

Protecting Developing Countries' Forests: Enforcement in Theory and Practice

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ABSTRACT *This paper relates the key findings of the optimal economic enforcement literature to practical issues of enforcing forest and wildlife management access restrictions in developing countries. Our experiences, particularly from Tanzania and eastern India, provide detail of the key pragmatic issues facing those responsible for protecting natural resources. We identify large gaps in the theoretical literature that limit its ability to inform practical management, including issues of limited funding and cost recovery, multiple tiers of enforcement and the incentives facing enforcement officers, and conflict between protected area managers and rural people's needs.*

Introduction

In many developing countries, forest management is shifting from an adversarial approach, in which governments exclude local communities from publicly-owned forests, toward more cooperative management regimes where communities participate in the management and even ownership of forests and wildlife. The aims of such a shift towards participatory community management of resources include greater accountability, reduced conflict, and—ideally—both improved livelihoods and better protected resources. Yet even with community-based management, some level of enforcement is almost inevitably required against poaching and other illegal uses of forest and park resources (Clark *et al.*, 1993). Despite substantial and well-developed law and economics literature on optimal enforcement, and despite considerable research addressing the management of natural resources in developing countries, few papers attempt to link the insights from the optimal enforcement literature with the protection of forest and wildlife resources in these countries. Similarly, little practical experience of enforcing regulations in parks and forests in developing countries informs the optimal enforcement literature.

In this paper we assess key findings in the optimal enforcement literature with respect to issues of practical policy concern for forest and wildlife protection in developing countries. We base our discussion on observations from numerous countries but many of our

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examples come from our experiences of forest management in Orissa state in eastern India, where one of the authors was a forest official, and from Tanzania, where participatory forest management (PFM) is being introduced and many enforcement issues remain unresolved. Our examples provide details of the key pragmatic issues facing those responsible for protecting natural resources where funding is limited and the local people rely heavily on illegal extraction of resources within protected areas.

In the second section we address three of the key themes that have been a focus of much of the optimal enforcement literature since Becker's 1968 seminal paper: why fines are not simply set as high as possible; assumptions over the objective function of the enforcement agent; and why the emphasis of the literature is on incomplete rather than full enforcement. We compare the findings of the literature with our empirical evidence, including the level of fines and the size of enforcement budgets. Because conservation biologists and policy-makers may feel that the full protection of a particularly endangered species is essential, we explore the extent to which the literature can inform the implementation of such 'full enforcement' mandates. Although understanding these aspects of optimal enforcement is critical for designing practical enforcement strategies, the literature marginalizes many issues that are critical for poor countries. In the third section we address a number of these issues, including multiple tiers of enforcement where individuals in each tier often have different objectives; conflict; and limited funds for enforcement. The fourth section concludes with a discussion of areas where developments in the literature could help to inform practical protected area policy.

Key Issues Addressed in the Early Optimal Enforcement Literature

The fundamental questions for issues of law enforcement were posed by Becker (1968, p. 170) who, recognizing that enforcement is costly, asked 'how many offences *should* be permitted and how many offenders *should* go unpunished' (emphasis in the original). Becker concluded that the greater the expected penalty (actual penalty multiplied by the probability of detection and punishment), the greater the deterrent effect on crime. Under a set of restrictive assumptions, Becker concluded that the optimal form of deterrence is to set fines as high as possible, while reducing the level of costly monitoring. The rationale behind Becker's argument is given succinctly by Malik (1990, p. 341): '[r]aising the probability of a fine is costly, since it requires devoting more resources to monitoring and apprehending individuals [whereas] raising the magnitude of a fine is costless'.

The Level of Fines

Following from Becker, the optimal enforcement literature identifies many reasons why fines should not simply be set as high as possible.¹ We discuss a number of these in this paper. First, fines must typically be capped at the level of an individual's wealth. If fines are capped, a lower fine for a less socially-damaging crime can induce individuals to switch away from more socially-damaging activities (Stigler, 1970, discusses such marginal deterrence in detail). Second, large fines can encourage socially wasteful avoidance activities that reduce the probability of an individual being caught and fined (see, for example, Malik, 1990; Lear & Maxwell, 1998). Third, fines considered excessive may not be politically viable (Rodriguez-Ibeas, 2002). Fourth, if the notion of 'fairness' of sanctions is included in analysis of optimal enforcement, then the optimal sanction is lower

than would otherwise be predicted, though the corresponding probability of sanctions being imposed could be either higher or lower (Shavell & Polinsky, 2000). Finally, when there is scope for bribes, higher official fines may simply result in greater scope for bribe taking (Mookherjee & Png, 1995). For a number of reasons, therefore, more recent theory predicts that the optimal level of enforcement is likely to require a relatively high probability of detection and a relatively low fine, compared with the conclusions from the early optimal enforcement literature.

Fines for the illegal theft of resources from parks and forests in poor countries do appear to be low relative to the social cost, particularly for wildlife. Fines may be so low as to do little if anything to deter illegal activities (Abbott & Mace, 1999). For example, in Ghana, fines for hunting protected species such as the civet cat (*Civettictis civetta*) or mona monkey (*Cercopithecus mona*) were 10 000 cedis (approximately US\$1.14 at the prevailing exchange rates when the research was undertaken), compared to market prices of about US\$11 and US\$13 respectively; the social values are likely to be much higher still (Ntiamao-Baidu, 1997; Damania *et al.*, 2005). Given that the average returns of hunting for farmers were approximately equal to the government daily wage in 1976 and 40% greater than average wages in 1993 (Ntiamao-Baidu, 1997), and that the probability of being caught is low, there is little to encourage farmers to stop hunting or to discriminate over which species they hunt (Robinson, 2008). In Malaysia, a court recently fined a man less than \$1900 for possessing a tiger carcass, although it is worth many times more on the black market and, again, even more from society's perspective (*Animal Planet News*, 2005).

In India, the civil jurisprudence has a rule of thumb that fines should be proportionate to the crime.² Consequently, fines for illegal collection of fuelwood and forest fruits and vegetables are low, reflecting the low absolute values of the illegal acts to the perpetrators and their low levels of wealth. However, the ecological costs imposed on the habitat itself are typically unaccounted for when punishments are set, and may be considerably greater. Fines for wildlife poaching in India are higher, reflecting the perceived increased severity of the crime, but are still low relative to the social cost of the crime (from the authors' experience).

In richer countries, fines are more likely to 'fit the crime' in line with the theory. For example, in the US, Colorado's 'Samson Law' imposes heavy penalties for illegally killing trophy-class animals. The \$10 000 fine for illegally killing a deer far exceeds the price of a single animal carcass in the market (Colorado Department of Natural Resources, 2005). Some poorer countries are starting to increase fines significantly for high social cost crimes, as is the case in Cameroon, where fines for hunting endangered species were increased to range from CFA50 000 to 200 000—approximately US\$100 to US\$400 (Agnagna & Koutou, 2001). These fines are still low compared with the social value of many of the species, but are high relative to the value to the poacher, which is typically the carcass value; therefore the deterrence effect of such fines, combined with a high enough probability of being caught, could be substantial. Yet in general, the current reality in many poor countries is that fines are typically too low to deter illegal activity, whatever the probability of being caught, even taking into account the costs associated with the illegal activity such as the purchase of a gun for hunting or the time and distance cost of finding the resource (Abbott & Mace, 1999).

A key reason for low and ineffective fines is that fines are not wealth contingent (Bar-Niv & Safra, 2002). When wealth varies among individuals, raising the fine and proportionately reducing the probability of detection results in a lower deterrence effect for

poorer individuals who cannot afford to pay the higher fines (Garoupa, 1997). Given that the wealth of people living near to protected areas in developing countries tends to be very heterogeneous, with many very poor people living close to these areas, for those who are not the poorest, fines may be relatively low and offer little disincentive. For the very poor, even if the fines are high relative to their wealth, they may have few alternatives to relying on resources from the protected areas, and so may continue to collect illegally whatever the punishment.

Because fines are typically low, finding mechanisms to increase the effective cost to the perpetrator of illegal activities is a key priority for many developing countries, particularly where wealth-contingent fines are not feasible. Increasing the cost of the punishment to those who are successfully convicted can be achieved through the use of prison sentences, which impose a high cost for both the rural poor and wealthier individuals, as can confiscating contraband. But legal systems often operate very slowly, resulting in a low likelihood of ultimate conviction and imprisonment. This situation reduces the expected penalty and therefore the effectiveness of enforcement efforts, and increases the administrative cost of prosecution. The concept of an 'enforcement chain' provides a useful starting point for explicitly analyzing each component of enforcement (Sutinen, 1987; Akella & Cannon, 2004). The overall effective deterrence of an enforcement regime is the product not only of the fine and the probability of being detected, but also the subsequent probabilities of detection, arrest, prosecution, and conviction. If one of these probabilities is very low, increasing the other probabilities will only have a small impact, whereas increasing the lowest probability will have a much greater impact. Effectiveness is therefore typically driven by the least effective of these processes. Despite the difficulty with each link in this chain in developing countries, much of the literature still assumes costly detection but costless and perfect prosecution following detection.

Even with low fines, we observe widespread avoidance activities that reduce the probability of capture and are socially wasteful. Such activities range widely in their cost to those illegally extracting forest resources or poaching wildlife and thus in their impact on social welfare. During our fieldwork we found that villagers in Thailand, China, Tanzania, and India all report simple and inexpensive avoidance activities, such as sending a child to determine whether forest guards have parked nearby and are likely to be patrolling, going out at night because rangers only patrol during the day, or waiting until a patrol has passed. On the other end of the cost scale, people poaching endangered charismatic species such as rhino in Africa invest in high-speed vehicles that enable fast getaways. Anecdotal evidence from our fieldwork suggests a strong empirical relationship between fines and costly avoidance activities that is not well developed in the theoretical literature. Further, our frequent observation of predictable ranger routes that are relatively easy to avoid suggests that patrols should be more strategic; yet again there is little in the literature to inform such spatial-temporal enforcement strategies.

The Enforcement Agency's Objective Function

The optimal enforcement literature typically assumes that the agency responsible for enforcement aims to maximize one of three functions: social welfare, including returns to the illegal activity; returns only to legal activities; or profits. Although most of the literature focuses on optimizing social welfare, there have long been criticisms in the literature, particularly when the perpetrator of the crime gets livelihood benefits but society brands

the crime illicit (Stigler, 1970). Milliman (1986) suggests that some value should be attached to illegal fishing because the perpetrator gets benefits from the theft. Clarke *et al.* (1993) pursue Milliman's idea by introducing in their paper a parameter to weight the illegal timber harvester's utility in the government's objective function. By systematically varying this parameter, different combinations of 'equity' and 'efficiency' objectives can be considered (Robinson, 1997). Less attention has been paid to the issue of private enforcement, in which a profit-maximizing enforcement agency aims to maximize fine revenue less the cost of enforcement (see Landes & Posner, 1975; Polinsky, 1980; Garoupa, 1997).

The optimal enforcement literature's discussion of including illegal activities with positive social value in enforcement regimes is not necessarily reflected in practical forest policy and management. In part this lack of attention to livelihood needs may derive from the domination of forest management by conservation rather than livelihood considerations. Yet whether governments and protected area managers incorporate the value of illegal activities in their decisions can lead to very different management strategies and raises serious equity concerns whenever poor people rely on forest and park resources for their income (Cavendish, 2000; Robinson *et al.*, 2002; Albers & Robinson, 2007).

Community-based forest management (CBFM) and some joint forest management (JFM) schemes provide legal rights to rural people to collect forest resources that were previously illegal, recognizing the importance of these resources to rural livelihoods and especially the rural poor. Such policies address rural livelihood issues while maintaining conservation goals, and reflect a less confrontational relationship between conservation agents and the resource-dependent rural poor. These policies may be motivated by fairness considerations in terms of the burden on local people of providing environmental services, poverty alleviation goals, practical concerns about conflict and safety in these regions, or a desire to reduce government management costs. Even within such policies, however, conflicts between national and regional priorities present problems.

The legitimization of forest resource collection is often informal in poor countries when national regulations do not reflect rural realities. Many protected area managers that we have talked with in Thailand, India, and Tanzania understand the livelihood issues and, despite the formal rules, have adopted unofficial practices to allow limited collection of forest products for home use. For example, for JFM in government preservation forests in Tanzania, national regulations mandate that no resources can be taken from these forests, even where villagers have traditionally used these resources and even where there are no alternatives. But we find that in practice, subsistence collection of forest resources is rarely punished.

Full versus Incomplete Enforcement

Whether or not the returns to the illegal activity are included in the enforcement agency's objective function, a central result of the enforcement literature is that when fines are capped and detection or punishment of crime is costly—as is almost always the case—it is rarely optimal to prevent all illegal activity.³ Budget constraints simply reinforce this conclusion. Perhaps not surprisingly then, most of the optimal enforcement literature ignores full enforcement. Yet whereas the optimal enforcement literature focuses almost exclusively on incomplete enforcement, many conservation biologists argue that a 'precautionary principle' of zero killing is the only option for highly endangered species with low

rates of reproduction (Bowen-Jones *et al.*, 2002). Moreover, zero tolerance of illegal activities is often mandated of protected area managers, especially to maintain IUCN classifications of nature reserves or national parks.

There are only a few examples in practice of 'perfect enforcement'. One is rhino poaching in Swaziland, which appears to have been eliminated through amendments of the Game Acts that increased significantly the powers of rangers and police officers, and through the introduction of 24/7 patrols with armed guards (using automatic assault rifles) and continuous radio contact (CITES, 2004). Mandatory minimum prison sentences were imposed for those caught with endangered species, and individuals were no longer permitted to pay a fine to avoid a prison sentence (something that had been favoured by the richer poachers). Such measures are extreme and very costly (raising issues of who can and who should fund such activities, and who benefits from the protection), but have been taken to protect a highly endangered species where conservationists consider zero tolerance the only way to avoid local extinction.⁴

Despite the focus of the optimal enforcement literature on incomplete enforcement, it offers some clues as to how full enforcement might be achieved for specific species or areas of land. For example, the literature has long recognized that legalizing less-socially damaging activities can induce individuals to switch away from more damaging actions (for example, Stigler, 1970; Friedman & Sjöstrom 1993; Mookherjee & Png, 1994). Similarly, Robinson (2008) suggests that the full protection of endangered species is more likely and more cost effective if hunting of less endangered species is permitted.

Varying the level of patrols and enforcement across space, or spatially differentiated enforcement, within a forest could go some way towards reconciling the conservationists' desire for 'perfect enforcement' with the practical realities of enforcement and the theoretical prediction that it is rarely optimal to prevent all illegal activity (Albers, 2010). Yet enforcement strategies in typical forest settings in developing countries are rarely spatial, and there is little in the optimal enforcement literature to inform such spatial strategies within a landscape. We find that forest managers may spread patrols somewhat evenly across the forests, which results in incomplete and ineffective enforcement everywhere; others may concentrate enforcement effort at the boundary of the protected area because there are easily accessible paths to patrol.

A number of papers have focused on the spatial patterns of illegal activity, which can be used to inform improved spatially-differentiated enforcement strategies. For example, Clayton *et al.* (1997) demonstrate that spatial patterns of hunting and trading babirusa (a wild pig species in Indonesia) can be used to inform spatial concentration of enforcement such as along trade routes or at markets rather than in the protected areas. Hofer *et al.* (2000) provide detail on the economic drivers of individuals' choices over where to hunt in the Serengeti. Even in wealthy countries with strong institutions for property rights enforcement, Wing and Tynon (2006) identify spatial patterns of illegal activity in public forest land in the US.

From an ecological and livelihoods perspective, it might be best to protect a smaller area of forest more effectively than a larger area of forest less effectively. From an economic efficiency perspective it may be best to forego patrols in very remote areas where villagers are unlikely to go and to permit extraction to occur in some outer 'buffer zone' (Albers, 2010; Robinson & Albers, 2006). The resulting patterns of enforcement and extraction can produce regions of full or complete enforcement, regions of deterrence, and other regions of incomplete enforcement (Albers, 2010).

One spatially-explicit policy, creating buffer zones at the boundaries of parks, aims to protect forest resources from edge effects and human disturbance and/or to provide resources for nearby local villagers who are excluded from protected areas (Wells & Brandon, 1992; Robinson & Albers, 2006). Although many management plans propose such buffer zones around protected areas, many forest reserves lack a legally defined buffer zone, in part because land designated for reserve or national park status cannot readily be legally redesignated for other uses, such as extraction or resource enrichment activities, as might be common in a buffer zone that aims to provide resources to rural people. In these cases, *de facto* buffer zones often arise. In Khao Yai National Park in Thailand, most of the park budget goes to enforcement, but park managers and villagers alike report that the park's outer region acts like an NTFP extraction zone (Albers & Robinson, 2007; MIDAS Agronomics Volume 3, 1993). In such situations, park management might be improved if an appropriately sized buffer zone were incorporated within the protected area, as can be found in the Amani Reserve in Tanzania (authors' observations). The economics literature provides little guidance to determining the appropriate size of a buffer zone. Recent work combines analysis of spatial extraction decisions with spatial enforcement decisions to determine the size of buffer zones as a function of enforcement budgets, opportunity costs of labour, and market access (Albers, 2010; Robinson *et al.*, 2005). Even with such guidance, adding buffer zones to existing parks faces regulatory challenges, which underscores the need to include buffer zones when new parks are being planned in order to address rural people's livelihood issues in addition to the long-term enforcement of access restrictions within more fully protected forest areas.

Under-Researched Practical Aspects of Enforcement

In this section we address key practical aspects of protected area management that have received scant attention in the literature yet are critical concerns in developing countries: sources of funding for enforcement activities; multiple layers of enforcement; equity; and conflict.

Enforcement Costs, Enforcement Budgets, and the Role of Fines

Not only are fines low in developing countries but enforcement costs tend to be high. Enforcement of access restrictions in developing country forests, beyond atypical settings, is very costly because the areas are large, densely vegetated, and the pressure on their use is high. Enforcement requires salaries for guards to patrol large areas in addition to vehicles, guard stations, and other equipment. These costs form a significant fraction of many forest and park management budgets. In Thailand, guard and other enforcement costs make up the bulk of the annual budget in national parks (MIDAS Agronomics Volume 3, 1993). In India, approximately 60% of the forest department budget is spent on enforcement activities that comprise salary costs, travel costs, and protection infrastructure (authors' estimates). Where there is little potential for tourism and recreation services, the enforcement costs rise as a percentage of budgets. Yet, with constraints on the level of fines, as predicted by the literature and as found in practice, those responsible for enforcement cannot simply reduce the costs of enforcement while maintaining its effectiveness by lowering the probability of being caught—and therefore lowering the costs of detection—and increasing the fine proportionately.

In many developing countries, budgets available for protecting key natural resources are negligible or even zero. Policies to involve local communities in the management of the nearby resources through versions of CBFM or JFM attempt to obviate the need for large government-provided enforcement budgets. But CBFM and JFM require access restrictions themselves, enforced by the villagers, which removes a cost for the government agency but remains a social cost. For example, where JFM has been introduced in Tanzania, village environmental committees are responsible for patrolling the forests but there is no budget available for remunerating these activities (Robinson & Lokina, 2008). The literature's focus on the socially optimal level of enforcement is therefore of little relevance, and indeed, the literature largely ignores the issue of where the enforcement budget comes from, whereas this question is often a central issue in a developing country setting. Forest and park managers there face a complicated situation with small or non-existent centrally-provided budget. Instead, they often rely on cost recovery through the collection of hunting licenses, fines, and tourism gate fees to augment budgets (Robinson, 2008).⁵ This could result in park managers focusing their enforcement efforts on more lucrative areas and offenders.

Cost recovery is more likely to be feasible where there are charismatic species (Robinson, 2008). For example, in 1990 the Tanzanian government earned US\$4.5 million from 'trophy' hunting licenses, compared with US\$1.9 million from the national parks system (Makombe, 1994). Similarly, although the parastatal TANAPA (Tanzania National Parks Authority) receives no direct government funding, it is able to obtain sufficient funds from tourism gate revenues supplemented by external donors (Robinson, 2008).⁶ The use of hunting revenue to protect resources is not unique to developing countries. In the US today, 'various licenses, fees and taxes on hunting and hunting equipment fund more than 90 percent of the budgets of state fish and wildlife agencies' (Burnett, 2001, p. 2). But these sources of revenue are unavailable in regions such as west Africa with few charismatic species.

In the literature, fines are almost always considered a costless transfer from the individual undertaking the illegal activity to the enforcement agency. Where cost recovery is a reality, fines play the critical role of funding enforcement. Yet when a department relies on fines for its enforcement budget, the more successfully it deters illegal extraction and hunting, the smaller its budget. What might be termed 'perfect enforcement', where no offences occur, will result in no income generation through fines. Budgets will therefore typically need to be generated through alternative funding sources, whether external or through legalizing and selling permits for less harmful, though previously illegal, activities (Robinson, 2008). New international market mechanisms such as payments for environmental services (PES) and the clean development mechanism (CDM) have the potential for governments and local communities to realize a share of the benefits of protected areas that accrue to those who do not bear the costs, including the international community (IAASTD, 2008). However, until such programmes are widespread and reach less unique forests, the relationship between budgets and fine revenue will remain a concern for forest managers.

Multiple Layers of Enforcement, Fairness, and Conflict

Most of the economics enforcement literature assumes that one agency or actor, typically a private or government agency, is the sole optimizer in determining levels of enforcement.

The literature rarely incorporates layers of jurisdiction or the incentives facing individuals in the implementation of an optimal plan, with a few key exceptions. First, Mookherjee and Png (1995) include two tiers of enforcement, one that detects illegal activities and another that sets the rules and monitors detection agents. In other exceptions, Sutinen (1987) and Akella and Cannon (2004) employ an enforcement chain that recognizes that different individuals and organizations are involved in different aspects of enforcement such as detecting the crime, making the charge, finding an individual guilty, and implementing the punishment. Similarly, some game theory and village institution literatures broaden away from a single optimizer perspective in discussing how a group agrees to establish rules. Despite these papers, the enforcement literature typically ignores the tiers of enforcement.

In practice, multiple tiers of enforcement is the rule rather than the exception. For example, in Similipal Biosphere Reserve (SBR) in Orissa, as elsewhere, enforcement comprises multiple tiers of agents with potentially differing incentives. Individual low-paid forest guards make up the first tier and patrol large areas on foot or bicycle with few resources and little supervision. Foresters form the second tier and supervise the forest guards (one forester is typically responsible for 8–10 beats) and undertake enforcement activities. Rangers and forest managers, with overall responsibility for supervision and developing forest protection strategies, make up the third tier—typically assumed to be the sole optimizer in theoretical models. The individuals in each tier are unlikely to fully share motivations and possess the same scope to influence enforcement decisions.

Because forest guards are at the frontline of enforcement, they have the most influence over how much and what type of enforcement actually happens. They can choose whom to punish and whom to let off, how much effort to put into enforcement, and whether to take bribes. These decisions are typically invisible to the other tiers of authority. Guards' decisions over whom to punish, either formally or informally, and from whom to take bribes, is often biased. For example, in Orissa the idea that some illegal actions are 'more illegal' than others is very much ingrained in the decisions of foresters and guards, many of whom are also locals (authors' observations). Because the guards are often sympathetic to the reality that new laws governing protected areas have deprived villagers of their traditional access to forest products, they often ignore illicit extraction by locals for home use from forest reserves and even national parks. But if guards choose whom to punish—perhaps influenced by the relative wealth of the illegal extractor or by the alternative options available to the individual—they can cause resentment among groups in the community who feel that they are more likely to be punished. Therefore guards who are, albeit informally, making decisions over what is an acceptable or 'fair' level of extraction, and what is a 'fair' punishment, may bring the enforcement regime closer to a social optimal that takes account of both resources and livelihoods, or, through lack of impartiality, may move the regime further from the social optimum.

Issues of fairness are particularly relevant in developing countries where illegal collection of resources is often undertaken by poor villagers who may have traditionally, albeit illegally, relied on resources from a particular protected area as a key contribution to their livelihoods. Concepts of fairness may depend on how many villagers appear to be 'getting away' with the illegal activity, whether the resource is collected for home consumption or to sell, and whether the individual caught is local. There is evidence that if rules are perceived as being fair, they are more likely to be accepted (Sutinen & Kuperan, 1999). Our interviews in Tanzania, China, and India, and one author's experiences as a forester all

reflect the tendency of guards to make differentiated enforcement decisions based on their concepts of equity and compassion, especially with respect to extraction for subsistence home use.

The optimal enforcement literature almost always assumes that there is a fixed relationship between the amount spent on enforcement and the effectiveness of that enforcement (key exceptions include Mookherjee & Png, 1995). But in reality, those actually responsible for enforcement—in Orissa the forest guards, in PFM in Tanzania the Village Environmental Committee—choose how much effort to put into enforcement. If rewards are not linked to performance and there is little monitoring, forest guards have little formal incentive to expend any effort. In fact, guards' incentives may centre around the time it takes to process violators, personal financial gain from bribes, and the issues of conflict and retribution within their villages.

Unsupervised guards face some flexibility in determining how they record and book a particular offence. For example, in India, when an individual is apprehended after killing a rare species or with valuable timber, guards often take the easier option of booking the offence as the 'compoundable' case of firewood, in which case the individual caught pays a fine commensurate with taking a headload of firewood and then is allowed to go, because this lesser offence requires far less paperwork for the guard. If the true offence is booked, the forester or forest guard must make a case record, transfer the illegal resource to a storage place, guard it until it is disposed of, and may be required to appear in court.

Booking the lesser offence reduces deterrence for more serious crimes but it does allow the guards to spend the reduced booking time on patrolling instead. By booking a lesser offence rather than no offence at all the guards are also signalling to the forest managers that they are doing their job in as much as they are patrolling and detecting and punishing illegal activity. In general, in Orissa, a compoundable case (in which the offender is released after the illegally taken goods are confiscated/compounded) takes between one and two hours for the forest guard to process; a 'prosecution' case (in which the offenders and goods are brought to the rangers' office where the goods are seized and offenders' case records prepared and individuals released under self-guarantee) takes between three and seven hours; and an arrestable case (in which offenders are prosecuted and then taken to court typically) takes between 10 and 24 hours of the guard's time. Most time tends to be spent processing wildlife products—if a carcass is seized there is an elaborate process including post mortem of the body, gaining a death certificate from a local veterinarian, and burning the carcass in front of a witness, which takes a minimum of eight hours. Another reason why foresters and forest guards may not be inclined to book more serious offences is the low rates of conviction that reduce the deterrence effect of the forest laws and further reduce the incentives for foresters to incur the extra cost of processing a 'prosecution' case.

Forest guards can also choose whether to take a bribe rather than make a formal charge, as we have seen in Orissa and suspect is occurring elsewhere. Bribes do provide some regulation of resource extraction; and indeed they create an incentive for the guards to put more effort into apprehending individuals (Mookherjee & Png, 1994). But with such informal regulation, much needed funds do not reach the authority responsible for protecting the resource, and little data can be collated concerning the number of illegal acts that are detected and punished.

Guards themselves often incur non-budget costs, such as social recrimination in their villages and threats of bodily harm. Conflicts between villagers who harvest or hunt

Table 1. Incidence of assaults on forest personnel in Orissa

Year	No. of cases	Personnel involved (No.)*	Personnel assaulted (No.)	Personnel injured/seriously injured (No.)	Personnel killed (No.)
1994–95	31	38	27	19	2
1995–96	45	48	31	17	0
1996–97	52	56	54	1	1
1997–98	57	66	49	15	2
1998–99	43	46	31	15	–
1999–2000	30	57	45	9	3
2000–01	36	81	66	23	0
2001–02	33	48	40	16	0

Note: *In Orissa state about 2000 personnel are engaged in forest patrols.

Source: State of Orissa, "Orissa Forest Status Report, 2003–04", photocopy (Bhubaneswar, Orissa, India: State of Orissa, Department of Forest and Environment [Aranya Bhawan] 2004).

illegally and the managers of nearby protected areas are well documented throughout the world. Yet the costs of conflict are rarely accounted for in the optimal enforcement literature. Punishing villagers for collecting resources from forests and parks, particularly those to which they have traditionally had access, can cause bad will between rangers and villagers. This situation is especially problematic if the ranger lives in the same village as those extracting illegally. Indeed, the introduction of community-based management implies that often individuals from the same community are both protecting forest resources from fellow community members and wanting to use a protected resource, potentially resulting in conflict. Such conflict can influence both the immediate and long-term protection of resources through the impact on social capital and cohesion within the village, in addition to the time spent managing conflict situations. This conflict makes the forest guard's job a dangerous one. Although unusual, it is not unheard of for rangers to be attacked or even killed by people extracting or hunting illegally (see Table 1). Including the costs of conflict, and recognizing that guards who feel in danger are less likely to want to risk apprehending people, suggests that an optimal enforcement strategy should put increased emphasis on detection rather than punishment, and possibly legalizing less harmful activities.

With the variety of incentives facing guards, it is difficult for researchers and forest managers to get reliable data on the extent of illegal activity, as we know from personal experience. In Orissa we hired individuals from the forestry department to work with the foresters and forest guards, recording the number of arrests and the illegal activity in addition to the location of the offence and socio-economic data on the offender. But even the records that we have accumulated almost certainly suffer from the decision of the foresters and forest guards to book most offences as fuelwood (Table 2).

Conclusion

Even with a trend towards less adversarial resource management approaches such as participatory forestry, CBFM, and JFM, enforcement remains the central tool for controlling resource extraction from forest parks and reserves in developing countries. That enforcement

Table 2. Number of recorded offences and typical punishment over 3 month period in Similipal Biosphere Reserve (authors' survey)

	Number of offences	Typical quantity confiscated	Typical fine
Fuelwood	52	20–30kg (1 headload)	Rs 100–200
Poles	10	2–12 poles	Rs 100–550
Timber	8	150–350 cubic feet	Rs 300–1000 (only 1 arrest)
Forest bird	1	1 bird	Arrested and sent to court
Grazing livestock	1	N/A	(Fined for possessing fuelwood)

faces a reality of under-funded enforcement agencies, underpaid staff with incentives that differ from those who set the rules, and inefficient institutions. Protection efforts are further complicated by poverty and resource dependence, low penalties, relatively high costs of enforcement, and conflict between managers and rural people's needs. Not surprisingly, in many developing countries current protected-area enforcement practices do not work—most protected areas in practice are anything but protected. Moreover, optimal enforcement models and recommendations from the law and economics literature are only partially relevant to resource managers in developing countries.

Our research identifies a number of areas where there is scope to reduce the gaps between theory and practice. First, the literature's emphasis on a sole optimizer misses the sometimes conflicting incentives facing multiple tiers of enforcement agents. Once multiple tiers are recognized, a framework for addressing problems of guards' motives, effort, bribes, fairness, livelihoods, and conflict becomes clearer. Second, the literature's failure to address the source of enforcement budgets and its focus on social welfare optimization marginalizes several key practical elements of enforcement, including the size and creation of enforcement budgets through cost recovery from fines, and how to deal with low fines relative to social value. Third, though a growing literature addresses temporal aspects of optimal enforcement including repeat offenders, little in the literature addresses spatial aspects of enforcement. Spatially differentiated enforcement, such as introducing a sufficiently large buffer zone into a protected area, would acknowledge that not all environmentally harmful activity can be prevented. In addition, spatial enforcement would permit less harmful activities in some regions, such as extraction near inhabited areas to reduce conflict and control areas of extraction. Fourth, guards react to complex incentives in ways that may further distort the relationship between the levels of the crime and the punishment. More data are needed to address the interactions between poachers and guards. Without increased research in these and other areas, the current literature will remain insufficient to inform pressing practical resource management policies in developing countries.

Notes

1. Without limits to the amount that an individual can be punished, any desired pattern of deterrence 'could be achieved at minimal cost by combining arbitrarily low monitoring with sufficiently steep penalties' (Mookherjee & Png, 1994, p. 1049), as proscribed by Becker (1968).
2. This point is reiterated in the literature. For example, Milner-Gulland and Leader-Williams (1992) predict that fines proportionate to the number of elephant kills are more effective than fixed fines.
3. That is, incomplete enforcement is an equilibrium under a broad range of parameters, either because marginal costs exceed the marginal benefits of moving towards full enforcement, or because of the need for marginal

- deterrence to prevent criminals from committing worse crimes. As Helsley and Strange (1994, p. 293) demonstrate: if 'marginal exclusion costs are positive, then there is always some illegal use in a subgame-perfect Nash equilibrium'; that is, it is 'uneconomical to exclude all free riders unless marginal exclusion costs are zero'.
4. In parallel, general poaching is reported to have been reduced by 90%.
 5. Cost recovery is an increasing reality in developing countries in many areas, as government agencies are being required to function as revenue-seeking parastatals rather than relying on externally determined and granted budgets (Nolan & Turbat, 1995; Robinson, 2008).
 6. The viability of such trophy hunting is also influenced by international conventions such as CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) and individual country laws, such as the US Endangered Species Act that has recently been relaxed to permit the import of endangered species (Mbaria & Kelley, 2005).

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