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Economic Studies

Discussion Paper
No. 0235

Protecting Eden: Markets or Government?

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November 2002

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ISSN 1444-4534 series, electronic publication

CIES DISCUSSION PAPER 0235

Protecting Eden: Markets or Government?

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ABSTRACT

The majority of species classified as “threatened”, “endangered” or “extinct” by the IUCN are to be found in government controlled parks and legally protected areas in developing countries. Dissatisfaction with the public sector’s record in protecting endangered species has prompted calls for the use of market based instruments and other economic incentives to promote more efficient environmental outcomes. In this paper we examine whether greater reliance on market based incentives would result in improved environmental outcomes in national parks. We address this issue by extending the incomplete contracts framework to the case of a renewable resource. We identify conditions under which private ownership or control of a national park induces more (less) efficient management of protected areas. The paper concludes with a discussion of the limitations of the analysis and the implications of these results for the conservation of biodiversity.

1 General Introduction

The mantle of government protection has done little to reverse the growing list of species classified as “threatened”, “endangered” or “extinct” by the IUCN. The vast majority of these species are to be found in government controlled parks and legally protected areas in developing countries (IUCN 2002). The proximate causes of the decline in wild animal populations are well documented and vary regionally and over time (Soule 1987). They include: poaching, illegal logging, agriculture, mining, intrusive developments and land clearing. Dissatisfaction with the public sector’s record in protecting endangered species has prompted calls for the use of market based instruments and other economic incentives to promote more efficient environmental outcomes.

This drive towards the use of the market and market based instruments is widespread. Thus in the pursuit of the maintenance of biodiversity there is a strong movement towards the protection of species by commercialisation. Examples include ranching for wildlife in the USA, Africa and elsewhere, the advocacy by Grigg (1995) and others of kangaroo farming, and crocodile farming in Australia. These initiatives have often been based in part on recognition of the predominance of private land in such societies and they are seen as a necessary supplement to public sector conservation, not as an alternative . Captive breeding programmes for the supply of wild animal products (such as bear bile) in Oriental medicine are yet another example of commercial operations. All of these programmes to some extent attempt to harness market forces to serve conservation objectives.

It is probably not possible as yet to draw any general and/or long term conclusions from these various policies. First because conservation objectives are complex, but also because they are essentially very long term. For this reason, if for no other, it is

important to establish the potential of commercial operations as a conservation tool. We explore this issue in the context of a simple model in Sections II and III. Of the many market based instruments that have been suggested, privatization of protected areas is one of the boldest and most controversial. This usually involves the provocative handing back of public assets to the private sector either in whole or part. At the lower end of the scale, there are concessions of various sorts, for example sited in National Parks. In what follows we focus on the stylized case, where a National Park is partly privatized in the sense that a fraction of the residual profits accrue to the owner-manager. We examine whether this greater reliance on market incentives would result in improved environmental outcomes, specifically in terms of biodiversity objectives.

At the outset an important qualification is in order. A definitive description of biodiversity is an enormously difficult and controversial task. Little is known about even the existing diversity of species. Estimates of the total number of species vary one to five hundred million species (Soule 1987). We circumvent these problems by assuming that individuals have well defined preferences for an “umbrella” or “keystone” species, whose survival is linked to the entire assemblage of life in the National Park under consideration (Holling *et al* 1995). Top predators such as tigers and lions would clearly satisfy this criterion, while for other species the link may be somewhat more tenuous (Damania *et al* 2003, Karanth 2002). A difficulty inherent in the pursuit of biodiversity is the selectivity of human preferences. The “warm furry” syndrome perhaps epitomised by for example the Northern Spotted Owl campaign in the USA or the Koala concerns in Australia, remains a systemic problem in conservation. While market forces are effective in signaling consumer demands,

there is no guarantee that species with commercial value are those in most need of protection. We address these and other issues in Section *V*.

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II OUTLINE OF THE MODEL

In this Section we examine whether greater reliance on market based incentives would result in improved environmental outcomes in national parks. We address this issue by extending the incomplete contracts framework to the case of a renewable resource.¹ We consider a natural resource such as a national park which has the potential to generate revenue through activities such as tourism, hunting, hiking and fishing. It is assumed that these activities variously cause some degree of environmental damage in the park. Administration of the park is delegated to a manager who can allocate effort (time and resources) to a number of activities. These include effort devoted to: (i) promote tourist activities and provide services to visitors, (ii) activities which protect and regenerate the resource (such as the control of weeds, feral animals, poaching, logging, etc), or (iii) leisure (i.e. shirking). If the manager is a public sector employee (PSE) (s)he receives a fixed wage, while in a “privatized” park some fraction of the residual profits accrue to the owner-manager,(OM). Clearly if it were possible to specify and enforce a complete and comprehensive contract, a public sector manager could be made to allocate effort in the socially optimal manner. Moreover, it would also be possible to specify a contract for the public sector manager, which results in the same outcome as under private ownership.² However, when the allocation of effort across activities is not

¹ Important contributions in the incomplete contracts literature include Hart, 1986; Hart and Moore 1990 and Hart et al, 1997, Laffont and Tirole 1999. Baker.

² It is worth noting that these sorts of issues were extensively explored in much earlier literature which contrasted the performance of owners and controllers (Kamerschen 1968, Monsen, Chui and Cooley 1968). Similarly, Liebenstein’s (1966) X-efficiency theory was heavily based on the difficulty of establishing complete labour contracts and spawned a large literature on related

contractible (i.e. non-verifiable), the outcomes may differ substantially. For the public employee the allocation of effort is determined by the net marginal disutility (utility) derived from each non-verifiable activity, while for the private manager profit seeking adds a new dimension to the problem. Since complete privatisation of national parks and wilderness areas seems highly unlikely, in the formal analysis we focus upon the more realistic situation where a manager's rewards are linked to market outcomes (i.e. profits or revenue), with full privatisation being the limiting case. We attempt to identify the circumstances under which the use of "high powered" incentives is likely to result in superior (inferior) environmental outcomes.³

The assumption that complete contracts may be impossible to specify seems plausible in the context of park management and wildlife conservation for at least three reasons. First, it is perhaps impossible to identify *ex ante* the full range of duties a park manager may be required to perform, in every contingency. Secondly it may be difficult to condition contracts on measurable environmental criteria, since the response of ecosystems and species to human intervention is stochastic and often unpredictable (May 1975). Finally, in the absence of full information about biological systems, on-the-job-learning is likely to play an important role in the management of endangered species, which further militates against contractual completeness.

It is assumed that the number of visitors to the park and their willingness to pay for a visit depends upon two key attributes: the abundance and diversity of wildlife and the

motivational issues including the question of the performance of owners versus franchisees in the then relatively new fast food industry e.g. (Shelton 1967) Much of this literature found significant differences in performance of different management regimes.

quality of service that is received from park employees.⁴ We begin by considering the case of a park that is managed by a government employee who receives a fixed wage.⁵ Effort will be allocated to various tasks to equalise the net marginal benefits to the manager from each activity. In contrast if the park is controlled by an owner-manager, profits play an important role in determining effort levels. To increase the profitability of the enterprise the owner-manager has a stronger incentive to raise revenue from park visitors. Hence, greater effort is expended on tourist related activities. However, increasing the flow of visitors, raises the level of environmental damage (i.e. lowers resource stocks). The manager could then choose to either ameliorate the damage by investing in environmental repair, or simply allow the resource to decline. Investment in damage mitigation and environmental protection will occur only if the marginal payoffs from environmental protection exceed those from investment in tourism.

Even in this highly simplified framework we find that in general it is impossible to determine whether private ownership induces greater environmental protection. However, in Section 1V we establish several results about the relative performance of private management. It is shown that the higher the level of shirking under public management, the greater are the opportunities for capturing environmental benefits through private contracting. However, the superiority of private management also depends on the nature of visitor demands and the costs of environmental protection. If visitors place a relatively high (low) weight upon wildlife stocks, there is a stronger

³ This is defined, albeit rather loosely, as maintenance and/or improvement in biodiversity. measured in terms of species and maintenance of the dynamic ecosystem.

⁴ This assumption captures in a simple way the notion that the biological resource(s) is the key attraction to the park, but that the willingness to pay for the experience is likely to depend also on the available facilities such as the quality of accommodation, service, tour guides, transport facilities, etc.

(weaker) incentive to protect wildlife under private management. Similarly, when the costs of environmental protection are high, there are stronger incentives in a private regime to reallocate effort to other activities, so that environmental outcomes deteriorate. While these results appear to be intuitive, they may be of assistance in identifying the conditions which are necessary for high powered incentives to produce environmental (and welfare) improvements. In Section V we discuss some examples in the light of these results.

This paper is related to a growing literature on performance related pay in the public sector. Much of this literature demonstrates that perverse incentive effects may arise when a job requires managers to perform several tasks, with only a subset of these being measured and rewarded. Unsurprisingly, in such circumstances, workers concentrate their efforts on the rewarded task to the detriment of other objectives (Baker 1992, Holmstrom and Milgrom 1991). In the context of the current study, these issues are of somewhat less significance since there is a primary and well defined objective – the conservation of the parks’ biodiversity.

The remainder of this paper is organised as follows. Section III presents the basic model. Section IV establishes several results concerning the relative efficiency of private and public management regimes. Section V discusses a number of other important factors that are not included in the model and concludes the paper.

III THE MODEL

⁵ The assumption of a fixed wage is both simple and realistic since it captures the usual non-performance based mode of remuneration in the public sector.

Consider a biological resource such as a national park, which has the potential to generate revenue as well as various externalities from activities such as tourism.

Visitor demands depend upon two key attributes of the park: the stock of the biological resource (such as the abundance of exotic wildlife) and the quality of tourist services available in the park. Visitor demand is given by:

$$Q = \gamma_1 X + \gamma_2 e^T - P \quad (1)$$

where X is the stock of the biological resource, e^T is tourist services provided in the park and P is the park entry fee.⁶

Equation (1) implies that improvements in either tourist services (e^T), or biological stocks (X) will raise the level of demand. The biological resource, X , may either be interpreted as a single charismatic species which attracts tourists to the park (such as tigers, elephants, orangutans), or an assemblage of species.⁷

Public Sector Management

We begin by considering the case where management of the park is delegated to a public sector employee hereafter PSE, who invests effort and available resources in three activities. First, the manager may devote effort to the provision of visitor services (e^T). Activities in this category might include effort and resources spent on providing, administering and monitoring the quantity and quality of tourist services provided in the park. Second, effort may be invested in activities that protect and regenerate the biological resource (e^w). These might include tasks such as the control of invasive species (e.g. pests and weeds), poaching and illegal logging. Finally, we allow for the possibility that the manager may shirk - i.e. consume leisure (e^L). The

⁶ It is of course possible to allow both the slope and the intercept of (1) to vary with X and e^T . This, however, complicates the analysis without adding further insight.

⁷ If X includes animals high in the food chain, such as the top predators, there is likely to be a close correlation between the steady state population of these species and the general state of the eco-system. Thus steady state changes in X would provide an indication of the state of the park environment. However, see later comments on 'selectivity' in Section V.

key assumption in the paper is that e^w , e^T , and e^L even if observable, are not wholly verifiable and hence cannot each be part of an enforceable contract. These assumptions reflect a common situation in developing country national parks where supervision of managers is weak and penalties for poor performance are the exception (Breedon and Wright 1996).

As is common place in the public sector, the PSE receives a fixed wage of w . In addition, (s)he obtains utility from stocks of the resource, $V(X)$, $V' > 0$, $V'' \leq 0$. This utility may either represent the manager's intrinsic preservation value for X , or it may reflect a concern for loss of reputation arising from a failure to manage the resource satisfactorily.⁸ Thus, the manager's per period utility is given by:

$$U = w - c_1(e^T) - c_2(e^w) + u(e^L) - V(X) \quad (2)$$

where $e = e^T + e^w + e^L$ is the total endowment of time, $c_i(e^K)$ ($i = 1, 2$) represents costs of effort invested in e^K ($k = T, w$) and $u(e^L)$ is utility from leisure. We make the standard assumptions about the convexity of $c_i(e^K)$: $c_i' > 0$, $c_i'' > 0$ ($i = 1, 2$), and concavity of $u(e^L)$, $u' > 0$, $u'' < 0$. Further, for analytical tractability we let $V(X) = \alpha X$ ($\alpha > 0$).

The park manager is assumed to be a fully tenured employee. It is recognised that this assumption may not apply in many cases – particularly in developing countries where appointments may be influenced by political considerations. Moreover, as is well established, tenure insecurity (like undefined property rights) is likely to induce short term opportunistic behaviour and would thus bias the results against any management regime associated with high levels of uncertainty. Since, the main aim of this paper is to explore the effects of high powered incentives when all other factors are held constant, we abstract from considerations of tenure insecurity.

However, in Section V we return to this issue and discuss the effects of uncertainty over tenure on environmental outcomes.

Turning next to the biological properties of the resource. The biological growth of the resource is given by $f(X)$, $f'' < 0$. Visitors to the park cause environmental damage defined by θQ , where θ is a damage parameter.⁹ On the other hand, effort invested in environmental protection and restoration has a net positive effect on the regenerative capacity of the resource: $\gamma_3 e^w$. Thus the net growth of the population is:

$$\dot{X} = f(X) - \theta Q + \gamma_3 e^w \quad (3)$$

where $f(X)$ describes biological growth, θ is the damage coefficient and γ_3 measures the effect of effort in environmental restoration (e^w) on population growth rate.

The manager maximises the net present value of utility given in (2), subject to the resource growth constraint defined in (3). The current value Hamiltonian is:

$$H = w - c_1(e^T) - c_2(e^w) + u(e - e^T - e^w) + \alpha X + \mu(f(X) - \theta Q + \gamma_3 e^w) \quad (4a)$$

where μ is the costate variable.

After rearrangement the necessary conditions simplify to:

$$-c_1' + c_2' - \mu(\theta\gamma_2 + \gamma_3) = 0 \quad (4b)$$

$$\dot{\mu} = \delta\mu - (\alpha + \mu(f' - \theta\gamma_1)) \quad (4c)$$

$$f(X) - \theta Q + \gamma_3 e^w = 0 \quad (4d)$$

Noting that in a steady state $\dot{\mu} = 0$, equations (4b) and (4c) may be combined to yield:

$$-c_1' - \frac{\alpha\theta\gamma_2}{\delta - f' + \theta\gamma_1} = -c_2' + \frac{\alpha\gamma_3}{\delta - f' + \theta\gamma_1} \quad (4e)$$

⁹ It is possible that individuals who place a relatively high value on wildlife are more likely to be employed in such positions.

To interpret equation (4e) observe that the LHS represents the net marginal costs of allocating effort to tourist service. This includes the direct marginal cost of effort devoted to tourism ($-c_1'$) and the effects of increased tourist flows on stocks of the resource, evaluated at the shadow price ($-\frac{\alpha\theta\gamma_2}{\delta - f' + \theta\gamma_1}$). The RHS of (4e) defines the net the marginal costs of allocating effort to environmental services. It includes the direct marginal cost of effort ($-c_2'$), and the effects of environmental services on resource stocks, evaluated at the shadow price $\left(\frac{\alpha\gamma_3}{\delta - f' + \theta\gamma_1}\right)$. Thus, effort is allocated between e^T and e^w until net marginal costs of each activity are equated. In what follows we assume that the shadow price of the resource is always positive so that it is optimal to conserve the resource in the steady state.

Private Management

Suppose instead that the government shifts to a regime of partial (regulated) privatisation, where a private manager (PM) or contractor is paid a fraction of visitor revenues. To facilitate comparison with the public management regime, it is assumed that the entry fee P , is regulated by the government and is held at the same level as under public management.¹⁰ Instead of receiving a fixed wage of w the private manager now receives a fraction b of the total revenue from tourism: bQP . In all other respects, the private sector manager is identical to the public manager. Clearly under full deregulation P is set optimally to maximise payoffs and $b = 1$. The central question we consider is how effort levels and wildlife stocks vary, when at a given (regulated) price (P), the park manager is allowed to retain some (or all) of the revenue from tourism.

⁹ If visits are for purposes such as hunting θ may be interpreted as the usual “catchability coefficient”.

The private manager's utility function is given by:

$$U_o = bQ_oP - c_1(e_o^T) - c_2(e_o^w) + u(e_o^L) - V(X_o) \quad (5)$$

where subscript o denotes variables under private management

The current value Hamiltonian is:

$$H_o = bPQ_o - c_1(e_o^T) - c_2(e_o^w) + u(e_o^L) - V(X_o) + \alpha X_o + \mu_o (f(X_o) - \theta Q_o + \gamma_3 e_o^w) \quad (6a)$$

The necessary conditions are:

$$\gamma_2 bP - c_{1o}' + c_{2o}' - \mu_o (\theta \gamma_2 + \gamma_3) = 0 \quad (6b)$$

$$\dot{\mu}_o = \delta \mu_o - (\alpha - \gamma_1 bP + \mu_o (f_o' - \theta \gamma_1)) \quad (6c)$$

$$f(X_o) - \theta Q_o + \gamma_3 e_o^w = 0 \quad (6d)$$

When $\dot{\mu}_o = 0$ in a steady state, equations (6b) and (6c) combine to yield:

$$\gamma_2 bP - c_{1o}' - \frac{(\alpha + \gamma_1 bP) \theta \gamma_2}{\delta - f_o' + \theta \gamma_1} = -c_{2o}' + \frac{(\alpha + \gamma_1 bP) \gamma_3}{\delta - f_o' + \theta \gamma_1} \quad (6e)$$

Once again the LHS represents the net marginal benefits of investing effort in tourism, while the right hand side is the net marginal benefits of effort in environmental restoration. Comparing (4e) and (6e) it can be seen that the introduction of higher powered incentives has ambiguous effects on the net marginal returns to effort allocated to each activity. On the one hand, the rewards to effort invested in tourism are increased by $b\gamma_2 P$ – an amount reflecting the marginal revenue from visitor flows. *Ceteris paribus* this will induce a greater allocation of effort to tourism. On the other hand, increased visitor flows result in greater environmental damage which alters the shadow value of the resource ($-\frac{(\alpha + \gamma_1 bP) \theta \gamma_2}{\delta - f_o' + \theta \gamma_1}$), which may be either greater or lower than under public management.¹¹ The overall effect is thus

¹⁰ We discuss the effects of full unregulated privatisation later in the paper.

¹¹ The shadow value is unambiguously higher if $f_o' > f'$ (i.e. $X_o > X$).

ambiguous. A similar argument reveals that it is not possible to determine the effects of privatisation on either effort in environmental restoration, or resource stocks at this level of generality.

Intuitively, the ambiguity arises from the conflicting forces under privatisation. Since the manager's payoffs depend on tourism, there is a greater incentive to raise revenue from park visitors. Thus, *ceteris paribus*, effort levels invested in tourism will rise.

However, there is a cost associated with this. Increasing the flow of visitors, raises the level of environmental damage (i.e. lowers resource stocks), which in turn reduces visitor demands. The manager could then choose to either ameliorate the damage by investing in environmental repair, or simply allow the wildlife population to decline.

Effort will be invested in damage mitigation only if the marginal payoffs from increasing (or maintaining) wildlife stocks, exceed those from investment in tourist related activities. Thus the outcome will depend upon the parameters of the problem - an issue that we address in the following section.

Finally, by differentiation of (6a) we note that if the park is fully privatized and the entry fee is completely deregulated, a profit maximizing owner would set a price which satisfies:

$$P^* = \frac{\alpha\theta + (\gamma_1 X_o + \gamma_2 e_o^T)(\delta - f_o' + \theta\gamma_1)}{2(\delta - f_o') + \theta\gamma_1} \quad (7)$$

where $b = 1$

If the regulated price (P) is less than the optimal profit maximising price P^* then full privatisation yields qualitatively similar results to those discussed in this paper.

IV Comparison of Outcomes

To assess the effects of privatization on the allocation of effort and resource stocks we consider three distinct cases. In the first it is assumed that tourists demands depend

primarily upon wildlife stocks, X (i.e. a relatively low value of γ_2). Next we consider the case where visitor demands are driven mainly by the desire to consume tourism services, e^T (i.e. a relatively low value of γ_1). Finally we explore the effects of allowing costs and shirking incentives to vary.

The main results are summarized in the following propositions.

Proposition 1a: If visitor demands depend mainly upon wildlife stocks, then an increase in b (the proportion of revenue from tourism paid to the manager) has the following effects. There is: (i) less effort invested in tourism services, (ii) greater effort is invested in environmental restoration and (iii) resource stocks rise,

(i.e. As $\gamma_2 \rightarrow 0$, then $\frac{de^T}{db} < 0$, $\frac{de^W}{db} > 0$, $\frac{dX}{db} > 0$.)

Proof: See Appendix.

Intuitively, an increase in b makes the manager more responsive to consumer preferences. Since visitors place a relatively higher weight upon wildlife stocks, there is a strong incentive to protect wildlife in order to maximize and sustain revenue from tourism. There is a reallocation of effort from tourism services to environmental protection and restoration. Moreover, it can be shown that there is an overall decline in the consumption of leisure, which implies that the increase in effort devoted to environmental services exceeds the decline in effort invested in tourism. Thus, when tourist demands are linked to stocks of wildlife, market driven incentives strongly serve conservation objectives and generate overall welfare gains.

Proposition 1b: If visitor demands depend mainly upon the level of tourism services, then an increase in b (the proportion of revenue from tourism paid to the manager) has the following effects. There is: (i) greater effort invested in tourism services, (ii) greater effort is invested in environmental restoration only if the damage caused by visitors is sufficiently high and (iii) the effect on resource stocks is ambiguous.

(i.e. As $\gamma_1 \rightarrow 0$, then $\frac{de^T}{db} > 0$, $\frac{de^W}{db} > 0$ if $\theta > \tilde{\theta}$, $\frac{dX}{db} < (<)0$.)

Proof: See Appendix.

In this case visitor demands depend mainly upon the level of non-wildlife related services. Greater reliance on market based incentives (i.e. an increase in b) induces the manager to more closely align the allocation of effort to consumer preferences. Thus investment in tourism related services increases. However, an increased flow of visitors raises the level of environmental damage. If the damage is sufficiently high and exceeds a certain threshold (i.e. $\theta > \tilde{\theta}$), the manager chooses to ameliorate the damage by investing greater effort in environmental protection. However, since consumers place a relatively low weight on wildlife stocks, incentives to invest in environmental protection are too weak and may not necessarily offset the damage from greater use of the park. Hence the impact on wildlife stocks is ambiguous. In this case, greater reliance on market forces could result in adverse conservation outcomes.

Propositions 1a and b accord entirely with intuition. Market based incentives provide a strong impetus to align effort levels and services with consumer preferences. If tourists place a low weight on wildlife stocks, greater dependence on market

incentives could lead to depletion in resource stocks. In welfare terms, which management regime is superior will therefore depend on the magnitude of the relative distortions. In environmental policy terms it is perhaps more important to determine whether market forces can be relied upon to raise wildlife stocks when consumer demands are not in the extreme ranges identified above, but depend upon both wildlife stocks and visitor services. *A priori* the outcome is unclear since there are at least two conflicting effects. First, under private management there is a trade-off between the benefits from an increased flow of tourists and the resulting need to invest more effort in environmental repair. When opportunities for restoration and damage mitigation are limited, the private manager has weaker incentives to protect resource stocks. In contrast, the incentive structure under public ownership induces greater levels of shirking. Since total effort levels are higher under private management, there are opportunities to improve both wildlife protection and tourism services.¹²

The following propositions provide conditions under which the private and public management can be unambiguously ranked.

Proposition 2a: If α is sufficiently small, then resource stocks under private management are unambiguously higher than under public management.

(i.e. As $\alpha \rightarrow 0$, $X_o > X$)

Proof: See Appendix.

Recall that α measures the intrinsic utility the manager obtains from wildlife stocks.

When α is small the public manager has weak incentives to engage in environmental

¹² Of course all these conclusions depend on some convergence between consumers concepts of

improvements and there is a high level of shirking (i.e. consumption of leisure rises). On the other hand, the private manager is motivated by the need satisfy consumer demands which depend upon both, service levels and wildlife stocks. Hence even in the limiting case where no intrinsic value is placed on resource stocks (i.e. $\alpha = 0$), the private manager invests effort in both activities. It follows that for sufficiently small levels of α both resource stocks and service levels are higher under private management, so that welfare improves unambiguously.

Proposition 2b If γ_3 is sufficiently small, then resource stocks under public management are unambiguously higher than under private management.

(i.e. As $\gamma_3 \rightarrow 0$, $X_o < X$)

Proof: See Appendix.

Proposition 2b has an obvious interpretation. Recall that γ_3 measures the marginal product of effort invested in environmental services. As γ_3 falls, opportunities for restoration and damage mitigation decline and the marginal payoffs from investing in environmental repair are low. In this case there are strong incentives to reallocate effort to other activities under both public and private management. However, since the private manager's rewards are linked to the revenue raised from tourists, there is a stronger incentive to invest in tourist services so that visitor flows are higher and wildlife stocks are lower. The weaker incentives under public management removes this tendency to run down resource stocks in order to generate revenue.

In summary the results suggests that public management is most likely to serve conservation objectives when visitor demands are unrelated to wildlife stocks (Proposition 1b) and/or the costs of protecting wildlife is sufficiently high (Proposition 2b). Conversely, when public employees care little about the resource under their protection (Proposition 2a), or when there is high demand for wildlife (Proposition 1a), the shift to high powered incentives would result in a superior outcome.

V Conclusions and Qualifications

The protection of endangered species is a costly activity. Estimates suggest that the expenditure necessary to protect (charismatic species) such as the black rhinos of Africa may exceed \$1,000 per animal per annum. However, actual funds available for protection lag substantially behind these recommended rates and are in the region of \$200 per rhino (du Toit 1998). Given the vast gap that exists between actual and required funding levels, there is an urgent need for all resources made available for conservation to be used efficiently. Despite the obvious policy importance of improving the efficiency of endangered species protection, there appears to have been little formal analysis of this issue.¹³ This paper has attempted to fill this gap in the literature. Drawing on the incomplete contracts framework we developed a model to identify the circumstances under which market based incentives would promote greater conservation. In general the nature of consumer demands, costs of protection and restoration and the incentives of government employees were shown to play a key role in determining the relative superiority of a market based approach.

¹³ There is a vast and growing literature on community based conservation examples include Barrett and Arcase 1995, Holling and Meefe 1996. This is not an issue that we address in this paper. It is acknowledged that community based initiatives may at times serve as a useful adjunct to the measures discussed in this paper.

Recent initiatives in Kenya's wildlife sector provide a useful example which illustrates both the potential and limits of market based initiatives. Over 70% of Kenya's wildlife is to be found on privately owned land (Emery 1998). Until recently the government retained exclusive responsibility for managing wildlife, with strict controls on consumptive uses of wildlife on private lands. Since the 1980's policy reforms have allowed private landholders to establish game ranches. There has been a general decline in wildlife populations throughout Kenya. However, the emerging evidence suggests that rates of wildlife decline are on average 40% lower on those private ranches which have large numbers of the "big five" charismatic species favoured by tourists (Emerton 1998, Norton-Griffiths 1998).

This illustrates an important qualification, which is consistent with the conclusions of the model. Markets tend to promote selectivity in that only the species that have commercial value, whether as tourist attractions, game targets or harvestable resources can be directly protected through commercialisation. Thus the pursuit of conservation and biodiversity through the use of market forces, would need to rely heavily on umbrella species and habitat spillovers. Where species of commercial value do not exist, market driven approaches may be of limited value. This however, does not detract from a fundamental implication of the analysis Even where prospects for commercialisation are limited, the use of high powered incentives, conditioned upon measurable environmental criteria, may induce more efficient management of park resources

An important issue that has not been considered in the paper is that of corruption. Anecdotal evidence suggests that corruption amongst forest officials may be widespread in many developing countries (Breden and Wright 1996). This is often a consequence of the relatively low wages that are paid to forest officials – frequently in

arrears (as in India). The model can readily be extended to allow for the payment of bribes by poachers to forest officials. It can be shown that high powered incentives would dilute some of the benefits from bribe taking – suggesting that in cases where corruption is pervasive a market driven approach may be desirable.¹⁴ To see why recall that under public management tourist demands for wildlife confer no benefit to the manager. Hence a public manager will accept a bribe from a poacher whenever the expected payoffs from bribery exceed his/her intrinsic utility from conservation. In contrast under private management, tourist demands for wildlife provide an additional link between environmental outcomes and managerial payoffs. Hence in a private regime a bribe will be accepted only if the expected payoffs from bribery exceed both the additional revenue from tourism and intrinsic utility from conservation. Thus the threshold bribe is higher under private management and this can be expected to reduce the incidence of corruption.

The formal analysis has also neglected the issue of tenure uncertainty. It is well known that tenure insecurity is likely to induce short term opportunistic behaviour and would thus favor any management regime associated with greater levels of certainty. There are strong reasons to suggest that tenure insecurity may be greater in public administrations since appointments are likely to be influenced by political considerations.¹⁵ However, there are also cases where violent conflicts and the weak enforcement of property rights may render private ownership insecure. Thus security of tenure under alternative regimes is likely vary both regionally and over time.

Since, the main aim of this paper is to explore the effects of high powered incentives

¹⁴ The problem of determining the optimal rewards for environmental managers in a corrupt regime has been analysed by Damania (2002).

¹⁵ *Sanctuary Asia*, 3, 2000 p 40 documents the case where local politicians in India have attempted to transfer the director Ranthambore Tiger Reserve for "...being too concerned about tiger protectionism .."

when all other factors are held constant, we have abstracted from this issue, while noting its importance.

APPENDIX

Proposition 1a:

The effects of a shift to a regime of high powered incentives are qualitatively analogous to increasing the fraction of revenues (b) paid to the manager. We thus evaluate the effects of increasing b on the FOCs defined (6b) – (6d). Totally differentiating the system of equations yields:

$$\begin{bmatrix} H_{e^T e^T} & H_{e^w e^T} & H_{e^T x} \\ H_{e^w e^T} & H_{e^w e^w} & H_{e^w x} \\ -\theta\gamma_2 & \gamma_3 & H_{xx} \end{bmatrix} \begin{bmatrix} de^T \\ de^w \\ dx \end{bmatrix} = - \begin{bmatrix} H_{e^T b} \\ H_{e^w b} \\ 0 \end{bmatrix} db \quad (A1)$$

where: $H_{e^T e^T} = -c_1'' + u'' < 0$; $H_{e^T e^w} = u'' < 0$ $H_{e^T b} = \frac{\gamma_2 P(\delta - f')}{\delta - f' + \theta\gamma_1} > (<) 0$

$H_{e^T x} = \frac{-f''\gamma_2\theta(\gamma_1 b P + \alpha)}{(\delta - f' + \theta\gamma_1)^2} > 0$; $H_{e^w e^w} = -c_2'' + u'' < 0$, $H_{e^w b} = \frac{\gamma_1 \gamma_3 P}{\delta - f' + \theta\gamma_1} > 0$

$H_{e^w x} = \frac{-f''\gamma_3\theta(\gamma_1 b P + \alpha)}{(\delta - f' + \theta\gamma_1)^2} > 0$, $H_{xx} = f'' - \theta\gamma_1 < 0$.

As $\gamma_2 \rightarrow 0$, then $H_{e^T b} = H_{e^T x} = H_{e^T e^T} \rightarrow 0$

Using Cramers Rule it follows that as $\gamma_2 \rightarrow 0$:

$$\frac{de^T}{db} = \frac{H_{e^w e^T} H_{e^w b} H_{xx}}{\Delta} < 0 \quad (A2)$$

where Δ is the determinant of the system which is assumed to be negative by the SOCs.

$$\frac{de^w}{db} = \frac{-H_{e^T e^T} H_{e^w b} H_{xx}}{\Delta} > 0 \quad (A3)$$

$$\frac{dx}{db} = \frac{H_{e^w b} (H_{e^T e^T} \gamma_3 + H_{e^w e^w} \theta \gamma_2)}{\Delta} > 0 \quad (A4)$$

Proposition 1b

As $\gamma_1 \rightarrow 0$, then $H_{e^w_b} \rightarrow 0$. Moreover as $\gamma_1 \rightarrow 0$, then $\mu > 0$ only if $\delta - f' > 0$. Thus,

$H_{e^T_b} > 0$. Thus as $\gamma_1 \rightarrow 0$:

$$\frac{de^T}{db} = \frac{H_{e^T_b}(H_{e^w_e^T}H_{xx} - \gamma_3 H_{e^w_x})}{\Delta} > 0 \quad (\text{A5})$$

$$\frac{de^w}{db} = \frac{H_{e^T_b}(H_{e^w_e^T}H_{xx} - \theta\gamma_2 H_{e^w_x})}{\Delta} > 0 \quad (\text{A6})$$

However as $\theta \rightarrow 0$, then $de^w/db < 0$ and conversely as $\theta \rightarrow \infty$ then $de^w/db > 0$. Since

de^w/db is continuous in θ , then from the Intermediate Value Theorem it follows that

there exists some $\tilde{\theta} \in (0, \infty)$, such that

$$\forall \theta < \tilde{\theta}; \quad \frac{de^w}{db} < 0 \quad \text{and} \quad \forall \theta > \tilde{\theta}; \quad \frac{de^w}{db} > 0.$$

$$\frac{dx}{db} = \frac{H_{e^T_b}(H_{e^w_e^T}\gamma_3 + H_{e^w_e^T}\theta\gamma_2)}{\Delta} > 0 \quad (\text{A7})$$

Proposition 2a:

Rearrange (4e) :

$$\delta + \theta\gamma_1 + \frac{\alpha(\theta\gamma_2 + \gamma_3)}{c_{1u}' - c_{2u}'} = f'_u \quad (\text{A8})$$

where subscript u denotes variables under public management.

Rearrange (6e):

$$\delta + \theta\gamma_1 + \frac{(b\gamma_1 P + \alpha_o)(\theta\gamma_2 + \gamma_3)}{-b\gamma_2 P + c_{1o}' - c_{2o}'} = f'_o \quad (\text{A9})$$

As $\alpha \rightarrow 0$, then (A8) and (A9) simplify to:

$$\delta + \theta\gamma_1 = f'_u \quad (\text{A10})$$

$$\delta + \theta\gamma_1 + \frac{b\gamma_1 P(\theta\gamma_2 + \gamma_3)}{-b\gamma_2 P + c_{1o}' - c_{2o}'} = f'_o \quad (\text{A11})$$

From equation (6b) it follows that in a steady state when $\dot{\mu} = 0$ then the shadow price

is $\mu = \frac{\alpha - \gamma_1 b P}{\delta - f' + \theta \gamma_1}$ which is assumed to be positive. By rearrangement of (6e) it then

follows that $-b\gamma_2 P + c'_{1o} - c'_{2o} < 0$. Thus comparing (A10) and (A11) it follows that

$f'_o < f'_u$. Since by assumption $f'' < 0$, then $X_o > X_u$.

Proposition 2b:

Differentiation of (4a) wrt e^w yields:

$$\frac{\partial H}{\partial e_u^w} = -c'_{2u} - u' + \mu \gamma_3 = 0 \quad (\text{A11})$$

When $\gamma_3 = 0$ there is a corner solution such that $e_u^w = 0$, (since $c'_{2u} > 0$ and $u' > 0$).

This implies that $c'_{2u} = 0$. Given that the shadow price of the resource μ is assumed to

be positive, it follows that equation (4b) cannot hold for any $e_u^T > 0$. Hence $e_u^T = 0$.

Differentiation of (6a) wrt e^T and e^w yields:

$$\frac{\partial H}{\partial e_o^T} = bP\gamma_2 - c'_{1o} - u' - \mu\theta\gamma_2 = 0 \quad (\text{A12})$$

$$\frac{\partial H}{\partial e_o^w} = -c'_{2o} - u' + \mu\gamma_3 = 0 \quad (\text{A13})$$

Observe that, when $\gamma_3 = 0$ there is a corner solution such that $e_o^w = 0$. However from

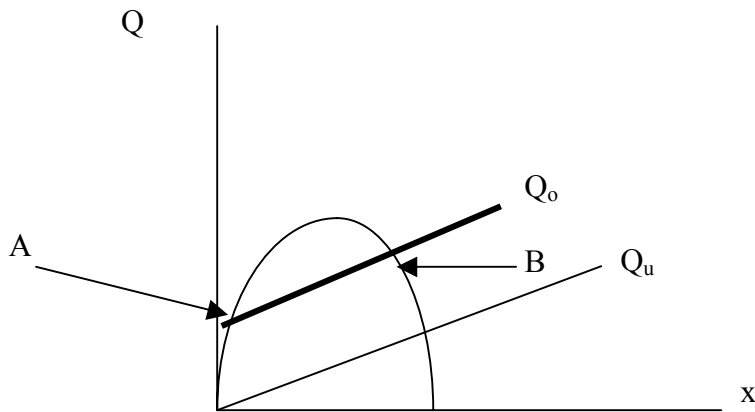
either (A12) or (6b) it can be seen that $e_o^T > 0$ is feasible, when the SOCs are

satisfied.

It follows that $Q_o = \gamma_1 X + \gamma_2 e^T - P > Q_u = \gamma_1 X - P$ for any given X . To determine the

effects on resource stocks consider diagram 1 below.

Diagram 1



As usual the concave function represents the biological growth curve and the higher line labeled Q_0 is the damage curve under private management, while the line Q_u is the damage curve under public management. It is clear that all steady state equilibria under private management occur at lower stocks. Note also that the private management equilibrium A in the diagram is unstable since the harvest line intersects the growth curve from above, while equilibrium B is stable (see May 1975 for details).

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