On the Endogeneity of Resource Comanagement: Theory and Evidence from Indonesia

Stefanie Engel, Charles Palmer, and Alexander Pfaff

ABSTRACT. *We examine theoretically the emergence of participatory comanagement agreements that share between state and user the management of resources and the benefits from use. Going beyond user-user interactions, our state-user model addresses a critical question—when will comanagement arise?—in order to consider the right baseline for evaluating comanagement's forest and welfare impacts. We then compare our model's hypotheses concerning de facto rights, negotiated agreements, and transfers (all endogenous) with community-level data including observed agreements in a protected Indonesian forest. These unique data could refute the model, despite being limited, but instead offer support.* (JEL Q28, Q57)

I. INTRODUCTION

Protected areas have been the leading instrument for forest conservation and their networks are continuing to grow. In developing countries, such areas may be established and maintained at the expense of local groups, conserving through exclusion or "fences and fines" (CITES) (Kiss 1990; Swanson and Barbier 1992; Tisdell 1995). Sometimes attempts to block resource uses are fruitless, implying that those protected areas are merely "paper tigers." Conflicts over natural resources and rights are reasons why protected areas may not fully conserve resources such as forests (see Albers and Ferraro 2006; Bulte and Engel 2006).

Yet those two possibilities for protection (i.e., fences and fines and paper tigers) do not exhaust the set of institutional possibilities for management of natural resources. Another option is to involve local user groups in managing resources. Such collaboration, or comanagement, involves the relevant state authorities negotiating with user groups to share the management of as well as the benefit from these resources (Borrini-Feyerabend et al. 2000; Carlsson and Berkes 2005).[1] For example, within forests, locals may be given responsibility for management and, in return, receive more rights to benefit from a forest (see, e.g., Baland and Platteau 1996; Knox and Meinzen-Dick 2000; Sims 2010).[2]

Initiatives of this kind are widespread, for forests (Edmonds 2002) and for coastal fisheries as well as irrigation (Ostrom 1990; Baland and Platteau 1996). Comanagement involves new costs and new benefits for the local resource users in addition to a trade-off for the state, namely, lower costs of management versus greater resource use by the locals.[3]

Much related research has focused upon intra-user-group or user-user interactions. Our focus is the state-user interaction and, specif-

[1] This can be in integrated conservation and development projects 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, Knox, and Di Gregorio 2001).

[2] Note our assumption, implicit in this text but explicit in our model below, that comanagement arises from a FF baseline. One way to say this is that to devolve rights the state must have them.

[3] Other factors in the decision to attempt comanagement could include equity, the policy's promotion by international donors, and evidence of successful management by users (Baland and Platteau 1996; Bulte and Engel 2006). Scherr, White, and Kaimowitz (2004) estimate that around 25% of forests in developing countries are currently owned or are controlled in some way by resource-dependent communities.

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The authors are, respectively, professor, Environmental Policy and Economics, ETH Zurich; lecturer, Department of Geography and Environment, London School of Economics; and associate professor, Sanford School of Public Policy, Economics, and Environment, Duke University, Durham, North Carolina.

ically, when comanagement will occur. First we develop a game-theoretic model that predicts when comanagement emerges, that is, when rights to resource use that are controlled by the state might be transferred to users. If the state has the rights, in other words, de facto control over the resource, it can limit user benefits. However, the critical feature of the model, reflecting many actual rights conflicts within the developing world, is that whether the state controls the resource is endogenous[4] since de facto property rights are the outcome of an initial state-user interaction, that is, a conflict. Second, in light of this new model, we compare model predictions with unique panel data describing new comanagement interventions in Lore Lindu National Park in Indonesia.

Previous models of comanagement (be they about forest, water, or fisheries) have assumed exogenous rights to resources.[5] Focusing on comanagement in protected forest, Barrett and Arcese (1998) and Skonhoft and Solstad (1996, 1998) consider impacts of comanagement on illegal hunting and wildlife conservation. Either households or the park has control over the wildlife stock. A model by Johannesen and Skonhoft (2005) assumes, in contrast, that both the park agency and the local people control wildlife—yet the rights again are exogenous, even though in this case the actors are strategically interdependent.

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

Muller and Albers (2004) model a protected-area manager interacting with local households in varied market settings. Their model has commonalities with ours, yet we assume no external, third-party enforcement; in other words, in ours everything is self-enforced. In addition, multiple possible endpoint outcomes or corner solutions are important within our results. Finally, Ligon and Narain (1999) study the effects of the state's policies upon community forest management when a community can potentially self-enforce any such collective agreements. While not explicitly focused on protected areas, this analysis finds that the state's rankings of policy options will depend in part on the community's ability to enforce collective agreements, a theme that is taken up in our model and empirics.

Most related empirical research also assumes that rights are exogenous, implicitly, since the institutions are used as independent variables for explaining resource outcomes. For example, Bardhan (2000) uses the property rights to water that are assigned by the state as an independent variable to explain irrigation outcomes. Similarly, Agrawal and Chhatre (2006) treat comanagement as an exogenous driver of forest outcomes.

Our model, where rights are endogenous, strongly suggests the need to control for or make use of the conditions that give rise to the observed institutions. For example, one might wish to instrument for the resource rights being local or comanagement emerging. Should comanagement occur only where the state could conserve natural resources via fences and fines, then comanagement could be *correlated with but not responsible for* positive resource outcomes. Comparisons with other cases could overestimate its impact. Or if comanagement arose where paper tigers are unable to constrain resource use, then comanagement could be correlated with but not responsible for livelihood improvement.

We model three possible endogenous outcomes. First is exclusion, where the state has de facto property rights and employs fences

[4] The model is adapted from Engel, López, and Palmer (2006) and Engel and López (2008), who consider interactions between resource-dependent communities and resource-extraction firms, given weak property rights. In their models, the firm limits a community's benefit from the standing forest by extracting the resource.

[5] While many studies of renewable resource comanagement are concerned with how intra-user group processes affect resource outcomes, some also look at the role of the state. In particular, there is a rich case-study literature on the comanagement of coastal fisheries (e.g., Pinkerton 1989; Pomeroy and Berkes 1997). Yet formal modeling of the state-user group interaction is absent in these studies.

and fines. Second is open access, where users have de facto property rights, implying a paper tiger. Third is comanagement, an outcome that is negotiated between the state and user groups and one in which a state effectively holds de facto rights, but the relevant local users are permitted to enjoy greater use of park resources in exchange for taking on some of the management responsibilities.

Our predictions are compared to the outcomes observed in Sulawesi, Indonesia. After decentralization within natural-resource sectors at the end of the 1990s, and given local demands for resource benefits, the head of Lore Lindu National Park pioneered new Community Conservation Agreements (referred to simply as KKMs, for *Kesepakatan Konservasi Masyarakat*) (Mappatoba 2004). These were formally between communities and the park authority, with both promotion and facilitation contributed by varied NGOs.

The data from repeated visits to Lore Lindu provide a rare opportunity to directly examine critical questions about *when* such a comanagement agreement might emerge. The data come from 50 communities, of which roughly half negotiated a KKM, providing observed proxies for some of the differences hypothesized to be critical in our model. We examine whether observed variations align with our model's predictions, albeit only for a relatively small set of communities. While these data do not support rigorous regressions, even our simple tables certainly could refute our model's prediction about the emergence of comanagement from within the fences-and-fines settings. Instead, they offer support.

Empirically, we examine first which actor wins de facto rights, noting that not all rights are observed directly, some are inferred. Next, among the settings where the park appears to have de facto rights, we compare communities with KKMs to those without. Then among KKMs, we compare predictions with observed transfers to the communities.

Our tables suggest that, as predicted, places where the park appears to have the de facto property rights feature higher conservation gains to forest, lower enforcement cost, and lower community benefits to extraction. Among settings where the park appears to have de facto rights, as predicted, our proxies for the community's ability to enforce the KKM (motivated by the collective-action literature) do correlate with the observed emergence of KKMs, that is, comanagement. Finally, regarding the within-KKM-agreements transfers, community characteristics have little explanatory power for variation across agreements.

II. MODEL

Here we present the basics and the intuition of our novel game-theoretic model of state-user interactions over land use within a context of weak formalized property rights. Our model is essentially an application, to this important conservation-policy problem, of the modeling approach of Engel, López, and Palmer (2006) and Engel and López (2008). Those papers integrated conflict and bargaining theories to examine the endogeneity of de facto rights. For our application of such thinking, we place all the formal elements within Appendix A, and below we focus upon the intuitions, starting with the conflict-and-rights component.

Conflict Determines Endogenous Property Rights

Property rights are the outcome of a war of attrition. Our two actors are "Park" and "Community," and our resource is forest. Engel, López, and Palmer (2006) consider bargaining within a context of forest exploitation, in particular logging (the actors are firm and community). Our bargaining occurs in a context of environmental benefits from forest conservation.

We assume that Park has de jure property rights over the forest but may be unable to enforce them, lacking funds and manpower sufficient to monitor the large and remote areas. These rights are challenged by locals (i.e., a community with longstanding forest claims), and either of these actors could obtain de facto forest-control rights. If Community could win a war of attrition, it could unilaterally exploit the forest, for example, collect fuelwood and do small-scale logging to reap use values (which likely require little in capital investment).[6] Park may be able to restrict that. If not—in other words, if Park cannot exclude Community—then Park also cannot enforce comanagement agreements. On the other hand, if Park can exclude Community, then Community and Park may bargain and they may reach a comanagement agreement to share management costs in exchange for more Community use benefits. For simplicity, we assume that each actor is risk neutral and has perfect information about the other.[7]

For greater generality, we allow that Park values not only environmental benefits of conservation but also, to an extent, the benefit that Community gets from resource use. Such a balance in the public objective is clearly consistent with our Indonesian case (see Section III) and other cases, for example, the many multiple-use protected areas found around the world (note that Joppa and Pfaff [2011] and Pfaff et al. [2013] examine their impacts on forests). Without question, some authorities will consider both resource and socioeconomic goals (for Costa Rica, Ferraro and Hanauer [2011] examine how such outcomes may trade off). Yet also we must note that public goals can be undermined by private individuals who work for public authorities but seek resource rents from illegal extraction. Per our model, bribes could be one interpretation of why Park values a Community's resource benefits. Despite reports of limited illegal logging by outside interests in LLNP, there is little evidence of bribes exchanged between Park and Community (see Mappatoba 2004). The possibility of bribed individuals working at cross-purposes is outside our Park model by construction, although it is important to recognize that it is a practical hurdle in reality.[8]

As noted formally in Appendix A, clearly we must assume that Park places a greater relative weight than does Community on the conservation benefits. Thus, Park prefers a lower extraction level than Community, and the degree may depend in part upon any influence of actors such as NGOs, which also have differing objectives. Actual extraction depends on who wins the war of attrition to get de facto forest rights. In general, the conflict game is won by the party able to stay longer in the potential conflict.

The results of the conflict model are intuitive. Any actor is likely to be able to stay in a resource conflict longer when that actor's benefits are higher and its costs are lower. Moreover, since the benefits of fighting are enjoyed over time while all the fighting costs are immediate, each actor is better able to stay in conflict when its discount rate is lower.

In each period, Community can attempt to exploit beyond the level Park prefers by investing additional effort into extraction of forest products, such as timber and rattan. Park can attempt to enforce via monitoring and enforcement to prevent excess extraction. If Community wins the conflict, it gains the present value of the additional stream of net forest benefits from extracting more than the Park would prefer. Thus, if Park loses this conflict and withdraws, a paper tiger (PT) park occurs. If Community loses the conflict, Park can enforce fences and fines (FF). Further, given perfect information, both actors can perfectly predict conflict outcomes. Thus the actor who loses withdraws immediately. PT outcomes have high Community forest extraction with no monitoring or enforcement, while FF outcomes have a lower Community extraction and high Park monitoring and enforcement.

To examine when comanagement might emerge, we focus on the situation when Park is more likely to win the conflict and, hence,

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

[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.

[8] See Robinson, Kumar, and Albers (2010), for example, for a useful review of how the economics literature on enforcement considers the practical issue of enforcing forest-access restrictions within developing countries, including in light of incentives faced by individual forest guards.

may enforce FF. Park is more likely to win if its benefits from reducing resource extraction are high. It is also more likely to win if its costs of monitoring and enforcing to impose FF are low, or Community's costs of forest extraction are high or Community's benefits from increased extraction are low. If Park's discount rate is low and/or Community's is high, Park is more likely to win.

However, while in such relatively supportive situations the Park could enforce FF, instead Park may choose to negotiate with Community a comanagement agreement (see the next section, below), that is, to delegate monitoring and enforcement of rules to Community. In return, it would allow greater resource extraction. That will not come about if Community wins the conflict game. As Park could not enforce agreements, PT will occur even if Park might prefer an agreement that reduces forest extraction. An ex post payment conditional on reduced extraction perhaps could benefit both actors, but since such payments were not observed within our empirical setting in Indonesia, we have limited our analysis of comanagement agreements to the cases in which Park could enforce a FF outcome. We refer to any such comanagement agreement specifically as a KKM, per the terminology from our Indonesian example. Table 1 shows the payoff matrix for all three outcomes.

These predictions are examined empirically below. We compare the values of our variable proxies between the observations for which Park appears to have de facto rights (i.e., either FF or KKM) and those for which Community appears to have the rights (PT).[9]

TABLE 1

	Payoff to Park	Payoff to Community
If Park Would Win Any Potential Conflict		
Fences and fines (FF), where high enforcement prevents extraction	$V(\tilde{L}_P) - K$	$B(\tilde{L}_P)$
Comanagement agreement (KKM) • Park saves on enforcement by devolving these tasks to Community • Community gets more extraction and possibly a transfer (that could be + or −)	$V(\hat{L}) - \Pi^C$	$B(\hat{L}) + \Pi^C$
If Community Would Win Any Potential Conflict		
Paper tiger park (PT), where lack of effective enforcement allows extraction	$V(\tilde{L}_C)$	$B(\tilde{L}_C)$
Comanagement agreement (KKM) • Not enforceable in PT unless transfer could be conditioned on performance.	—	—

Note: For notation see Appendix A; $0 < \tilde{L}_P < \hat{L} < \tilde{L}_C < F$.

Community-Park Negotiation under De Facto Park Rights

Here we focus on cases where the Park is able to self-enforce property rights (i.e., could impose FF) yet may choose to negotiate a comanagement agreement (KKM). One key to comanagement and decentralized natural resource management is lower cost for local communities to monitor and enforce rules. They use local knowledge and traditional monitoring and enforcement mechanisms (e.g., ostracism). Thus, Park may devolve costs of monitoring and enforcement in exchange for some additional extraction of resources.

If negotiation between the Park and the Community is Nash bargaining, then each actor receives her reservation utility plus a share of the aggregate gains generated by the monitoring-cost savings of comanagement.[10] Intuitively, given FF as the default option, the gains are net benefits from some increase in extraction plus the reduction in the total costs of all monitoring and enforcement effort less the reduction in conservation benefits.

As shown formally in Appendix A, a KKM is more likely to result when the loss in the conservation benefits from increased forest extraction and/or Community's costs of moni-

[9] It is important to note that of these three institutions, only KKMs are directly observed. Among non-KKM institutions, FF and PT outcomes have to be inferred (see Section IV).

[10] The share of that net gain is related to the actor's bargaining power (see Muthoo 1999).

toring and enforcement are low or when the Community's gain in net benefits from increased resource extraction or Park's cost of enforcing FF outcomes is relatively high.

There may also be a transfer involved, which we will call a transfer to Community (it can be negative). It rises with Community bargaining power, Park enforcement costs, and Community enforcement costs. It falls with conservation benefits lost under a KKM and Community net benefit from increased extraction (see Appendix A). Coasian thinking might have the Community pay Park not to impose FF, despite a (de facto) right to do so, implying a negative transfer. For instance, Park could get some of the nontimber forest products collected.[11]

Finally, we note that many parameters that determine the conflict outcome also determine whether comanagement emerges and may directly affect resource outcomes. This endogeneity of when the Park holds de facto rights, and when Park chooses a KKM instead of imposing FF, suggests that using institutional variables such as comanagement as independent variables to explain the resource or welfare outcomes could be problematic. Models of institutional determinants like ours could help to overcome this challenge, for instance by helping to identify candidate instruments for institutions, that is, factors that do affect the chance of observing comanagement but do *not* directly affect the outcome.

III. DATA

Here we briefly present background about Lore Lindu National Park (LLNP) in Indonesia, including information on surveys and other methods used to gather data in this area. In addition, we provide some context for a better understanding of the negotiated KKMs, our focus, along with some basic statistics about the observed agreements.

[11] 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 Program and a Participatory Forest Management Program in Ethiopia; for example, see Behera and Engel (2006) and Rustagi, Engel, and Kosfeld (2010).

About LLNP

LLNP covers a mountainous area of over 200,000 ha that is dominated by primary and secondary forest, in the province of Central Sulawesi. The region is renowned for its unique biodiversity. For instance, LLNP is one 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, Mardiastuti, and Mühlenberg 2004, 2005).

Despite decentralization after the fall of Suharto in 1998, all national parks are still run by the central government (within the Ministry of Forestry), which holds de jure property rights to all the natural resources. By combining three protected areas that were established during 1973–1981, Indonesia's government officially founded LLNP in 1993 (Birner and Mappatoba 2003). Land customarily used by local communities was in the park, and a few communities moved out of the park to its borders (Mappotoba 2004). Strict rules prohibit forest use by communities within the park. In contrast, use rights in the local communities tended to be based upon traditional *adat* rights or customary laws. Variation in extraction by communities inside LLNP suggests both FF and PT scenarios.

There are 60 communities at LLNP's borders and seven more in two enclaves in the park (Figure 1). The provincial capital, Palu, is close to the northern end of the park, featuring relatively good roads to many communities. Agriculture is the primary source of income in the area, with paddy rice the principal food crop and cocoa and coffee the most important cash crops (Maertens, Zeller, and Birner 2006).[12] Agricultural expansion has been said to be one of the primary drivers of past deforestation within LLNP (Maertens 2003).

Beginning in 1999, and upon the initiative of the head of LLNP at that time, KKMs were established as a strategy for park authorities and local communities to comanage forest in-

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

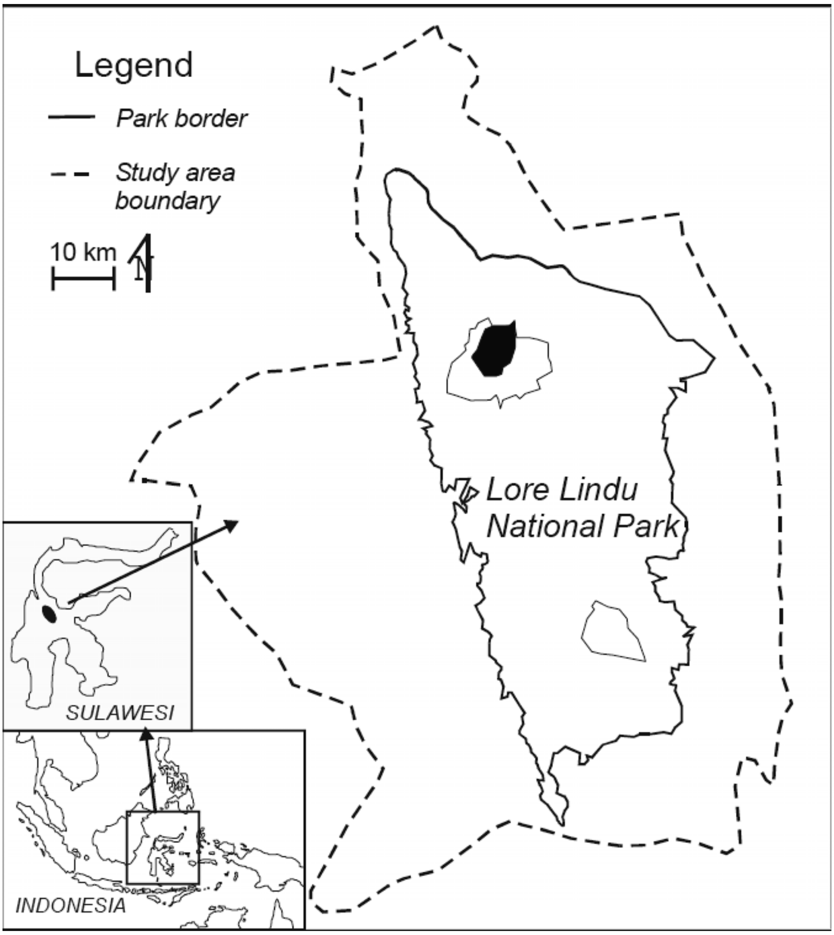

FIGURE 1
Map of the Study Area

side the park's borders. Mediated by local and international NGOs, KKMs were negotiated to resolve conflicts between communities' needs and conservation's demands (Mappatoba 2004). The official aim of KKMs is to overcome the major threats to LLNP, including forest conversion for agricultural land, rattan extraction, logging, hunting of protected endemic animals, and collection of eggs of the protected maleo bird (ANZDEC 1997).

Under the KKM, some of the long-standing community claims to park resources were recognized in exchange for communities undertaking management responsibilities. While de jure property rights to forest continue to be held by the Indonesian government, limited forest-use rights for communities were tacitly institutionalized in these KKMs.[13]

Data

Within the interdisciplinary research program STORMA, 80 of 119 communities in

[13] Institutionalization occurred via a new interpretation of Indonesia's 1999 Forestry Law by the head of LLNP (Mappatoba 2004). This gave substantial decision-making powers to local governments and formalized community forest rights (Palmer and Engel 2007).

the Lore Lindu region were surveyed using stratified random sampling in 2001 (Zeller, Schwarz, and van Rheenen 2002). Data addressed demography, household livelihoods, land use, and social institutions. In 2006, this survey approach was repeated with the same sample, although dropping to 72 communities due to constraints on funding and time.[14] The second survey included KKM questions. Earlier it was not known which communities had negotiated agreements, with the exception of six villages surveyed previously (Mappatoba 2004).

Remote sensing data were collected in addition by STORMA for 2001 and 2006. Based on 15 × 15 m pixels, they describe observed land-use classes including "broadleaved (closed) forest" and "mosaic" (i.e., degraded forest and agriculture), as well as a number of agricultural land uses. A map of communities' land claims was overlaid upon a land-use map, using the data that were collected within a comprehensive, five-year participatory mapping project undertaken between 1998 and 2003 (Mappatoba 2004).[15]

A total of 50 communities claim forest inside LLNP. All claim forest outside it as well. Of these, 28 negotiated a KKM with the park. Local and/or international NGOs were facilitators, many having operated in the community prior to negotiation of the KKM. These NGOs have differing policy objectives. The 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 with other NGOs. Another local NGO, JAMBATA, has an environmental focus and strong links to the international development NGO CARE.[16] It works in a small number of communities, where six agreements arose in total, of which three were cofacilitated.

The NGO responsible for facilitating most agreements is the Nature Conservancy (TNC), an international conservation NGO that has worked with LLNP on conservation management plans since 1992. The 21 agreements promoted by TNC, and sometimes cofacilitated with JAMBATA or YTM, included more detail about resource-use regulations.

All negotiations formally are between only the communities and the park, usually completed within a year, although often the park kept a low profile for political reasons (i.e., to signal its intentions to uphold strict de jure regulations). While the NGOs were key to facilitating these negotiations, the park had the final say on KKM rules and management.

The typical KKM process involved facilitators and communities working together to map areas and draft the KKM. Mapping was undertaken in 24 (86%) of the cases, and the park was usually in attendance, while local government was less often present. By 2006, 24 KKMs (86%) had been formally recognized by the park authorities. In general, KKM agreements allowed communities to remain settled in LLNP (for those yet to be resettled outside), plus the authority to manage natural resources, in exchange for the community's commitment to implementing a forest-management plan and enforcing that effectively.

Traditional forest rights were agreed upon in 22 KKMs (79%), while the "right" to remain in a current location was granted in 16 KKMs (57%). Agricultural assistance was agreed on in 13 cases (46%), although the data fail to identify the source of the observed assistance for all of the cases. Common rules included limits on timber harvest (86%); restrictions on forest conversion (64%); restrictions on plantation development (57%); restrictions on harvest, use, and sale of rattan (57%); and restrictions on the use and sale of timber (50%). All communities established an enforcement system within the KKM.

[14] Those dropped from the survey in 2006 were located farthest away from the Park, with little or no dependence on Park resources and no territorial claims within LLNP borders.

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

[16] In previous work on comanagement in TNLL, CARE was also involved in facilitation (Mappatoba 2004). But since its deals attempted simply to maintain TNLL rules, no new benefit streams were negotiated in a manner consistent with agreements facilitated by TNC, YTM, and JAMBATA. Thus, CARE agreements were excluded.

TABLE 2
Labeling Non-KKM Communities (De Facto Property Rights)

	FF	KKM	PT
Number 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 the KKM column for KKM versus PT; FF column for KKM versus FF; and PT column for PT versus FF.
** Significant at 0.05; *** significant at 0.01.

IV. EMPIRICAL RESULTS

Our model examined the endogenous emergence of three institutional outcomes. Ranking from the perspective of Community: the worst is fences and fines (FF), in which Park can block forest extraction; a negotiated agreement (KKM), where Park could block extraction but negotiates with Community to raise extraction to save on monitoring and enforcement; and a paper tiger (PT) outcome, in which Park is unable to block extraction.

The strength of our unique data is the observation and description of these KKMs. However, an immediate challenge is how to distinguish among the non-KKM settings, or institutions, within the data. Local actors may be confident that they can identify de facto property rights, for example, FF versus PT settings, on the basis of their personal experiences or others' anecdotes. We, however, do not observe this distinction in the non-KKM data.

We use the observed rates of deforestation to identify the de facto property rights within the 22 non-KKM communities, to distinguish the FFs from PTs. Thus if forest increased from 2001 to 2006 for any such observation, then we assigned FF. If forest fell, then we assigned PT. Our rationale is that in FF, Park wins the conflict game and chooses a lower level of extraction and hence also deforestation, while in PT, Community wins the conflict game and chooses a higher extraction level and hence also greater deforestation. Recall that this observed deforestation is within a protected area where it is prohibited, so it is essentially by definition indicating some degree of PT. Also, since Community does not prefer reforestation, it is reasonable to infer FF if observing reforestation in an area. Table 2 shows significant deforestation differences between observed KKMs and these two groups. The KKMs are in the middle, with deforestation above FF and below PT.

Who Wins De Facto Rights?

As KKMs are observed and we have distinguished the non-KKM institutions in Table 2, Table 3 can start 'testing' hypotheses, beginning with the Hypothesis Set 1 in Appendix A, by describing the relevant patterns in the data. Specifically, it compares means using our observed proxies for model variables (the rationales for which are within Appendix B).[17]

Table 3 begins with the conservation benefits of Park. Communities in close proximity to an important bird-watching site feature higher gains from conservation. This should raise willingness of Park to fight for rights. Consistent with this prediction, 44% of Communities are proximate to bird sites for the institutions in the de facto Park rights settings, FF and KKM, significantly higher than the 18% proximate to bird sites for PT.[18]

Table 3's proxies for the costs of enforcement by Park are the proximity to a park ranger office, the distance to the provincial capital (Palu, with LLNP headquarters and provincial government), and the proportion of

[17] For Tables 3–6, equality of variances assumption is tested using Levene's test. When there are large differences between t-tests or the normality assumption is violated, then a Mann-Whitney test is used instead for examining differences between groups.

[18] Per Sims (2010), birdwatchers may spend money in and around villages close to these sites. This could lower Community's net benefits from degrading forest. That a single proxy might be correlated with multiple parameters is a recurring feature of our data.

TABLE 3

Endogenous De Facto Property Rights Statistics: Park De Facto Rights (FF + KKM) versus Community De Facto Rights (PT)

	Proxies' Group Averages	
	FF and KKM (39)	PT (11)
ΔV = Additional benefits to park from reduced resource extraction	Expect higher	Expect lower
Near a prime bird watching area	0.44*	0.18
K = Park's cost of enforcement	Expect lower	Expect higher
Near a park ranger office (K lower)	0.69**	0.27
Distance to Palu and provincial government, km	79*	110
Mean % slope above $>20°$	9.92*	11.34
Δb = Community's benefits from greater resource extraction	Expect lower	Expect higher
Existence of food shortages, 1980–2001	0.64**	0.91
Maximum % loss of harvest, 1980–2001	51.67	63.18
% temporary outmigrants 2001 (b lower)	2.46**	0.35
% 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 of rattan, per kg, 2001	625	707
Price of timber, per m^3, 2001	516,053***	668,182
Δe = Community's costs of extracting more resources	Expect higher	Expect lower
% 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	Expect higher	Expect lower
Government/NGO credit program during the period 1980–2001 (1 = yes)	0.93**	0.64
Other credit program, 1980–2001	0.46	0.27

Dependent Variable: FF-or-KKM (vs. PT)				
Variable (Parameter Proxied)	Coeff.	Std. Err.	Z	$P>\|z\|$
Mean % hilly area, $>20°$ (K)	−0.1375	0.0805	−1.71	0.087*
Price rice, Rp per kg, 2001 (Δb)	−0.0012	0.0006	−2.04	0.041**
Near a prime bird watching area (ΔV)	0.6801	0.5150	1.32	0.187
% children 13–18 in school, 2001 (Δe)	0.0083	0.0087	0.96	0.336
Number of observations		48		
Prob. $>$ chi^2		0.0278		
Pseudo R-squared		0.2107		

Note: Significant differences between the group averages of these proxy variables are indicated within the first column (FF and KKM).
* Significant at 0.10; ** significant at 0.05; *** significant at 0.01.

Community land characterized as "hilly" (over 20° in GIS data). While hilly terrain supports the modeled hypothesis in this case, we are not sure this proxies enforcement costs alone.[19] Greater distance to enforcement (i.e., to park ranger and government offices) perhaps more clearly raises enforcement cost. We can see in Table 3 that the values across the groups for both those proxies support the hypothesis that higher enforcement costs will raise the probability of observing PT.

Considering Community benefits from extraction, 5 of our 10 proxies for this variable in Table 3 exhibit significant differences between groups. As for the variables above, all support the model predictions. Greater food shortages across two prior decades are consistent with higher expected benefits to Community from using forested lands for food production, raising the probability of a PT. A higher share of Community's population that migrates temporarily suggests less value in extracting, giving Park a greater chance of claiming de facto rights. Finally, prices for rice, coffee, and timber are significantly lower in places where it seems Park could exclude Community, consistent with the logic that lower Community gains from use permit FF as the default outcome.[20]

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

Finally, higher Community discount rates lower the value of extraction benefits from winning de facto rights, relative to the costs of claiming the rights in the first place. This predicts more FF and KKMs, yet robust proxies for a Community discount rate are difficult to isolate. Credit is one reasonable option, since across locations that are equally credit constrained, having more credit should lower discounting. The data for government and NGO credit suggest more credit in the first column, seeming to imply lower discount. Yet it is also quite likely that the provision of credit may have been targeted at the poorer communities, which have credit constraints and thus higher discounting (see Appendix B).

That raises the more general issue of correlated variables and motivates additional support from regressions despite the limited data. With a subset of the proxies, the right-hand side of Table 3 explains the probability of Community being in FF-or-KKM versus in PT (regressions are attempted for the initial hypotheses only, those with most observations). Supporting the results from Table 3, a higher probability of FF-or-KKM is found where the land is less hilly (maybe lower enforcement cost) and rice prices are lower (lower extraction benefit). Also consistent with Table 3 yet not significant, the proximity to an important bird-watching site and proportion of children aged 13–18 in school both have the expected sign.

As noted, our sample's limits unfortunately hinder inference about KKM drivers. However, this examination has highlighted the model's value, for example, for identification of a potential instrument from among the exogenous KKM drivers such as distance to Palu, species with conservation benefit, land slope, historical food shortages, and harvest loss. Clearly some such factors will fail the exclusion restriction, since they directly affect the resource or livelihood outcomes of interest. Still, this can help to generate options.

When Do KKMs Arise under De Facto Park Rights?

Here we compare Communities that have negotiated a KKM (28 communities) with those where it appears Park could negotiate a KKM but instead simply excludes (11 FFs), focusing upon Communities that apparently feature de facto Park rights, in order to "test" Hypotheses Set 2 (Appendix A). A parameter that was not relevant for the earlier hypotheses

[19] If agriculture is more difficult on hilly terrain, Community use benefits may be lower there (though Maertens, Zeller, and Birner [2006] note rice on slopes). That would predict less PT for hilly areas, not more. On the other hand, it could also raise the dependence on nontimber forest products.

[20] The numbers of households dependent on timber harvesting are relatively small. We include them anyway, as they could have a large influence on observed deforestation.

TABLE 4
Endogenous Participation (Given Park Rights): Fences and Fines (FF) versus Negotiated Agreements (KKMs)

	Proxies' Group Averages	
	FF (11)	KKM (28)
s = Community's cost of enforcement	Expect higher	Expect lower
Number of households, 2001	365.09	252.00
% native households, 2001 (lowers s)	71.99*	85.89
Land distribution (Gini), 2001 (ambiguous effect on s)	0.406	0.385
% households with no land, 2001	10.91*	3.57
Conflict among native households, 1995–2001	0.91*	0.64
Conflict native and migrant households, 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
% in labor sharing (lowers s)	21.31	22.98
K = Park's cost of enforcement	Expect lower	Expect higher
Near a park ranger office (lowers K)	0.73	0.67
Distance to Palu and provincial government, km	61*	86
Mean % slope above > 20°	12.56***	8.94
$V(\tilde{L}_P) - V(\hat{L}) =$ change in Park's benefits	Expect higher	Expect lower
Near a prime bird watching area	0.45	0.42
$B(\hat{L}) - B(\tilde{L}_P) =$ change in Community's benefits	Expect lower	Expect higher
Existence of food shortages, 1980–2001	0.55	0.68
Maximum % loss of harvest, 1980–2001	56.36	49.82
% temporary outmigrants 2001 (lowers B)	0.877*	3.08
% 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 of rice, per kg, 2001	2,186	2,139
Price of coffee, per kg, 2001	5,000	4,174
Price of rattan, per kg, 2001	616	630
Price of timber, per m^3, 2001	519,815	514,815
% households with off-farm earners, 2001	9.13	9.29
% children 13–18 in school, 2001	35.94	41.76

Note: Significant differences between the group averages of these proxy variables are indicated within the first column (i.e., FF)

* Significant at 0.10; ** significant at 0.05; *** significant at 0.01.

but is of great importance here, for Park's decision about whether to do comanagement, is Community cost of monitoring and enforcement. This affects Park's belief that a KKM can work. Table 4 presents group means for our proxies for this cost. Overall we find that these strongly support the theoretical predictions.

More specifically, the collective action literature (Agrawal 2001) suggests smaller and more homogenous communities self-monitor at lower cost. In Table 4, communities where KKMs arise tend to be smaller, though the difference is not statistically significant. For homogeneity, though, we do see a significant difference. KKMs are in locations with, on average, 86% native households, whereas the non-KKM observations averaged 72%.

Land ownership may not only be linked to homogeneity but also indicate potential for conflicts in objectives and even actual conflict (see below). In Table 4, the difference in the Gini coefficient for land is not a significant predictor, though. This may reflect two effects of economic heterogeneity within the collective action literature: homogeneity in economic endowments may be conducive to collective action; yet heterogeneity could improve management if a few may benefit more and/or have the necessary endowments to act unilaterally or as leaders. Along these lines, the fraction of households with no land at all has a significant difference in Table 4, and is one that supports the model prediction given that landless households may well be more likely to violate any restrictions upon forest uses, increasing potential for conflict and making collective action more difficult.

Previous conflict may not only lower Community's ability to organize around an agreement but also signal to Park that somebody at the table to sign agreements may not mean as much per future behaviors. Within Table 4, the measures of evidence of among-native and native-vs.-migrant prior conflict, which proxy for higher costs of enforcement, both support the prediction. For the conflict with other communities proxy, the direct measure supports the hypothesis but is not significant, unlike the other proxies for Community's capacity to enforce. The fact of having split from a community previously also seems to indicate higher Community enforcement costs, yet this variable also is not significant.

As Park's monitoring and enforcement costs may be reduced via a KKM, higher cost should motivate a KKM. The proxy of proximity to the ranger's office goes in that direction but is not significant. The other critical distance is significant: distance to Palu is higher on average for KKM versus for FF. Hilly land goes in the other direction but may proxy for lower use benefits and higher Community enforcement costs as well.

Table 4 also includes our sole proxy for the losses to Park from forest extraction. Group differences are not significant, although their sign is consistent with the model's predictions. Concerning benefits of extraction, food shortages support the model but are statistically insignificant. Seven other proxies also are not significant. Four are significant and three do not support the model, although some of these proxies for benefits may also be factors in Community enforcement costs (e.g., outmigrants or livelihood dependence), which could explain these results.[21] One important proxy for the benefits from extraction within LLNP, fraction of Community land inside the park, is significant and supportive.

[21] Note that since the Community enforcement costs are not relevant for Hypothesis Set 1, possible confounding such as noted here is of relevance only for Hypothesis Sets 2 and 3.

What Explains Transfers within KKMs?

Table 5 focuses on Communities with KKMs in order to test Hypothesis Set 3 (in Appendix A). Proxy means are compared for the KKMs where agricultural benefits were or were not delivered as part of compensation for restricted forest usage, noting that such agricultural benefits were the only benefits observed to be transferred within this study. Recall that at least in our model, transfers could be positive, flowing to a Community, or negative, flowing to Park. We focus here upon the observed benefit transfers and note that in our Indonesian setting, those are always zero or positive flows to Community.

Table 5 has few statistically significant differences. The dichotomous nature of our data about having any transfers occur at all restricts this effort to test, as we cannot see how proxies vary with the size of actual transfers. In the table's comparison of means, Community knowledge about movement by other communities is associated with getting benefits. NGO concerns and prior conflicts also look supportive but are insignificant, and beyond that we can see no significance for Park's conservation benefits or for Park's enforcement cost proxies; only two proxies' differences are significant for the change in Community use benefits, one of which supports predictions; and there is one significant difference for Community cost of enforcement—prior conflict—and it is supportive.

Roles of NGOs?

As noted, three NGOs (TNC, JAMBATA, YTM) played key roles in facilitating 28 comanagement agreements (KKMs) in our survey. While each NGO supports forest conservation as a goal, each is distinct. To see whether we should distinguish the NGOs in the data, *t*-tests were redone for the 21 TNC agreements and separately for the 7 agreements by JAMBATA and YTM: the KKMs were combined with FF for comparing to PT (redoing Table 3); and then just the KKMs were compared to FF (redoing Table 4). All of those results are

TABLE 5
Endogenous Tranfers to Community (Given a KKM): Delivered Agricultural Benefits (Yes) versus None (No)

Proxies	Proxies' Group Averages	
	Yes (11)	No (17)
τ = Community's bargaining power	Expect higher	Expect lower
Conflict with park over forest	0.55	0.47
Know that other communities moved	0.82***	0.18
Know that KKMs allow forest use	0.64	0.53
Know that KKMs cede forest rights	0.73	0.65
NGO worried about forest degradation	0.45	0.24
$V(\tilde{L}_P) - V(\hat{L}) =$ change in Park's benefits	Expect lower	Expect higher
Near a prime bird watching area	0.27	0.53
K = Park's cost of enforcement	Expect higher	Expect lower
Near a park ranger office (K lower)	0.55	0.76
Distance to Palu and provincial gov't, km	99	78
Mean % slope above $>20°$	8.00	9.48
$B(\hat{L}) - B(\tilde{L}_P) =$ change in Community's net benefits	Expect lower	Expect higher
Existence of food shortages, 1980–2001	0.64	0.71
Maximum % loss of harvest, 1980–2001	40.91	55.59
% temporary outmigrants 2001 (b lower)	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 m^3, 2001	463,636	550,000
% households with off-farm earners, 2001	9.18	9.36
% of children 13–18 in school, 2001	40.61	42.50
s = Community's cost of enforcement	Expect higher	Expect lower
Number of households, 2001	218.91	273.41
% native households, 2001 (s lower)	91.77	82.09
Land distribution (Gini), 2001	0.34	0.41
% households with no land, 2001	2.77	4.09
Conflict among native households, 1995–2001	0.54	0.73
Conflict native and migrant households, 1995–2001	0.23	0.13
Conflict with another village, 1995–2001	0.46*	0.13
Previously part of another village	0.18	0.18
% population in labor sharing (s lower)	29.89	18.51

Note: Significant differences between the group averages of these proxy variables are indicated within the first column (i.e., FF)
* Significant at 0.10; ** significant at 0.05; *** significant at 0.01.

consistent with our tables, supporting the Park-Community model perspective upon when any comanagement agreement at all would be expected to arise.

Still, within that model, a potential NGO role is to affect the model's parameters, for example, to influence the relative weight that Park puts on conservation. That could affect conditions within a KKM, as a higher weight on conservation should reduce the transfers to the communities in the event of comanagement (reiterating here that we do not in the data observe all the sources of observed transfers). For instance, within LLNP, TNC had greater resources and access to local and national governments than YTM or JAMBATA and thus might have influence sufficient to raise the weight put on conservation benefits.

Checking this prediction in the data, despite the limited data, supports this idea, as agricultural benefits were supplied in a quarter of TNC agreements but were supplied in over half of the JAMBATA-or-YTM agreements. That said, not only are data limited, but also before assigning causal effect we would need to know how NGOs choose locations, since perhaps an NGO very interested in transfers seeks out conditions facilitating them.

While we cannot test these in our data, given such an interesting result of this type we might consider also other parameters that could be affected by an NGO's intervention. For instance, Community's bargaining power might increase with training or information provided by NGOs, and if so, it should increase transfers within a KKM. Going in the other direction, NGOs likely also could help to improve either or both of Park's monitoring and enforcement or Community's internal sanctioning capacities.

V. DISCUSSION

We developed a novel game-theoretic model of a state-user interaction between a protected-area authority and a local community that is on the periphery of a park. Unlike in previous studies on comanagement, the de facto property rights over a park's natural resources are endogenous to parameters that vary across settings. Theory indicated some conditions under which comanagement is most likely when the park has ability to exclude. This has important implications for examining the impacts of comanagement, implying the need to control for the influences of the conditions that lead comanagement to occur.

Next we evaluated the extent to which predictions matched observed agreements. Using a unique dataset on KKMs collected in the Lore Lindu National Park in Sulawesi, Indonesia, we find that as predicted Park appears more likely to win de facto property rights where conservation benefits are higher, Park enforcement costs are relatively low, and Community benefits from extraction are lower.

Within settings where Park appears to have de facto rights, we compared KKM Communities to non-KKM Communities, introducing the capacity of Community to enforce a KKM. Our results confirm that, as predicted, KKMs are more likely when Community capacity to enforce is greater, with greater homogeneity, less conflict, and fewer landless actors. Finally, in KKMs we find Community knowledge of other communities' experiences to be correlated with a greater chance of transfers. That said, results for transfers are weaker than for other hypotheses, in part due to a smaller sample and limits on the transfers data.

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 comanagement initiatives in India and Ethiopia (Behera and Engel 2006; Rustagi, Engel, and Kosfeld 2010). Thus testing our model's predictions using, for example, the data from different Indian states that exhibit a large variation in transfers within the country's Joint Forest Management Program could be a very interesting extension within this line of research.

Also, we note that our current dataset can only proxy for the model's parameters. Other data certainly could be collected to estimate such parameters' values more directly. For example, Community's costs and benefits from extraction could be estimated using the data from community and household surveys. Also, where comanagement is about to be implemented, such data could be gathered in order to help evaluate its future impacts. Other possible extensions follow from a broadening of our modeling's assumption (following our empirical setting) that any negotiated agreements with de facto community rights would be ineffective. The reason for that assumption is that implementation needs to be conditional on performance, with periodic transfers based on monitoring of forest outcomes. In other settings, such as in the Participatory Forest Management (PFM) program in Ethiopia, this might well be possible. State management was ineffective before the PFM, for instance, implying that comanagement emerged under de facto community rights.

Our model also provides insights on recent discussions of whether raising the payments for reducing emissions from deforestation and degradation (REDD+) might lead to a recentralization of forest resources in developing countries. In a recent paper, Phelps, Webb, and Agrawal (2010) voiced concern that REDD+ might reverse decentralization trends in natural resource management by concentrating the policy—and forest carbon rights—within national governments. This could be a concern if decentralization had benefitted communities by transferring to them at least partial control over these natural resources.

In our model, REDD+ payments would increase the sensitivity of Park benefits to resource extraction. This would, first, make Park more likely to win the conflict game. That makes PT less likely and supports the idea that REDD+ payments could strengthen the position of a state vis-á-vis communities. Second, if comanagement emerged then Community's payoff would decrease. Thus, REDD+ could reduce community welfare.

A third effect of such payments suggests a potential gain from bundling policies, should community welfare be a central concern. If Park wins de facto rights, an increase in the sensitivity of Park benefits might lower the probability that a KKM comes about. This, too, supports concerns that Community may be negatively affected by payments to state authorities. Yet Park may prefer to negotiate if its enforcement costs are sufficiently high, and an option to increase the likelihood of a KKM emerging could be, for instance, to bundle payments with investment in Community enforcement capacity.

Further, in lieu of payments to a state a REDD+, policy could embed carbon rights in comanagement, with the global payments used to incentivize the communities toward increasing forest carbon stocks above the agreed baseline level (see Palmer 2010, 2011). In our model, this would add carbon sequestration benefits to the community's objective.

APPENDIX A: FORMAL MODELING FOR PARK-COMMUNITY INTERACTIONS

Conflict Determines Endogenous Property Rights

Let $v(F-L)$ denote the per-period environmental benefits to society, and thus to Park (P), from forest conservation given forest extraction L, with F denoting the initial level of forest. We assume that this v is increasing and concave in $F-L$, $(v'>0, v''<0)$.

Let $b(L)$ denote per-period net benefits of forest exploitation to Community (C), which reduces forest by L. We assume b is increasing and concave in L $(b>0,\ b''<0)$, and $b(0)=0$. C incurs a cost of attempting to withdraw forest products, denoted as $e(L)$, assumed convex in L $(e'>0,\ e''>0)$. The discount rate of actor i is denoted as r^i $(i\in\{C, P\})$.

If C could choose the level of resource extraction unilaterally then it would

$$\max_{L_C} B(L_C)\equiv b(L_C)-e(L_C).$$

The solution, denoted by $\tilde{L}_C$, satisfies

$$B'(\tilde{L}_C)=b'(\tilde{L}_C)-e'(\tilde{L}_C)=0. \qquad [A1]$$

P values not only society's conservation benefits but also C's use benefits, with weight λ $(0<\lambda<1)$ on conservation. If it could choose unilaterally, then it would

$$\max_{L_P} V(L_P)\equiv \lambda v(F-L_P)+(1-\lambda)B(L_P).$$

The solution, denoted by $\tilde{L}_P$, satisfies

$$V'(\tilde{L}_P)=-\lambda v'(F-\tilde{L}_P)+(1-\lambda)B'(\tilde{L}_P)=0. \qquad [A2]$$

Comparing [A1] and [A2], we can see that[22]

$$\tilde{L}_P<\tilde{L}_C. \qquad [A3]$$

Thus, with positive weight on conservation $(\lambda>0)$, P prefers lower extraction than C.

Staying in conflict involves costs and benefits. P incurs the costs of monitoring and enforcement, K. If P wins the conflict it gains a stream of benefits from being at its preferred level of extraction instead of C's:

$$\frac{\Delta V}{r^P}\equiv\frac{V(\tilde{L}_P)-V(\tilde{L}_C)}{r^P}.$$

C if successful faces the cost of additional extraction, denoted as $\Delta e\equiv e(\tilde{L}_C)-e(\tilde{L}_P)$, but by winning the conflict it also gains the net present value of the additional stream of benefits,

$$\frac{\Delta B}{r^C}\equiv\frac{B(\tilde{L}_C)-B(\tilde{L}_P)}{r^C}.$$

Withdrawal by P yields a PT park with no monitoring or enforcement and high extraction $(\tilde{L}_C)$. If C with-

[22] A formal proof is available on request. Likewise for proof of $\tilde{L}_P<\hat{L}<\tilde{L}_C$ in Appendix A.

draws, though, P can enforce FF, where there is a lower level of extraction by C ($\tilde{L}_P$) and high monitoring and enforcement by P.

Three cases can be distinguished. First, where $\Delta e > \Delta b/r^C$, C simply never enters into such conflict because the effort costs of additional extraction (beyond the level P desires) are too high. Thus if P's net benefits from conservation are positive, namely, $\Delta V/r^P > K$, then P will always win the conflict and will establish de facto property rights over the forest.

Second, if $\Delta e < \Delta b \equiv b(\tilde{L}_C) - b(\tilde{L}_P)$, C will always extract, as benefits exceed the costs even in the same period. Third, for $\Delta b/r^C > \Delta e > \Delta b$, or equivalently, $\Delta e > \Delta b > \Delta e r^C$, the conflict is won by the actor that can stay in conflict longer. Computing for each actor the maximum length of time in conflict while receiving a nonnegative expected payoff (denoted t^C and t^P for C and P, respectively) and setting $t^C > (<) t^P$, the condition for C (respectively P) to win the conflict can be obtained formally as by Engel, López, and Palmer (2006).

If P wins the conflict game, it can enforce a FF situation and may choose to do so. In this case P's payoffs per period are given by $V(\tilde{L}_P) - K$, while C's benefits are $B(\tilde{L}_P)$. However, given this default option, P and C may negotiate a comanagement agreement. If C wins the conflict game, then a PT situation always results. C's per-period net benefits from extraction are $B(\tilde{L}_C)$, while P receives reduced conservation benefits $V(\tilde{L}_C)$.

Community-Park Negotiation under De Facto Park Rights

The transfer from P to C under an agreement is denoted Π^C, while s denotes C's costs of an internal monitoring and sanctioning system that substitutes for P's efforts (K). If $s < K$, there is an incentive for P to consider comanagement to reduce monitoring and enforcement costs in exchange for greater resource extraction. We denote the negotiated extraction level by $\hat{L} > 0$.

For modeling negotiation between P and C as Nash bargaining, we denote C's and P's bargaining power as τ and $1 - \tau$, respectively. C's per-period payoffs under the agreement are given by $B(\hat{L}) - s + \Pi^C$. C's reservation utility is $B(\tilde{L}_P)$, as P would win a potential conflict. P's reservation utility is $V(\tilde{L}_P) - K$. Thus, the total benefits to be divided under any comanagement agreement are $V(\hat{L}) + B(\hat{L}) - s$. The Nash bargaining solution is given by

$$\begin{aligned} B(\hat{L}) - s + \Pi^C &= B(\tilde{L}_P) \\ &+ \tau[V(\hat{L}) + B(\hat{L}) - s - B(\tilde{L}_P) - (V(\tilde{L}_P) - K)] \\ \Rightarrow \Pi^C &= \tau[K - (V(\tilde{L}_P) - V(\hat{L}))] \\ &- (1 - \tau)[B(\hat{L}) - B(\tilde{L}_P) - s]. \end{aligned} \quad [A4]$$

TABLE A1
Hypothesis Set 1: Who Wins De Facto Rights?

	Park De Facto (FF or KKM) More Likely	Community De Facto (PT) More Likely
P's benefits from reduced resource extraction, ΔV	High	Low
P's enforcement and monitoring costs, K	Low	High
C's resource extraction costs, Δe	High	Low
C's benefits from resource extraction, Δb	Low	High
C's discount rate, r^C	High	Low
P's discount rate, r^P	Low	High

TABLE A2
Hypothesis Set 2: Which Institution Given De Facto Park Rights?

	FF More Likely	KKM More Likely
Change in C's net benefits $B(\hat{L}) - B(\tilde{L}_P)$ due to change in resource extraction	Low	High
P's cost of enforcement, K	Low	High
C's cost of enforcement, s	High	Low
Change in P's conservation benefits $V(\tilde{L}_P) - V(\hat{L})$ due to change in resource extraction	High	Low

Note: See equation [A5].

Furthermore, note that any negotiations over a comanagement agreement will succeed only if the "size of the cake" exceeds the sum of both actors' reservation utility, namely, if $V(\hat{L})+B(\hat{L})-s-B(\tilde{L}_P)-(V(\tilde{L}_P)-K)>0$, or equivalently,

$$B(\hat{L})-B(\tilde{L}_P)-s-(V(\tilde{L}_P)-V(\hat{L}))+K>0. \qquad [A5]$$

Given the option of FF, a KKM is more likely to result when the loss in the conservation benefits from increased extraction $(V(\tilde{L}_P)-V(\hat{L}))$ and/or C's costs of monitoring and enforcement (s) are low, or when C's gain in net benefits from increased extraction $(B(\hat{L})-B(\tilde{L}_P))$ and/or P's costs of enforcing FF (K) are relatively high.

The forest extraction level that is allowed under a comanagement agreement, $\hat{L}$, would be chosen jointly by the two parties in order to maximize the "size of the cake." The negotiated extraction level under comanagement will lie in between the extraction levels that are preferred by P and C (i.e., extraction levels will satisfy $\tilde{L}_P<\hat{L}<\tilde{L}_C$).

Regarding possible negative transfers (i.e., positive transfers from C to P), we can see such a negative transfer $\Pi^C<0$ if $\Rightarrow\tau[K-(V(\tilde{L}_P)-V(\hat{L}))]<(1-\tau)[B(\hat{L})-B(\tilde{L}_P)-s]$. This is more likely for small K (i.e., the monitoring costs are less of the "cake") or for $V(\tilde{L}_P)-V(\hat{L})$ or $B(\hat{L})-B(\tilde{L}_P)$ large (i.e., when C gains strongly from increased extraction and/or loss in conservation value to P is large) or for small s (i.e., C's monitoring is cost effective).

TABLE A3
Hypothesis Set 3: What Transfer Level Given the KKM Institution?

	Within-KKM Transfer to Community Higher When:
C's bargaining power, τ	High
P's enforcement costs, K	High
Change in P's conservation benefits $V(\tilde{L}_P)-V(\hat{L})$ due to change in resource extraction,	Low
Change in C's net benefits from resource extraction, $B(\hat{L})-B(\tilde{L}_P)$	Low
C's cost of enforcement, s	High

Note: See equation [A4].

APPENDIX B

TABLE B1
Rationales Underlying Proxies

Proxy	Effect of Proxy on Variable	Rationale
ΔV = Additional benefits to Park from reduced extraction;		
$V(\tilde{L}_P)-V(\hat{L})$ = Change in Park's benefits due to change in resource extraction		
Community area neighbors a prime bird-watching site, 2001	+	Proximity to a prime bird-watching site in the park raises Park benefits from reduced extraction.
K = Park's cost of enforcement		
Community area neighbors a park ranger office, 2001	−	Better accessibility to Community and surrounds makes it easier (cheaper) for Park to monitor (smaller K).
Mean % hilly area (>20°)	+	The larger the area defined as hilly, the harder and more difficult for Park to monitor. (*Note:* Could also affect Δb, $B(\hat{L})-B(\tilde{L}_P)$, Δe, and s.)
Distance to Palu: location of Park headquarters and provincial government (km)	+	The further away from Palu, the higher the Park's enforcement costs.

(table continued on following page)

TABLE B1
Rationale Underlying Proxies *(continued)*

Proxy	Effect of Proxy on Variable	Rationale
Δb = Community's benefits from greater resource extraction;		
Δe = Community's costs of extracting more resources;		
$B(\hat{L}) - B(\tilde{L}_P)$ = Change in Community's net benefits from change in resource extraction		
Food shortages, 1980–2001 (1 = yes)	+	Evidence for drought/food subsidies/food shortages indicates larger Community benefits from forest conversion for agriculture.
Max % loss of harvest due to drought, 1980–2001	+	
% Community population as temporary outmigrants, 2001	−	The more outmigrants, e.g., working in city, less dependence on forest for livelihoods and lower benefits from extraction.
% of Community's total area located inside park	+	The more territory inside park, the higher Community benefits from park forest exploitation.
% households with principle livelihoods dependent on timber, 2001	+	Greater proportion of households engaged in timber and/or rattan, the more benefits to Community from forest exploitation (direct use only).
% households with principle livelihoods dependent on rattan and timber, 2001	+	
Price rice, Rp per kg, 2001	+	Higher prices imply greater incentives to further exploit forest, and higher benefits from extraction.
Price coffee, Rp per kg, 2001	+	
Rattan price Rp per kg, 2001	+	
Timber price Rp per m^3, 2001	+	
% households with off-farm earners, 2001	(+/−)	More households in off-farm labor implies greater opportunity costs of time hence raising Community extraction costs (reducing *net* benefits). (*Note:* 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 labor to households implies greater opportunity costs of time and Community extraction costs (reducing *net* benefits).
r^C = Community's discount rate		
Government/NGO credit program, 1980–2001 (1 = yes)	+/−	Evidence of credit indicates collateral and possibilities for investment for future returns. Effect on ambiguous since either the already wealthy (low r^C) can access credit (have collateral) or credit is targeted at the poor (high r^C) in order to alleviate poverty.
Other credit program, 1980–2001 (1 = yes)	+/−	
s = Community's costs of enforcement		
Number of households in community, 2001	+	More households/people increases costs of effective collective action necessary for establishing effective monitoring and enforcement system.
% households as natives, 2001	−	Greater ethnic homogeneity decreases costs of effective collective action.
Evidence of conflict among native households, 1995–2001 (1 = yes)	+	Previous conflict makes effective collective action more difficult and more costly.

(table continued on following page)

TABLE B1
Rationale Underlying Proxies *(continued)*

Proxy	Effect of Proxy on Variable	Rationale
Evidence of conflict between native & migrant households, 1995–2001 (1 = yes)	+	
Evidence of conflict with households from another community, 1995–2001 (1 = yes)	+	
% households with no land, 2001	+	Increasing numbers of households without land leads to greater potential for rule breaking within communities thus making effective collective action more difficult and costly.
Land distribution, 2001 (Gini)	+/−	Increasing inequality in economic endowments could either make effective collective action more difficult and costly, or those with greater endowments could engage in unilateral action or lead community more effectively leading to lower *s*.
Community previously part of another community	+/−	Evidence for split from another village could either make collective action harder to undertake due to possibility of conflict in the past, or easier due to smaller population or greater ethnic homogeneity resulting from the split.
% working population in labor sharing groups	−	The more workers engaged in labor sharing, the easier to enable effective collective action.
τ = Community's bargaining power		
Evidence of conflict over forest conversion in park, between Community and 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 KKMs: allow villages to use forest/forest products (1 = yes)	+	The more the community knew about other KKMs and their potential benefits, the stronger its bargaining power.
Type of knowledge from KKMs: give forest rights to Communities (1 = yes)	+	
Why KKM? NGO worried about forest degradation (1 = yes)	+	The more the NGO is worried about forest degradation, the more power the Community has.

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