land and the overall fraction with no land display significant differences in Table 4 which support the model prediction here.

Previous conflict itself, we suspect, would not only lower Community ability to organize around an agreement but also signal to a Park that even if somebody came to the table to sign an agreement it might not mean as much in terms of future behaviors. Within Table 4, the measures of evidence of among-native and native-migrant prior conflict that proxy for higher costs of enforcement both support the prediction. For the conflict with other communities, both the direct measure and the fact of having split from a community previously also support the hypothesis but unlike the other two proxies here for Community capacity to enforce they are not of statistical significance. The same is true of a labor-sharing measure suggesting low s .

The Park's cost of monitoring and enforcement, K , here is playing the role of the cost savings, i.e. benefits, from negotiating a KKM (versus KKM's expected cost of potential forest loss that motivated park concerns with Community capacity above). Thus higher K should motivate KKMs and the proximity to the ranger's office proxy goes in that direction but it is not significant. The other critical distance is significant, though, i.e. the distance to Palu is higher on average for KKM versus FF observations. Hilly land goes the other direction but as noted above may proxy for lower b as well.

Turning finally to v (conservation benefits) and b (Community use benefits) as well, Table 4 presents these for completeness although again we suspect that v will be essentially always sufficiently high to yield Park concerns about surrendering control while b will be essentially always sufficiently high that communities prefer a KKM given that the alternative is pure exclusion. Concerning v , we see that we cannot test this parameter well, as the group averages are not statistically significantly different, although the small difference does happen to be in the direction supporting the model.

Concerning b , the difference in what we imagine is a key benefits variable (as in Table 3), food shortages, also supports the model predictions and is bigger than the small difference for the v proxy, however it also is not statistically significant. Five others also are insignificant though four are significant and of those, three of them do not support the model predictions. What would seem an important proxy for benefit, the fraction of community land inside the Park is significant and supports the model. This features a seemingly large difference (i.e., 69% for KKMVs versus 47% for FFs, though it is worth noting a 15% difference was not statistically significant in Table 3).

TABLE 5 HERE

4.3 What Explains Transfers Under Co-management?

Table 5 permits comparisons of proxies' group averages, like Tables 3 and 4, but now considering only communities with KKMVs. The comparisons are between the negotiated agreements that were said to have delivered agricultural benefits (as part of compensation for restricted forest use) and the agreements where none were provided. Agricultural benefits were the only benefits observed to be transferred in this study.

As we find few statistically significant differences, while we do not reject our model's predictions at this level, of course neither can we confirm them. However, an examination of transfers also provides the novelty of empirical study of community bargaining power or, more precisely, proxies for power that could affect the transfers.

Note from our model that in principle transfers could be positive (flowing to Community) or negative (flowing to Park). We focus here upon the observed benefit transfers and note that those are always zero or positive flows to the Community.

The bargaining power comparisons in Table 5 are all supportive of the model. That said, as noted very few are significant. Community knowledge about movement by other communities is statistically associated with more delivered benefits, while other types of knowledge (about forest use and forest rights) are just not significant. Additionally, NGO concerns and prior conflict looks supportive but are insignificant.

Beyond that, a quick skim of Table 5 confirms many insignificant differences with none significant for conservation benefits (v) and Park enforcement cost (K) and only two significant for Community use benefits (b), only one of which supports our predictions. There is one relatively large significant difference for Community cost of enforcement (s), for the prior conflict with another community. It is supportive.

5. Discussion

We developed a game-theoretic model of an interaction between a protected area authority and a local community on the periphery of a park. Its main feature is that the *de facto* property rights over a park's natural resources are endogenous to parameters that vary across settings. This is in contrast to previous studies on co-management.

Theoretical results indicated the conditions under which co-management is likely to arise, in terms of conservation benefits of forest, public enforcement costs, private community ability to enforce agreements and other fundamental parameters of forest conservation settings. Co-management arises, potentially, when a park has the ability to exclude a community. It is a means of reducing monitoring costs for the park, at the cost of conceding limited forest use rights that provide benefits to the community.

If co-management arises when parks can exclude but the outcomes of such agreements are compared with all other cases, then their effectiveness in promoting forest conservation may easily be overestimated. The appropriate comparison for the impact on both forest and livelihoods is exclusion and, of course, involves tradeoffs.

Next we evaluated the extent to which our new model's predictions about the settings in which these outcomes may arise correspond to some observed agreements. Using a unique dataset on community conservation agreements (KKMs) collected in the Lore Lindu National Park in Sulawesi, Indonesia, we find that the park appears to have been more likely to win *de facto* property rights where there are higher gains to conservation and where enforcement costs are relatively cheap for the park authority. It is also more likely where the community has fewer benefits from extraction, e.g. where food shortages have been less prevalent in the past, and where there are more out-migrants and lower commodity prices. These findings all supported the model.

Within settings where the park appears to have *de facto* rights, we compared the KKM to the non-KKM communities, introducing the critical issue of the ability and capacity of the community to enforce an agreement. Proxies for this factor follow our theoretical predictions in predicting a KKM outcome. Our empirical results suggest that the community's ability and capacity to self-enforce a KKM is more likely where there is greater ethnic homogeneity, less evidence of prior conflict, and where more households hold land for agricultural purposes. These results fit with much of the collective action literature including Ligon and Narain's (1999) finding that state policy preferences depend on community ability to enforce collective agreements.

Finally, our model also addresses variation across KKMs' terms, specifically transfers, as the result of a negotiation process that depends on bargaining power and fallbacks. These could be positive or negative but no negative transfers were observed in our data. For LLNP, we find that certain types of knowledge, i.e. about involuntary movements of other communities out of the park, seem to correlate with stronger bargaining power. That said, results for transfers under co-management are weaker than for the first two sets of hypotheses, likely at least in part due to reduced sample.

It could be that observing a wider range of transfers would increase our ability to test the model. Other studies have indicated evidence of negative transfers in co-management initiatives in India and Ethiopia (Behera and Engel, 2006; Rustagi et al., 2010). Thus, testing model predictions using, for example, data from different Indian states, which exhibit a large variation in transfers within the country's Joint Forest Management Program, could be an interesting extension within this line of research.

Other possible extensions follow from broadening of our modeling assumption (following our empirical setting) that negotiated agreements with *de facto* community rights would be ineffective. The reason is that implementation need be conditional on performance with periodic transfers based on monitoring of forest outcomes. In other settings, e.g. in the Participatory Forest Management (PFM) program in Ethiopia, this might be possible. State management was ineffective before PFM, implying that co-management emerged under *de facto* community rights. More generally, certainly the growing attention to payments for environmental services (PES) involves conditional transfers (see Engel et al., 2008). This would be an interesting extension to our model and one relevant for Reducing Emissions for Deforestation and Degradation (REDD).

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Figures and tables

FIGURE 1: Conflict game between Community and Park

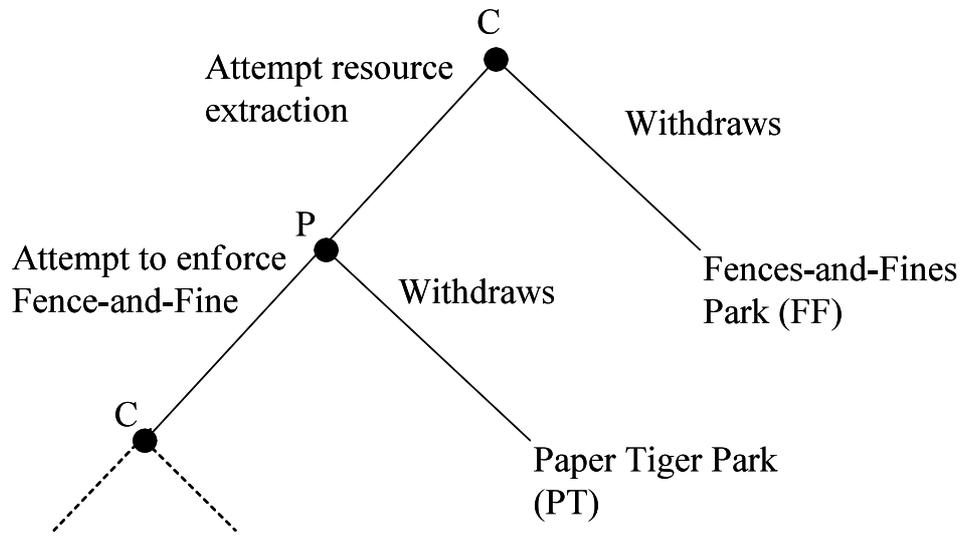
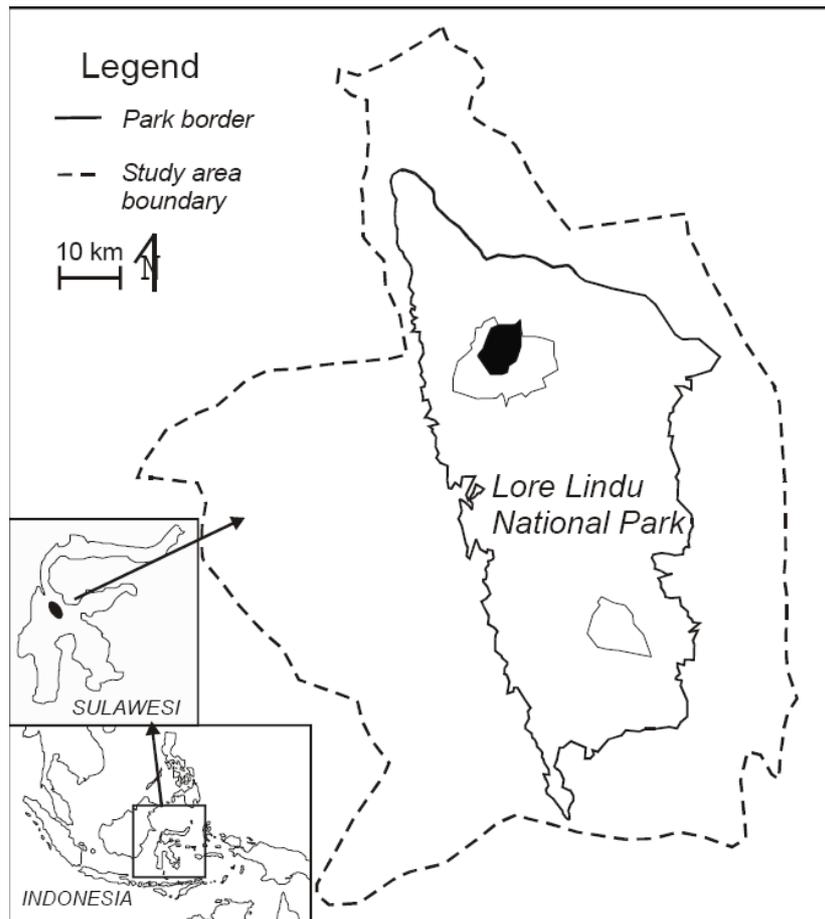


FIGURE 2: Map of the study area



Source: Stability of Rainforest Margins in Indonesia (STORMA)

Note: The dark area denotes a water body within one of the enclaves.

TABLE 1
Payoff Matrix for Model Outcomes

	Payoff to P	Payoff to C
IF PARK (P) WOULD WIN ANY POTENTIAL CONFLICT:		
Fences-&-Fines (FF) , where high enforcement prevents any extraction	$v(\bar{L}) - K$	0
Co-management agreement (KKM) -Park saves on enforcement by devolving these tasks to Community -Community gets some extraction & possibly a transfer (that could be + or -)	$v(\bar{L} - \hat{L}) - \Pi^C$	$b(\hat{L}) - e(\hat{L}) - s + \Pi^C$
IF COMMUNITY (C) WOULD WIN ANY POTENTIAL CONFLICT:		
Paper Tiger park (PT) , where lack of effective enforcement allows extraction	$v(\bar{L} - \tilde{L})$	$b(\tilde{L}) - e(\tilde{L})$
Co-management agreement (KKM) <i>Not enforceable in PT unless transfer could be conditioned on performance.</i>	-----	-----

TABLE 2
Labelling Non-KKM Communities (i.e. *de facto* property rights)

FOREST CHANGE	‘FF’	KKM	‘PT’
# of communities	11	28	11
L (rate of change in forest cover within the park, 2001 - 2006)	7.268***	-0.257**	-6.360***

Note: Significance of differences between means are indicated in KKM column for KKM versus PT, in FF column for KKM versus FF, and in PT column for PT versus FF: *** = 0.01; ** = 0.05; * = 0.1

**TABLE 3 -- Endogenous *De Facto* Property Rights
Fences-and-Fines (FF+KKM) vs. Paper Tigers (PT)**

PROXIES	Proxies' Group Averages	
	FF & KKM (39)	PT (11)
$v(L)$ = conservation benefits of park	<i>expect v higher</i>	<i>expect v lower</i>
Near a prime bird watching area	0.44*	0.18
K = park's cost of enforcement	<i>expect K lower</i>	<i>expect K higher</i>
Near a park ranger office (<i>K lower</i>)	0.69**	0.27
Distance to Palu and provincial gov't	79*	110
Mean % slope above >20°	9.92*	11.34
b = community's benefits from use	<i>expect b lower</i>	<i>expect b higher</i>
Existence of food shortages, 1980-2001	0.64**	0.91
Maximum % loss of harvest, 1980-2001	51.67	63.18
% temporary outmigrants 2001 (<i>b lower</i>)	2.46**	0.35
% of community area located inside park	62.87	47.67
% principle livelihood from timber 2001	0.56	0.89
% principle livelihood rattan and timber	5.77	2.39
Price of rice, per kg, 2001	2,152**	2,482
Price of coffee, per kg, 2001	4,324**	5,510
Price rattan, per kg, 2001	625	707
Price timber, per m3, 2001	516,053***	668,182
e = community's extraction costs	<i>expect e higher</i>	<i>expect e lower</i>
% households with off-farm earners, 2001	6.82	6.43
% of children 13-18 in school, 2001	40.12	31.31
r^C = community's discount rate	<i>expect r higher</i>	<i>expect r lower</i>
Government/NGO credit programme, during the period 1980-2001 (1 = yes) (<i>r lower</i>)	0.93** (see note below)	0.64 (see note below)
Other credit programme, 1980-2001 (<i>r lower</i>)	0.46	0.27

Significant differences between the group averages of these proxy variables are indicated within the first column ('FF&KKM'): *** = significant at the 0.01 level; ** = significant at 0.05; * = significant at 0.1

Note concerning Government/NGO credit: receiving such credit is highly correlated with being close to the Park HQ (i.e., monitorable), most likely due to the costs of accessing the credit infrastructure. While we wanted to report this, for completeness, we feel we cannot independently test this factor.

**TABLE 4 -- Endogenous Participation (given Park rights)
Fences-and Fines (FF) vs. Negotiated Agreements (KKM)**

PROXIES	Proxies' Group Averages	
	FF (11)	KKM (28)
<i>s</i> = community's cost of enforcement	<i>expect s higher</i>	<i>expect s lower</i>
Number of households, 2001	365.09	252.00
% native households, 2001 (<i>s lower</i>)	71.99*	85.89
Land distribution (Gini), 2001	0.406	0.385
% households sold all land, 1995-2001	2.78**	0.55
% households with no land, 2001	10.91*	3.57
Conflict among native hh, 1995-2001	0.91*	0.64
Conflict native & migrant, 1995-2001	0.45*	0.18
Conflict with another village, 1995-2001	0.36	0.29
Previously part of another village	0.36	0.18
% population in labor sharing (<i>s lower</i>)	21.31	22.98
<i>K</i> = park's cost of enforcement	<i>expect K lower</i>	<i>expect K higher</i>
Near a park ranger office (<i>K lower</i>)	0.73	0.67
Distance to Palu and provincial gov't	61*	86
Mean % slope above >20°	12.56***	8.94
<i>v(L)</i> = conservation benefits of park	<i>expect v higher</i>	<i>expect v lower</i>
Near a prime bird watching area	0.45	0.42
<i>b</i> = community's benefits from use	<i>expect b lower</i>	<i>expect b higher</i>
Existence of food shortages, 1980-2001	0.55	0.68
Maximum % loss of harvest, 1980-2001	56.36	49.82
% temporary outmigrants 2001 (<i>b lower</i>)	0.877*	3.08
% of community area located inside park	46.89**	69.15
% principle livelihood from timber 2001	1.68*	0.13
% principle livelihood rattan and timber	12.10*	3.28
Price rice, per kg, 2001	2,186	2,139
Price coffee, per kg, 2001	5,000	4,174
Price rattan, per kg, 2001	616	630
Price timber, per m3, 2001	519,815	514,815

Significant differences between the group averages of this proxy variables are indicated within the first column (i.e. 'FF'): *** = significant at the 0.01 level; ** = significant at 0.05; * = significant at 0.1

TABLE 5 -- Endogenous Terms (given a KKM)**Delivered Agricultural Benefits vs. None**

PROXIES	Proxies' Group Averages	
	Delivered (11)	None (17)
τ = community's bargaining power	<i>expect τ higher</i>	<i>expect τ lower</i>
Conflict with park over forest	0.55	0.47
Know that other communities moved	0.82***	0.18
Know that KKM's allow forest use	0.64	0.53
Know that KKM's cede forest rights	0.73	0.65
NGO worried about forest degradation	0.45	0.24
$v(L)$ = conservation benefits of park	<i>expect v lower</i>	<i>expect v higher</i>
Near a prime bird watching area	0.27	0.53
K = park's cost of enforcement	<i>expect K higher</i>	<i>expect K lower</i>
Near a park ranger office (<i>K lower</i>)	0.55	0.76
Distance to Palu and provincial gov't	99	78
b = community's benefits from use	<i>expect b lower</i>	<i>expect b higher</i>
Existence of food shortages, 1980-2001	0.64	0.71
Maximum % loss of harvest, 1980-2001	40.91	55.59
% temporary outmigrants 2001 (<i>b lower</i>)	3.08	3.07
% of community area located inside park	64.59	72.09
% principle livelihood from timber, 2001	0.00*	0.20
% principle livelihood rattan and timber	4.59	2.44
Price rice, per kg, 2001	2,289*	2,042
Price coffee, per kg, 2001	4,300	4,088
Price rattan, per kg, 2001	588	677
Price timber, per m3, 2001	463,636	550,000
s = community's cost of enforcement	<i>expect s higher</i>	<i>expect s lower</i>
Conflict among native hh, 1995-2001	0.54	0.73
Conflict native & migrant, 1995-2001	0.23	0.13
Conflict with another village, 1995-2001	0.46*	0.13

Significant differences between the group averages of this proxy variables are indicated within the first column ('Delivered'): *** = significant at the 0.01 level; ** = significant at 0.05; * = significant at 0.1

APPENDIX A Proof of $\hat{L} < \tilde{L}$

Suppose $\hat{L} \geq \tilde{L}$. Then, by concavity of b , $b'(\hat{L}) \leq b'(\tilde{L})$. From (4) and (1), this implies $v'(\hat{L}) + e'(\hat{L}) \leq e'(\tilde{L})$, and hence, since $v' > 0$, $e'(\hat{L}) < e'(\tilde{L})$. However, given the convexity of e , this would imply that $\hat{L} < \tilde{L}$, which contradicts our initial assumption. Thus $\hat{L} \geq \tilde{L}$ is not possible, and it must be that $\hat{L} < \tilde{L}$.

APPENDIX B RATIONALES UNDERLYING PROXIES

Variable	Effect of proxy on variable	Rationale
$v(L)$ = conservation benefits		
Community area neighbours a prime bird-watching site, 2001	+	LLNP contains many endemic bird species with a number of bird-watching sites located in and around the park.
K = park's cost of enforcement		
Community area neighbours a park ranger office	-	Better accessibility to community and surrounds makes it easier (cheaper) for park to monitor (smaller K)
Mean % hilly area ($>20^\circ$)	+	The larger the area defined as 'hilly', the harder and more difficult for Park to monitor [could also affect b and s]
b = community's use benefits		
Food shortages, 1980-2001 (1 = yes)	+	Evidence for drought/food subsidies/food shortages indicates larger benefits from forest conversion for agriculture
Max % loss of harvest due to drought, 1980-2001	+	
% village population as temporary outmigrants, 2001	-	The more outmigrants, e.g. working in city, the less dependence on forest for livelihoods.
% of community's total area located inside park	+	The more territory inside park, the more community benefits from park forest exploitation.
% HH with principle livelihoods dependent on timber, 2001	+	Greater proportion of HH engaged in timber and/or rattan, the more benefits to community from forest exploitation (direct use only).
% HH with principle livelihoods dependent on rattan & timber, 2001	+	
Price rice, Rp per kg, 2001	+	Higher prices imply greater incentives to further exploit forest.
Price coffee, Rp per kg, 2001	+	
Rattan price Rp per kg, 2001	+	
Timber price Rp per M3, 2001	+	
Price rice land (rice), Rp per ha, 2001	+	Higher land prices imply greater incentives to capitalize on more forest reduction
Price land (other ag), Rp per ha, 2001	+	
e = community's extraction costs		
% households with '01 off-farm earners	+	More households in off-farm labour implies greater opportunity costs of time hence raising community extraction costs. (may also impact on s)
% of children 13-18 in school, 2001	+	More children between ages of 13 and 18 in school who would otherwise supply labour to households implies greater opportunity costs of time and community extraction costs.

r^C = community's discount rate		
Government/NGO credit programme, 1980-2001 (1 = yes)	?	Evidence of credit indicates collateral and possibilities for investment for future returns. Effect on ambiguous since either the already rich can access credit (have collateral) or credit is targeted at the poor in order to alleviate poverty.
Other credit programme, 1980-2001 (1 = yes)	?	
s = community's costs of enforcement		
# hh, 2001	+	Collective action theory: more HH/people increases costs of effective collective action necessary for establishing effective monitoring and enforcement system
% hh natives, 2001	-	Collective action theory: greater ethnic homogeneity decreases costs of effective collective action
Evidence of conflict among native hh, 1995-2001 (1 = yes)	+	Collective action theory: Previous conflict makes effective collective action more difficult and more costly
Evidence of conflict between native & migrant hh, 1995-2001 (1 = yes)	+	Collective action theory: Previous conflict makes effective collective action more difficult and more costly
Evidence of conflict with hh from another village, 1995-2001 (1 = yes)	+	Collective action theory: Previous conflict makes effective collective action more difficult and more costly
%HH sold all land, 1995-2001	+	Collective action theory: greater land inequality, increasing numbers HH without land and evidence for HH (illegally) selling community land makes effective collective action more difficult and more costly
%HH with no land, 2001	+	
Land distribution, 2001 (Gini)	+	
Village previously part of another village	+/-	Evidence for split from another village could either make collective action easier to undertake (smaller s) or harder
%working population in labour sharing groups	-	Collective action theory: the more workers engaged in labour sharing, the easier to enable effective collective action
τ = community's bargaining power		
Evidence of conflict over forest conversion in park, between village & park	+	Experience of conflict with park gives the community leverage over dealing with the park
Knowledge of other communities moving out of the park, 2006 (1 = yes)	+	Knowledge of other communities implies community can learn about strategy
Type of knowledge from KKM: allow villages to use forest/forest products, (1 = yes)	+	The more the community knows about other KKM and the costs and benefits of an agreement, the stronger its bargaining power?
Type of knowledge from KKM: give forest rights to communities, (1 = yes)	+	
Community knowledge of KKM before or during KKM (1 = yes)	+	The more the community learns about other KKM before it negotiates its own KKM, the more bargaining power it has
Why KKM? NGO worried about forest degradation, (1 = yes)	+	The more the other party is worried about forest deg and the more it has preferences to claim forest, the more power the community has
Why KKM? Village wanted to claim forest, (1 = yes)	+	