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TOURISM, POACHING AND WILDLIFE CONSERVATION: WHAT CAN INTEGRATED CONSERVATION AND DEVELOPMENT PROJECTS ACCOMPLISH?

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Tourism, Poaching and Wildlife Conservation:

What can Integrated Conservation and Development Projects accomplish?

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Abstract

Integrated Conservation and Development Projects (ICDPs) have frequently been established in Africa to improve wildlife conservation and the welfare of local communities. However, their effectiveness so far has been hampered by conflicts and illegal harvesting activities. Within a Gordon–Schäfer-type model, this paper focuses on the strategic interaction between the manager of a protected area and a group of local people living near the park. The park manager benefits from wildlife through non-consumptive tourism and safari hunting. The local people benefit through hunting, although this is illegal according to existing laws, but they also bear costs as wildlife causes agricultural damage. Depending on the economic and ecological environment, we show that ICDPs relying on money transfers to the local people derived from the park manager's activities may or may not promote wildlife conservation. In addition, we demonstrate that the effects on the welfare of the local people are ambiguous.

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1 Introduction

Protected areas have long been recognized as the single most important method of conserving wildlife and preserving biological diversity. For most African countries, this practice dates back to the colonial era, and the objective has always been to protect wild animals and natural habitats through *strongly* restricted wildlife utilization. However, the establishment of protected areas has often displaced rural communities from their traditional lands. This policy has also alienated the wildlife from the local people, and has frequently transformed wildlife from a valuable commodity into a threat and a nuisance (Kiss, 1990; Swanson and Barbier, 1992; Martin, 1993; Barrett and Arcese, 1995; Gibson and Marks, 1995; Songorwa, 1999). For these and other reasons, many protected areas have operated directly against the economic interests of the local communities (see, e.g., Brandon and Wells, 1992; Milner-Gulland and Leader-Williams, 1992; Wells, 1992; Wells and Brandon, 1992; Nepal and Weber, 1995), and persistent poaching pressure has led to a growing recognition that this 'fences and fines' approach has failed to achieve its objective of preserving wildlife (Marks, 1984; Leader-Williams and Albon, 1988; Kiss, 1990; Swanson and Barbier, 1992).

Hence, the main approach to recent wildlife management schemes has been to include the local people to gain their cooperation and support, which has eventually resulted in the so-called Integrated Conservation and Development Projects (ICDPs) (see, e.g., Wells and Brandon, 1992). These projects involve varying levels of local participation, ranging from pure benefit sharing, such as transfers from wildlife-related activities, to a more far-reaching design of community-based management in which local communities are trained to manage and control resources. While the core objective of these projects is protected area conservation (Brandon and Wells, 1992), the aim is to achieve this by promoting economic development and by providing local people with alternative income sources that do not threaten wildlife.

This paper focuses on ICDPs based on pure benefit-sharing strategies. Several existing ICDPs engage in game meat distribution as well as revenue sharing, under which a part of the park's income is distributed to local people in the form of cash transfers (see, e.g., Brandon and Wells, 1992; Barrett and Arcese, 1995). These elements directly improve local income and welfare, and are implemented separately or in combination in several existing ICDPs. Well-known examples are the CAMPFIRE in Zimbabwe, the ADMADE program in Zambia and the Serengeti regional conservation project in Tanzania (see, e.g., Brandon and Wells, 1992; Barrett and Arcese, 1995 and 1998; Gibson and Marks, 1995).[1]

However, the functioning of ICDPs may be limited by possible design dilemmas and trade-offs inherent in linking conservation and development. Wells and Brandon (1992), Ferraro (2001), and Ferraro and Kiss (2002), among others, question the underlying assumption that local people will respond to benefit transfers by voluntary refraining from activities that would otherwise undermine natural resource conservation. That is, local people may incorporate new sources of income as complements to existing activities rather than as substitutes for them. These authors therefore stress the need to change incentives from indirect measures (say, through the agricultural sector) to direct measures; that is, transfers conditional on conservation results.

Possible shortcomings of the benefit-sharing components of ICDPs are also discussed by Barrett and Arcese (1995). They argue that transfers of game meat from managed harvests

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1 In addition, several ICDPs generate benefits to the local people through local job creation in the formal sector and stimulation of increased productivity in the agricultural sector. For instance, the Lupande development project in Zambia promotes agricultural improvements and offers local villagers employment opportunities as game scouts, park guards etc. (Wells and Brandon, 1992). Employment in park activities has also been generated by the ADMADE and CAMPFIRE programs (Barrett and Arcese, 1995). For a broader review of existing ICDP strategies, see e.g., Brandon and Wells (1992), Wells and Brandon (1992) and Barrett and Arcese (1995).

may increase local people's dependence on game meat and thereby promote illegal hunting. They also identify the functioning, or lack of functioning, of rural markets as a factor limiting the effectiveness of money transfers from tourism. They argue that, for cash transfers to work, local people must be able to exchange money for food or other consumption goods. However, in rural and remote areas, the opportunity to do this is often constrained by poor access to markets due to high transaction costs, for example (Muller and Albers 2004).[2]

Some unintended effects of ICDPs on illegal hunting and wildlife conservation have also been analysed within explicitly formulated economic models. One such contribution is from Barrett and Arcese (1998), who analyse the ICDP components of money transfers from tourism and transfers of game meat to the local people by using a household model. They assume that the household hunts illegally for its own consumption. In this framework, the household responds to game meat transfers by substituting illegal meat for legal meat and, consequently, this policy succeeds in discouraging illegal hunting. However, Barrett and Arcese find that the sum of the illegal and legal offtake increases, and hence game meat distribution reduces the degree of wildlife conservation. Skonhoft (1998) analyses a similar scheme for game meat distribution but reaches the opposite conclusion regarding wildlife conservation. The conclusions differ because Barrett and Arcese consider the local people as the active agent, whereas the park agency controls the wildlife stock in Skonhoft's model. Skonhoft assumes that the park manager earns income from safari hunting and by providing non-consumptive tourism services such as observing wildlife. By forcing the park manager to transfer a fixed share of the wildlife harvest to the local people, the return from safari hunting is reduced relative to the return from wildlife under tourism. Consequently, the park manager responds by making further investments in wildlife conservation.

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2 The pioneering theoretical exposition of missing markets is by De Janvry et al. (1991).

Barrett and Arcese (1998) show that money transfers from non-consumptive tourism may increase illegal hunting by generating a positive income effect on game meat consumption. Although the mechanism is different, this result is consistent with that of Skonhoft's (1998) model of the park manager. If the park manager is instructed to transfer a fixed share of the tourism income to the local people, the return from tourism is reduced relative to the return from safari hunting. The park manager responds to this by reducing investment in wildlife conservation. Hence, both contributors suggest that ICDPs relying on money transfers fail to conserve wildlife. (See also Muller and Albers (2004), who show how the ICDP's optimal transfers depend on the market for labour and resources.)

In this paper, we formulate a stylized bio-economic model to analyse the impact of the ICDP's benefit-sharing components. Unlike in previous models, *both* agents—the park manager and a group of local people living near the protected area—are assumed to harvest wildlife and to respond to economic incentives. *Strategic* interdependence between the park manager and the local people is therefore incorporated. The basic structure of the model is presented in section 2. Transfers within the ICDP framework are analysed in section 3. We examine two types of money transfer from the park manager to the local people: transfers from safari hunting and transfers from non-consumptive park activities. In section 4, we compare the ICDP solution with the solution of the social planner. Both the pre-ICDP and ICDP situations are analysed under biological and economic equilibrium. Biological equilibrium implies that harvesting equalizes natural growth all the time. The economic equilibrium is that of the Nash one-shot game. Throughout the text, we use general functional forms as well as refer to solutions based on the so-called Gordon–Schäfer assumptions. Details are in the Appendix.

2 The basic model and the pre-ICDP solution

We consider the conflicting interests between the agency managing the protected area and the local people living in the vicinity of this area. The park agency benefits from the wildlife through safari hunting and non-consumptive tourism services such as wildlife viewing. The local people also hunt wildlife, but as the wildlife knows no boundaries and moves freely in and out of the protected area, the game also destroy agricultural crops and compete with livestock when outside the protected area. Hence, in this model, as in reality, the wildlife also represents a nuisance for the local people. Hunting by the local people is illegal. However, because the funds are small and the areas are large, poaching cannot be prevented by the park manager (see, e.g., Kiss, 1990). Hence, *de jure* and *de facto* property rights differ.

The local people are treated as a homogeneous group, which implies that there are no conflicting interests among them. Hence, in our framework, individuals conform to group norms, and in line with tradition, the elders are assumed to be in charge of group activities (Marks, 1984). It is assumed that the net benefit of the wildlife is maximized. The hunting strategy of the local people is therefore not of the open-access type (but see section 5 below). The park agency is assumed to maximize the profit from the two park activities. However, in section 5, we also discuss briefly how culling, rather than safari hunting, used to reduce grazing intensity and maintain the ecological system, influences conservation and the welfare of the local people.

The two production activities practised by the conservation agency, non-consumptive tourism and hunting, and illegal hunting by the local people are constrained by wildlife abundance. Throughout, we let one stock of wildlife X, measured in numbers of animals or biomass, represent the whole game population. The population dynamics are determined by natural growth and hunting, and in biological equilibrium, the total offtake equals natural growth. If e_1 and e_2 are the levels of hunting effort of the park manager and the local people, respectively, the equilibrium relationship between the wildlife stock and the effort levels may be expressed as:

$$X = X(e_1, e_2)\,. \tag{1}$$

Increased hunting effort reduces the stock, $\partial X / \partial e_i < 0$, i =1,2. Throughout, a positive stock level is assumed, $X > 0$.

Under the Gordon–Schäfer assumptions, the harvesting functions are linear with regard to effort and stock level; i.e., $y_i = q_i e_i X$, where q_i is the productivity (catchability) coefficient. In addition, the natural growth function is specified as the logistic, $F(X) = rX(1 - X / K)$, where r is the intrinsic growth rate and K is the carrying capacity. Given these functional forms, equation *(1)* is a downward-sloping linear relationship in (e_1, e_2) space, and its slope is determined by the relative hunting productivity. For a given stock level, this line is also termed the *iso-conservation* schedule. Hence, a line closer to the origin represents effort combinations for which there is more wildlife (see Appendix for details).

The park manager obtains income from hunting wildlife, by selling hunting licences, and from non-consumptive tourism. The net benefit of hunting depends on hunting effort and the stock level, and is typically given by $H_1 = H_1(e_1, X)$, with $\partial H_1 / \partial X > 0$ because more wildlife means a higher offtake for a given effort level, and $\partial H_1 / \partial e_1 > 0$ if the hunting profit is positive (see below). $W(X)$ represents the profit from non-consumptive tourism, and implies that more wildlife makes the park more attractive, but at a decreasing rate; i.e., $W'(X) > 0$ and $W''(X) < 0$. In addition, $W(0) = 0$. Hence, the income from non-consumptive tourism is similar to the so-called 'wealth effect' in models of optimal growth (Kurz 1968). The profit of the park manager is therefore:

$$\pi = H_1(e_1, X) + W(X)\,. \tag{2}$$

The local people derive utility from hunting wildlife illegally. The poaching benefit is a function of hunting effort and the stock level; i.e., $H_2 = H_2(e_2, X)$, with $\partial H_2 / \partial X > 0$. However, $\partial H_2 / \partial e_2$ may be positive or negative (see below). Wildlife is also a nuisance, and the damage cost $D(X)$ is assumed to depend on the size of the stock. More wildlife means more damage, $D'(X) > 0$, while there is no damage if there is no wildlife; $D(0) = 0$ (Zivin et al., 2000).[3] Accordingly, the net benefit to the local people is given by:

$$U = H_2(e_2, X) - D(X). \tag{3}$$

In the absence of a unified resource policy, there are several externalities. The traditional reciprocal harvesting externalities work through the hunting benefit functions. In addition, there are reciprocal stock externalities related to the stock values: more hunting effort by the park manager, *ceteris paribus*, induces a positive externality on the local people through a reduction in $D(X)$. On the other hand, more hunting effort by the local people induces a negative external effect on the park manager through a reduction in $W(X)$.

The economic problem of the park agency is to determine the profit-maximizing hunting effort under the ecological constraint *(1)*, given the effort of the local people. The direct effect of increased effort is a higher harvesting benefit. However, more hunting effort reduces the wildlife stock, which in turn lowers the non-consumptive benefit and increases the hunting cost. The park manager will therefore expend effort on hunting to equalize the marginal benefit and marginal cost of hunting, which depend on the two stock effects. Hence, the necessary condition for a maximum, given a positive effort level, is:

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3 As wildlife is a nuisance, hunting by the local people also represents damage control. In reality, damage control is also performed through fencing and other measures more directly related to protecting the crop. Such measures are, however, neglected, in the present model.

$$\partial H_1(e_1, X) / \partial e_1 + [\partial H_1(e_1, X) / \partial X](\partial X / \partial e_1) + W'(X)(\partial X / \partial e_1) = 0 . \qquad (4)$$

Because $\partial X / \partial e_1$ is negative, while $\partial H_1 / \partial X$ and $W'(X)$ are positive, $\partial H_1 / \partial e_1$ is positive. Under the functional forms of the Gordon–Schäfer model, this term yields the harvesting profit per unit effort (see below and the Appendix).

The first-order condition *(4)* is also be the park manager's best-response function, denoted by $R_1(e_2)$ in Figure 1. It is downward sloping because increased hunting effort by the local people increases the pressure on wildlife and thereby reduces the optimal hunting effort of the park manager. Along the best-response curve, profit depends on the effort of the local people, $\pi = \pi(e_2)$, and the envelope theorem implies $d\pi(e_2) / de_2 = (\partial H_1 / \partial X + W')\partial X / \partial e_2 < 0$. In Figure 1, π^0 and π^1 yield two iso-profit curves, where $\pi^1 > \pi^0$.

The economic problem of the local people is to determine the utility-maximizing harvesting effort e_2, subject to the ecological constraint *(1)* and the effort of the park manager. The direct effect of more effort is an increased hunting benefit. The indirect effect, working through a smaller wildlife stock, is twofold. First, increased effort lowers utility through higher hunting costs. Second, unlike in the problem of the park manager, greater effort increases utility by lowering wildlife numbers, which results in reduced crop damage. The local people take these trade-offs into account when deciding the optimal harvesting effort. For a positive effort level, the necessary condition for maximum harvest is:

$$\partial H_2(e_2, X) / \partial e_2 + [\partial H_2(e_2, X) / \partial X](\partial X / \partial e_2) - D'(X)(\partial X / \partial e_2) = 0 . \qquad (5)$$

Because $\partial X / \partial e_2 < 0$, while $D'(X)$ and $\partial H_2 / \partial X$ are positive, $\partial H_2 / \partial e_2$ may be either positive or negative. Hence, in contrast to the park manager, the unit harvesting profit of the local people may be positive or negative. If there is extensive damage, profit will be negative, which implies that the optimal strategy is to harvest enough for a negative harvesting profit per unit of effort to be balanced by a small number of nuisance animals. Whether this happens also depends on the harvesting activity of the park manager.

Figure 1 about here

Equation *(5)* represents the local people's best-response function, denoted by $R_2(e_1)$ in Figure 1. Along the best-response curve, utility depends on the effort of the park manager, $U = U(e_1)$, and the envelope theorem implies $dU(e_1)/de_1 = (\partial H_2/\partial X - D')(\partial X/\partial e_1)$. Accordingly, greater effort by the park manager reduces the optimal utility of the local people if the marginal harvesting benefit dominates the marginal damage effect; i.e., if $(\partial H_2/\partial X - D') > 0$. Hence, under this condition, the iso-utility curves, U^0 and U^1, in Figure 1 are such that $U^0 > U^1$. Otherwise, in the 'nuisance' case, when $(\partial H_2/\partial X - D') < 0$, greater effort by the park manager is beneficial because reduced damage dominates the reduced harvesting benefit. This is illustrated by the two iso-utility curves $U^3 > U^2$. These iso-utility curves bend in the opposite direction to that of U^0 and U^1 (see the Appendix).

In what follows, we assume an interior solution, in which the Nash equilibrium is given by the effort levels $e_1^* > 0$ and $e_2^* > 0$ in Figure 1.[4] the best-response function of the park agency is steeper than that of the local people, in accordance with the Gordon–Schäfer model (see the Appendix). In addition, the iso-conservation schedule through the Nash equilibrium $X^* = X(e_1^*, e_2^*)$ is steeper than the best-response curve of the local people, but is flatter than that of the park manager. This also accords with the Gordon–Schäfer model. The location of

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4 Depending on prices, values and costs, in addition to ecological factors, boundary solutions with either $e_1^* = 0$ or $e_2^* = 0$ can arise. This may happen if a high marginal tourist value is accompanied by a high hunting cost-

the equilibrium stock level can imply so-called biological overexploitation; i.e., $X^* < X^{msy}$. This may arise if, for instance, the cost–price ratios of hunting are low and the nuisance value is high relative to the marginal valuation of poaching.

The detailed comparative static results can be determined in the linear specification of the model by using the Gordon–Schäfer assumptions. The harvesting profit of the park manager is then $H_1(e_1, X) = (p_1 q_1 e_1 X - c_1 e_1)$, where p_1 is the price of the safari hunting licence, assumed to be fixed, while c_1 is the unit price of organizing the hunting, also assumed to be fixed. The harvesting benefit of the local people is $H_2(e_2, X) = (p_2 q_2 e_2 X - c_2 e_2)$, where the values of p_2, q_2 and c_2 generally differ from those of the park manager (see also section 4). In addition, the stock values are assumed to be linear; i.e., $W(X) = wX$ and $D(X) = \gamma X$, with $w > 0$ and $\gamma > 0$ being the fixed marginal tourist benefit and fixed marginal damage cost, respectively.

Consider first the effect of an increase in the price of safari hunting licences p_1. The relative profitability of consumptive and non-consumptive activities of the park manager is affected, and the price increase results in greater hunting effort, given the effort levels of the local people. This causes an outward shift in $R_1(e_2)$, and hence, $\partial e_1^* / \partial p_1 > 0$ and $\partial e_2^* / \partial p_1 < 0$. The mechanism behind these effects is that increased hunting effort by the park manager causes the wildlife stock to shrink, and in turn, the local people find it economically rewarding to expend less harvesting effort. However, it can be demonstrated that the increased effort of the park manager dominates the indirect effect relating to the local people. We therefore find $\partial X^* / \partial p_1 < 0$, so the new economic equilibrium intersects with an iso-

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price ratio of the park manager. We then have $e_1^* = 0$ together with $e_2^* > 0$. The opposite case may arise if a high cost-price ratio of hunting is accompanied by a low nuisance value (also see the Appendix).

conservation schedule further from the origin. The profit of the park manager increases, $\partial \pi^* / \partial p_1 > 0$, while the utility effect for the local people depends on the sign of $(\partial H_2 / \partial X - D')$. If the marginal harvesting benefit dominates, then $\partial U^* / \partial p_1 < 0$. In the opposite 'nuisance' case, when $(\partial H_2 / \partial X - D') < 0$, we find $\partial U^* / \partial p_1 > 0$, in which case, increased profit for the park manager is associated with improved welfare for the local people (see the Appendix).

Table 1 about here

Increased profitability in non-consumptive tourism has the opposite effect of an increase in p_1. Hence, $R_1(e_2)$ shifts downwards, and $\partial e_1^* / \partial w < 0$ and $\partial e_2^* / \partial w > 0$. Therefore, the indirect effect of reduced harvesting by the park agency results in more poaching effort being expended by the local people, partly to reduce crop damage, and partly to reap a greater harvesting benefit. Again, the direct effort effect dominates the indirect effect, which results in $\partial X^* / \partial w > 0$. The profit of the park manager increases, while the effect on the utility of the local people is ambiguous. However, if the marginal benefit of harvesting exceeds the marginal damage, the increased profitability of the non-consumptive activity of the park manager improves economic conditions for the local people (see the Appendix for details).

Increased wildlife-induced damage motivates the local people to expend more harvesting effort and $R_2(e_1)$ shifts upwards. Therefore, $\partial e_1^* / \partial \gamma < 0$ and $\partial e_2^* / \partial \gamma > 0$. The mechanism is that increased hunting effort by the local people reduces the wildlife stock, to which the park manager responds by devoting less effort to harvesting. We also find $\partial X^* / \partial \gamma < 0$. Consequently, the profit of the park manager falls as the income from both tourism activities shrinks. In addition, more nuisance reduces the welfare of the local people.

The rest of the comparative static results are reported in Table 1. Note the ambiguous effects on hunting effort of an increase in p_2. An increase in p_2 increases the net harvesting benefit and motivates the local people to expend greater hunting effort. On the other hand, the increase in p_2 also reduces the value of wildlife damage relative to the value of wildlife meat, which has the opposite effect. Hence, the standard result, $\partial e_2 / \partial p_2 > 0$, only arises if the nuisance is low relative to the harvesting cost. If the nuisance is relatively high, the price increase leads to reduced harvesting effort by the local people and to more wildlife.

3 The ICDP solution

So far, we have analysed the economic and ecological equilibrium when there are no transfers from the park manager to the local people. We now consider the ICDP situation to determine how such transfers may affect wildlife conservation and the welfare of the local people. The ICDP transfers are modelled by assuming that the local people, perhaps through the legal system, are granted some of the park benefits, and hence, some property rights over the wildlife. In what follows, the (exogenous) fractions $0 \le \alpha \le 1$ and $0 \le \beta \le 1$ of the incomes from safari hunting and non-consumptive tourism, respectively, represent these transfers. Accordingly, the profit of the park manager changes to:

$$\pi = (1-\alpha)H_1(e_1, X) + (1-\beta)W(X). \tag{6}$$

The benefit of the local people becomes:

$$U = H_2(e_2, X) - D(X) + \alpha H_1(e_1, X) + \beta W(X). \tag{7}$$

The stock-effort condition *(1)* implies that increased hunting effort by the local people, *ceteris paribus*, reduces wildlife abundance. Because the transfers from safari hunting and non-consumptive tourism are related to the stock of wildlife, equations *(6)* and *(7)* indicate that there is an indirect effect of the level of transfers received on the hunting activity of the local people. Hence, in the presence of ICDPs, there are additional costs of increased hunting effort, which work through reduced transfers from the protected area. In the ICDP scenario, local people take this into account when choosing their effort levels. For the park manager, it is the shifts in the relative valuation of the park benefits that matter. Hence, assuming an interior solution, the first-order conditions for the park manager and the local people, respectively, are:

$$(1-\alpha)\{\partial H_1(e_1,X)/\partial e_1+[\partial H_1(e_1,X)/\partial X](\partial X/\partial e_1)\}+(1-\beta)W'(X)(\partial X/\partial e_1)=0, \tag*{(8)}$$

$$\partial H_2(e_2,X)/\partial e_2+[\partial H_2(e_2,X)/\partial X](\partial X/\partial e_2)$$

$$-D'(X)(\partial X/\partial e_2)+[\alpha\partial H_1/\partial X+\beta W'(X)](\partial X/\partial e_2)=0. \tag{9}$$

Following Skonhoft (1998), we consider three different ICDP schemes: (i) uniform transfers from the two activities, in which case, $0<\alpha=\beta<1$; (ii) only transfers from non-consumptive tourism, in which case, $\alpha=0$ and $0<\beta<1$; and (iii) only transfers of harvesting benefits, in which case, $\beta=0$ and $0<\alpha<1$. We analyse these schemes in turn.

Given condition *(8),* case (i), uniform transfers, does not change the relative valuations of harvesting and non-consumptive wildlife utilization of the park manager. Consequently, the best-response function $R_1(e_2)$ is unchanged (see Figure 2). However, $R_2(e_1)$ shifts inwards because transfers increase the marginal cost of hunting and reduce hunting effort (see above). The new Nash equilibrium is therefore characterized by more harvesting effort by the park manager and reduced harvesting effort by the local people. Moreover, the new equilibrium is below the original iso-conservation schedule and is consistent with more conservation. The effect on the welfare of the local people is ambiguous. The direct effect is clearly positive, while the indirect effect, which works through the increased harvesting effort of the park manager, may be positive or negative. The sign depends on whether the marginal nuisance dominates the marginal harvesting benefit. If the marginal nuisance dominates, the increased harvesting of the park manager reduces the nuisance by more than it reduces the harvesting benefit and, consequently, the indirect effect reinforces the direct positive effect on the welfare of the local people. Otherwise, the welfare effect is ambiguous.

Surprisingly, the effect on the profit level of the park manager is, in general, also ambiguous. This is because the transfers expand profit opportunities because, *ceteris paribus*, an increase in the stock of wildlife increases the income from safari hunting as well as from non-consumptive tourism. If these effects are strong, uniform transfers may increase the profit of the park manager. Therefore, there is a potential for more wildlife and higher welfare for both parties under an ICDP scheme based on uniform transfers. Increased welfare represents an efficiency gain of the transfers.

Figure 2 about here

In case (ii), with $0 < \beta \leq 1$ and $\alpha = 0$, the value of the non-consumptive use of wildlife reduces relative to the value of hunting by the park manager. Consequently, as illustrated in Figure 3, the best-response curve $R_1(e_2)$ shifts outwards. Compared to the pre-ICDP scenario, transfers from non-consumptive tourism increase the marginal cost of hunting for the local people, who consequently find it economically rewarding to reduce their hunting effort. The new best-response curve $R_2(e_1)$ therefore shifts inwards. Hence, the new Nash equilibrium is characterized by reduced hunting effort by the local people and greater effort from the park manager; i.e., $\partial e_1^* / \partial \beta > 0$ and $\partial e_2^* / \partial \beta < 0$.

Figure 3 about here

However, as the best-response curves shift in opposite directions, the conservation effect is ambiguous and depends on the relative effort shifts. The important factor is the local people's valuation of game meat relative to the price of safari hunting. It seems reasonable to assume that the price of hunting licences exceeds the local valuation of game meat (see below). In this case, it can be shown that income transfers from tourism lead to greater wildlife conservation, as illustrated in Figure 3. This result contrasts with the finding of Skonhoft (1998), who focuses solely on how transfers affect the decision problem of the park manager (see above).

Like uniform transfers, this type of transfer may also increase the welfare of the local people. The conservation effect is positive and substantial if the effect on the hunting effort of the park manager is small; that is, if the price of safari hunting licences is high relative to the local valuation of game meat. Such advantageous conditions for safari hunting reinforce the welfare effect for the local people (i.e., the indirect welfare effect is insignificant) and the park manager (i.e., the indirect effect on profit is large). Thus, an ICDP policy relying on income transfers from non-consumptive tourism is more effective if the return on safari hunting is high.

Now consider case (iii), in which $0 < \alpha \leq 1$ and $\beta = 0$. This scheme increases the relative value of the non-consumptive activity and, consequently, it is economically beneficial for the park manager to reduce hunting effort, and so $R_1(e_2)$ shifts inwards (Figure 4). This time, $R_2(e_1)$ also shifts inwards. The new equilibrium is therefore characterized by lower total effort and hence, $\partial X^* / \partial \alpha > 0$. Although the mechanisms are different, this result is consistent with the prediction of Skonhoft's (1998) single-agent model. Figure 4 illustrates a situation in which the local people reduce their effort, while the effort of the park manager increases.

Figure 4 about here

This type of ICDP transfer therefore succeeds in promoting wildlife conservation, while the welfare effects are ambiguous. If the price of safari hunting licences is high relative to the local valuation of game meat, the hunting effort and offtake of the park manager increases. In addition, greater wildlife conservation raises the income from non-consumptive tourism. These effects may offset the direct effect of transfers and hence increase the profit of the park manager. In turn, greater harvesting effort from the park manager, which weakens the positive conservation effect, may strengthen the positive welfare effect for the local people if the marginal nuisance dominates the marginal harvesting benefit.

4 Social planner's solution

It has been demonstrated that the benefit transfers of the ICDP may succeed in promoting wildlife conservation and improving the welfare of the local people. We now study how these redistribution schemes fit to the social planner's solution of a unified resource management policy. Assuming that the profits from park activities and the net benefit of the local people are given equal weight,[5] the problem of the social planner is to maximize:

$$(\pi + U) = H_1(e_1, X) + W(X) + H_2(e_2, X) - D(X), \tag{10}$$

subject to the ecological constraint *(1)*.

The following two equations yield the first-order conditions for maximum:

$$\partial\pi / \partial e_1 + [\partial H_2(e_2, X) / \partial X](\partial X / \partial e_1) - D'(X)(\partial X / \partial e_1) \leq 0,\ e_1 \geq 0, \tag{11}$$

$$\partial U / \partial e_2 + [\partial H_1(e_1, X) / \partial X](\partial X / \partial e_2) + W'(X)(\partial X / \partial e_2) \leq 0,\ e_2 \geq 0. \tag{12}$$

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5 It is beyond the scope of this paper to discuss this assumption critically.

The complementary slackness conditions are indicated explicitly because either $e_1^s = 0$ or $e_2^s = 0$, or both $e_1^s = e_2^s = 0$, are strong candidates for a solution (the superscript 's' denotes the social planner's solution) . The reason for this is that there may be large gaps in harvesting productivity and harvesting profitability between the two agents. These gaps would make it socially beneficial to steer hunting activity towards the most productive and profitable agent. Alternatively, in the case of a high marginal benefit from non-consumptive tourism and a small marginal damage cost and low harvesting values, it may be profitable for both agents to refrain from hunting. The Appendix demonstrates that a corner solution *unambiguously* arises under the Gordon–Schäfer assumptions.

In what follows, we assume that hunting is profitable, and that harvesting by the park manager is more productive and profitable than is harvesting by the local people. This seems reasonable as the price of safari hunting licences exceeds the price of game meat on the local market (see, e.g., Cater, 1987; Holmern et al., 2002). In addition, the hunting productivity of the park manager is presumably high relative to the productivity of the local people because the former use more sophisticated weapons and hunting methods (see, e.g., Arcese et al., 1995). This case is illustrated in Figure 5, in which the vertical line e_1^s illustrates the positive harvesting effort of the park manager following the implementation of the social planner's solution.

Figure 5 about here

The vertical line at e_1^s is to the right of the park manager's best-response function in the Nash pre-ICDP solution. This is because the social planner takes into account the fact that harvesting by the park manager imposes a positive externality on the local people in the form of reduced crop damage. However, whether the wildlife stock at the social optimum is below or above the market level is ambiguous (see the Appendix). A high marginal income from non-consumptive tourism and a small marginal nuisance tend to increase the stock of wildlife in the social optimum. On the other hand, because the social planner restricts wildlife harvesting to the relatively productive and profitable agent, the overall profitability of harvesting is higher than in the market equilibrium and this tends to reduce the stock of wildlife. Figure 5 illustrates the case in which the first effect dominates so that $X^s > X^*$.

The benefit-sharing components of ICDPs may shift the pre-ICDP solution towards the social planner's solution with respect to both the allocation of hunting effort and the extent of wildlife conservation. As demonstrated in section 3, this happens for transfers from non-consumptive tourism and for transfers from safari hunting if the price of safari hunting licences is high relative to the local valuation of game meat. However, note that this result is based on the assumption that the marginal damage is low, so that the wildlife stock in the social optimum is above the market level. The opposite result emerges if the marginal damage is high, so that $X^s < X^*$. In general, it is indeterminate whether transfers to the local people shift the pre-ICDP solution towards the social planner's solution.

5 Summary of the findings and concluding remarks

Integrated Conservation and Development Projects (ICDPs) attempt to promote wildlife conservation and economic development among local communities. However, studies of existing ICDPs have revealed various difficulties. In this paper, we have added a new element to the analytical literature analysing ICDP's benefit-sharing components; namely, the strategic interdependence between the conservation agency and the local people is represented when both agents harvest wildlife. For the park manager, wildlife has consumptive and non-consumptive value, while to local people, wildlife represents both a benefit and cost.

We have focused on ICDP instruments related to income transfers from non-consumptive tourism and safari hunting. The analysis predicts that uniform transfers, under which local people are given property rights over the wildlife in the form of a fixed share of the park profit, reduce poaching and increase wildlife conservation. We find that transfers from safari hunting also promote wildlife conservation. In addition, income transfers from non-consumptive tourism may increase the stock of wildlife if local people's valuation of game meat is low relative to the price of hunting licences. The welfare of the local people increases only if the effect of the money transfers dominate the effect of poaching and wildlife-induced damage. This happens in the nuisance case and under relatively advantageous economic conditions for safari hunting. We have also analysed how redistribution schemes compare with the social planner's solution. We found that ICDP instruments can shift the pre-ICDP equilibrium away from the social optimum if the marginal damage is high relative to the marginal harvesting value for the local people. This demonstrates that greater conservation may contradict the social planner's solution, in which all benefits and costs of the wildlife are taken into account.

Models only approximate reality and are only as good as the assumptions on which they are based. It is beyond the scope of this paper to address how ICDP transfers are distributed among the local people, and the extent to which various distribution schemes are consistent with the current adherence of individual conformity to group norms. Whether utility maximization is an adequate representation of the behaviour of smallholder farmers living under complex and often harsh conditions may also be questioned. Alternatively, assuming that the poaching strategy is of the pure open-access type affects our conclusions because, in that case, the stock of wildlife, under certain conditions, is determined by the zero-rent harvesting condition of the local people. This arises under the Gordon–Schäfer assumptions, under which $H_2(e_2, X) = (p_2 q_2 X - c_2) = 0$, and hence, ICDP transfers have no effect on the stock of wildlife. Since the nuisance effect on the local people is also unaffected by the transfers, and because there is no harvesting benefit, the welfare effect of the various transfer schemes is equivalent to the amount of the direct transfers.

Throughout, we have also assumed that the park manager maximizes profit from both park activities. However, in many protected areas and parks, there is no commercial hunting, and hunting activity is simply culling to maintain the ecological system (see, e.g., Starfield and Bleloch 1986). The goal of the park manager is then typically to maintain a large and 'sustainable' stock of wildlife. Under such a management scheme, the best-response function of the park manager coincides with the iso-conservation schedule representing the target stock size. Hence, the various types of ICDP transfer would simply change the best-response function of the local people, which implies reduced harvesting benefits and the same level of nuisance. We have also ignored the possibility of cooperation between the local people and the wildlife management authority, although ICDPs, in principle, are based on, and are intended to promote, cooperation. The two agents are also assumed to have full information about each other's harvesting technology and costs, which is questionable. However, these simplifications have enabled us to identify the important driving forces behind harvesting and wildlife utilization that are apparent in more complex, and hence realistic, settings.

Figures

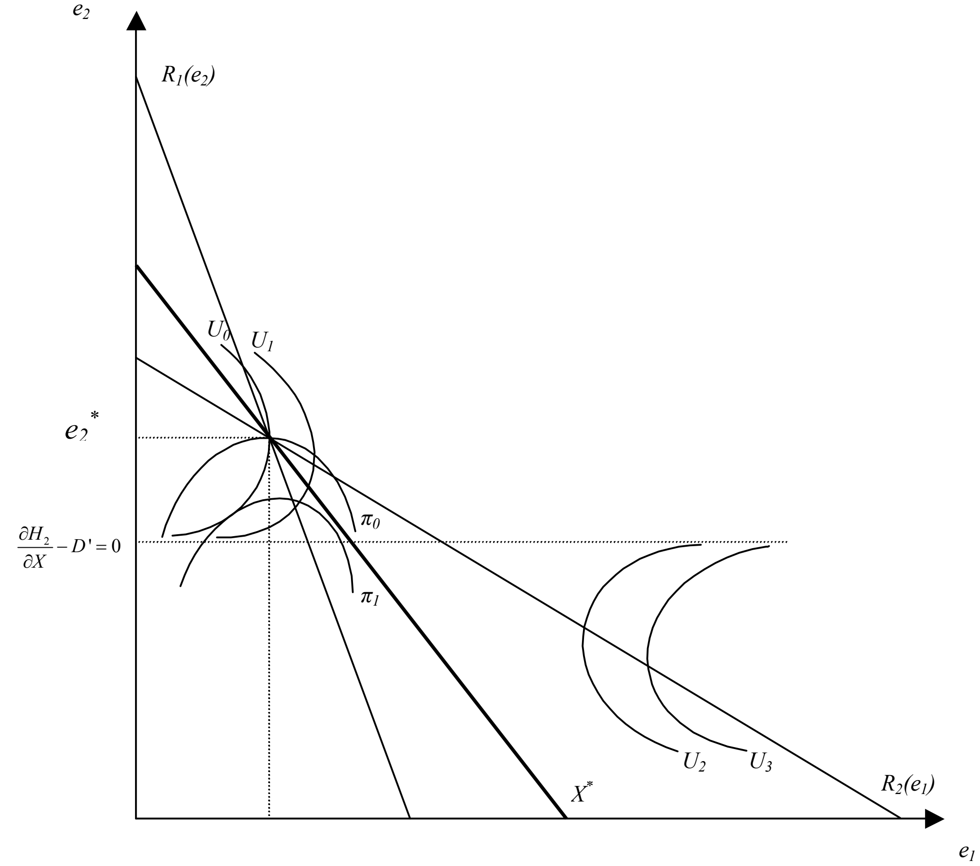

Figure 1: The pre-ICDP equilibrium.

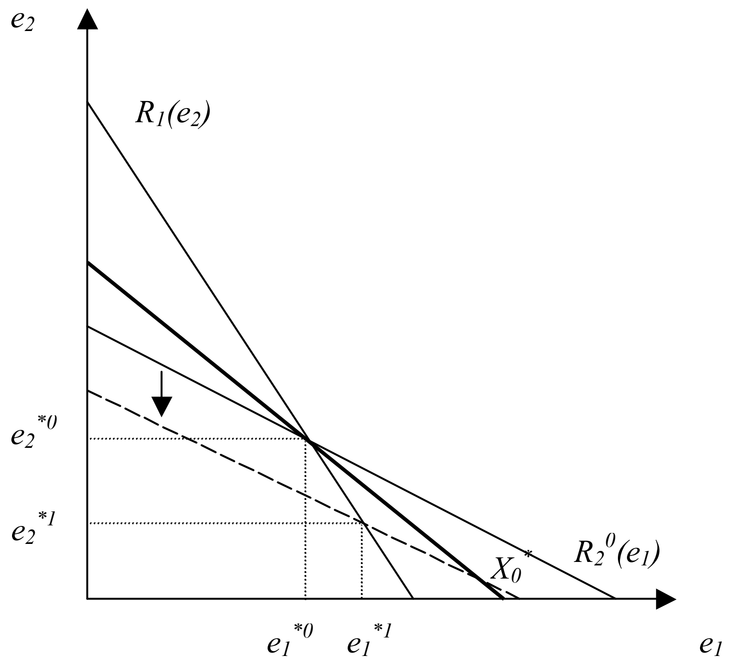

Figure 2: ICDP policy: uniform transfers, $0 < \alpha = \beta < 1$. e_i^{*0} and e_i^{*1} denote pre-ICDP and ICDP effort levels, respectively.

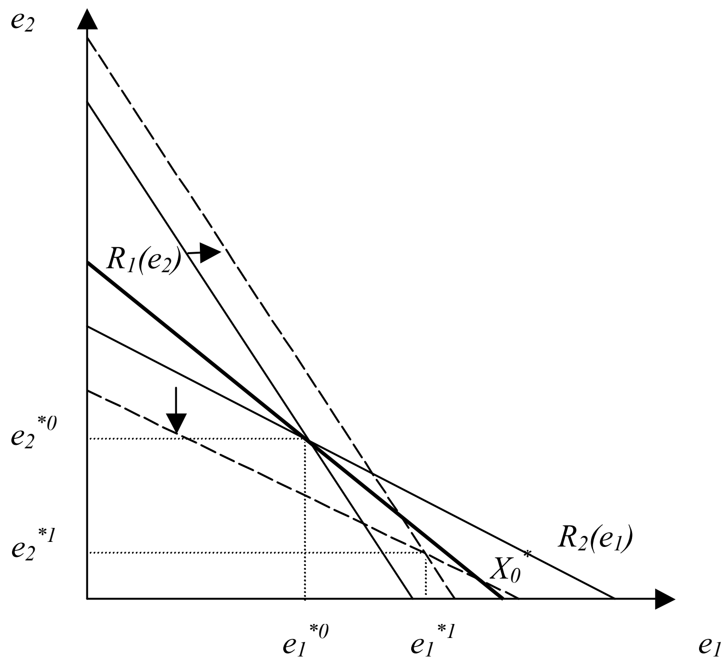

Figure 3: ICDP policy: transfers from non-consumptive tourism, $0 < \beta < 1$ and $\alpha = 0$. e_i^{*0} and e_i^{*1} denote pre-ICDP and ICDP effort levels, respectively.

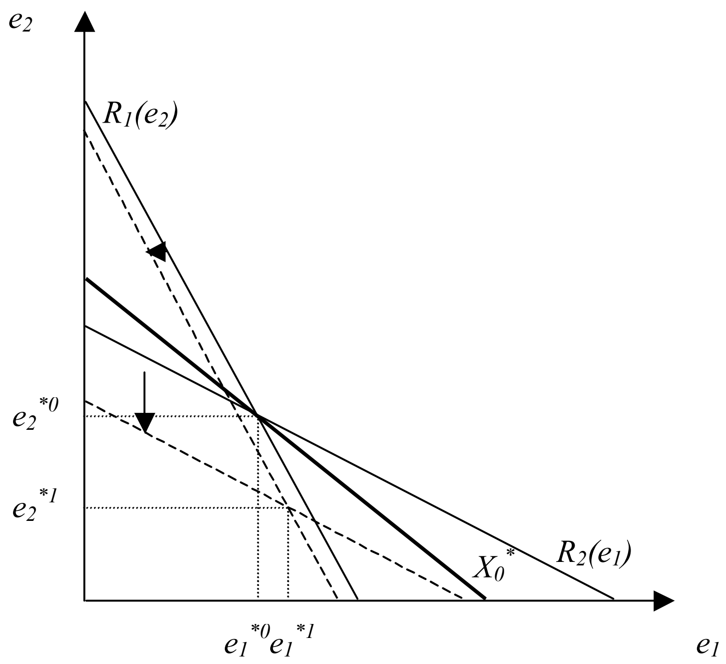

Figure 4: ICDP policy: transfers from safari hunting, $0 < \alpha < 1$ and $\beta = 0$. e_i^{*0} and e_i^{*1} denote pre-ICDP and ICDP effort levels, respectively.

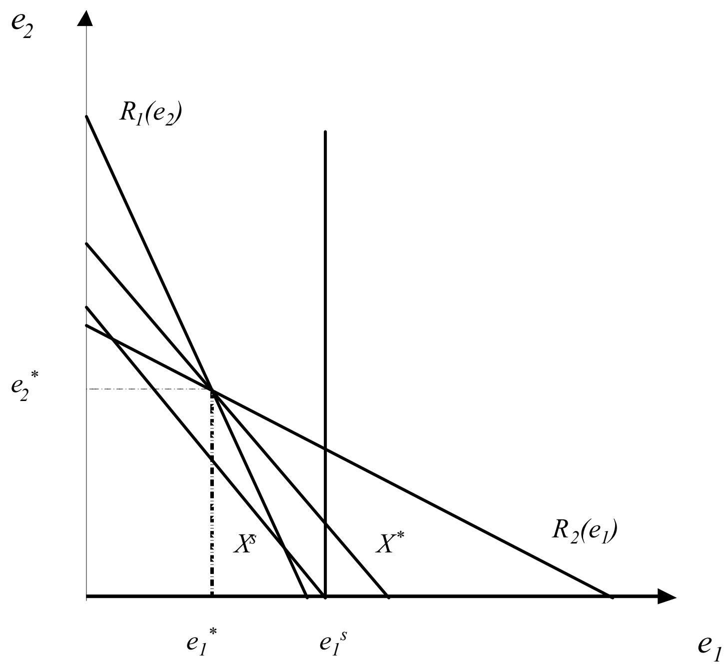

Figure 5: The social planner's solution.

Appendix

The basic model

With Schäfer harvesting functions and linear stock values (see the main text), the profit and utility functions, respectively, are as follows.

$$\pi = (p_1 q_1 X - c_1)e_1 + wX \tag{A1}$$

$$U = (p_2 q_2 X - c_2)e_2 - \gamma X \tag{A2}$$

When natural growth is specified by the logistic (see the main text), we find $rX(1 - X / K) - q_1 e_1 X - q_2 e_2 X = 0$ in ecological equilibrium. Hence $X = 0$ and the stock-effort relationship is:

$$X = K(1 - q_1 e_1 / r - q_2 e_2 / r) > 0 \tag{A3}$$

For a fixed stock level, this is also the iso-conservation line under the Gordon–Schäfer assumptions (cf. the main text).

Maximizing *(A1)* with respect to e_1, subject to *(A3)* together with a fixed e_2, yields the best-response function of the park agency:

$$e_1 = R_1(e_2) = (r / 2q_1)\left[1 - w / p_1 r - c_1 / p_1 q_1 K)\right] - \left[q_2 / 2q_1\right]e_2 . \tag{A4}$$

Maximizing *(A2)* with respect to e_2, subject to *(A3),* and a fixed e_1, yields the best-response function of the local people:

$$e_2 = R_2(e_1) = (r / 2q_2)\left[1 + \gamma / p_2 r - c_2 / p_2 q_2 K\right] - \left[q_1 / 2q_2\right]e_1 . \tag{A5}$$

Solving for effort levels and the stock level yields:

$$e_1^* = (r/3q_1)[2(1 - c_1/p_1q_1K) - (1 - c_2/p_2q_2K) - 2w/p_1r - \gamma/p_2r], \tag{A6}$$

$$e_2^* = (r/3q_2)[2(1 - c_2/p_2q_2K) - (1 - c_1/p_1q_1K) + 2\gamma/p_2r + w/p_1r], \tag{A7}$$

$$X^* = (K/3)\left[1 + (w/p_1r - \gamma/p_2r) + c_1/p_1q_1K + c_2/p_2q_2K\right]. \tag{A8}$$

Along the best-response function, the utility of the local people changes according to $dU(e_1)/de_1 = (q_1K/r)(-p_2q_2e_2 + \gamma)$ in the Gordon–Schäfer case. Minimum utility along $R_2(e_1)$ is therefore obtained when $e_2 = \gamma/p_2q_2$, which coincides with the condition $\partial H_2/\partial X - D' = 0$ in the general case (cf. the main text). The iso-utility curves have the regular shape above this effort level, while they bend in the opposite direction in the nuisance case. This can be seen from the total differential of *(A2)*, for a fixed utility level, which, after some rearrangement, is $de_2/de_1 = (q_1K/r)(p_2q_2e_2 - \gamma)/(\partial U/\partial e_2)$. The comparative static effects on effort and stock are given by equations *(A6)–(A8)*. Note the ambiguous effects of p_2 (see the main text).

Differentiating (A1) and (A2) in equilibrium and using the envelope theorem yields the profitability and utility comparative static results. The effects of a shift in, say, w are:

$$\partial\pi^*/\partial w = X^* + (p_1q_1e_1^* + w)(\partial X/\partial e_2)(\partial e_2^*/\partial w), \tag{A9}$$

$$\partial U^*/\partial w = (p_2q_2e_2 - \gamma)(\partial X/\partial e_1)(\partial e_1^*/\partial w). \tag{A10}$$

Because $(\partial X/\partial e_2)$ is negative while $(\partial e_2^*/\partial w)$ is positive, the sign of (A9) is ambiguous. However, after substituting for X^* and e_1^*, it can be shown that the expected result,

$\partial\pi^* / \partial w > 0$, holds. However, the sign of $\partial U^* / \partial w$ is indeterminate, but is negative in the nuisance case.

The ICDP solution

The profit and utility functions under the Gordon–Schäfer functional specifications are:

$$\pi = (1-\alpha)(p_1 q_1 X - c_1)e_1 + (1-\beta)wX \ , \tag{A11}$$

$$U = (p_2 q_2 X - c_2)e_2 - \gamma X + \alpha(p_1 q_1 X - c_1)e_1 + \beta wX \ . \tag{A12}$$

The best-response functions are:

$$e_1 = R_1(e_2) = (r/2q_1)\left[1-(1-\beta)w/(1-\alpha)p_1 r - c_1/p_1 q_1 K\right] - \left[q_2/2q_1\right]e_2 , \tag{A13}$$

$$e_2 = R_2(e_1) = (r/2q_2)\left[1+\gamma/p_2 r - c_2/p_2 q_2 K - \beta w/p_2 r\right] - \left[q_1(1+\alpha p_1/p_2)/2q_2\right]e_1 . \tag{A14}$$

Differentiation yields:

$$\begin{bmatrix} 1 & q_2/(2q_1) \\ q_1(1+\alpha p_1/p_2)/(2q_2) & 1 \end{bmatrix}\begin{bmatrix} de_1 \\ de_2 \end{bmatrix} = \begin{bmatrix} w/\left[2(1-\alpha)p_1 q_1\right] \\ -w/(2p_2 q_2) \end{bmatrix} d\beta + \begin{bmatrix} -\left[(1-\beta)w\right]/\left[2(1-\alpha)^2 p_1 q_1\right] \\ -p_1 q_1 e_1/(2p_2 q_2) \end{bmatrix} d\alpha . \tag{A15}$$

The determinant of this system is $(1/4)\left[3-\alpha p_1/p_2\right]$, which is assumed to be positive. This implies that $R_1(e_2)$ is more negatively sloped than $R_2(e_1)$. For $p_1 > p_2$ (see the main text), there must be an upper limit on α.

We demonstrate the profitability and utility effects in the uniform transfers case, in which $0 < \alpha = \beta \leq 1$. Setting $\alpha = \beta = \sigma$ and differentiating *(A11)* and *(A12)* with respect to σ, and using the envelope theorem, yields:

$$\partial \pi^* / \partial \sigma = -(p_1 q_1 e_1 X^* - c_1 e_1^* + wX^*) - (p_1 q_1 e_1^* + w)(K / r) q_2 (\partial e_2^* / \partial \sigma), \qquad (A16)$$

$$\partial U^* / \partial \sigma = (p_1 q_1 e_1^* X^* - c_1 e_1^* + wX^*) - (p_2 q_2 e_2^* - \gamma)(K / r) q_1 (\partial e_1^* / \partial \sigma). \qquad (A17)$$

Inserting $\alpha = \beta = \sigma$ into equation *(A15)* and solving for $\partial e_2^* / \partial \sigma$ gives:

$$\partial e_2^* / \partial \sigma = -2(p_1 q_1 e_2 + w) / \left[p_2 q_2 (3 - \sigma p_1 / p_2) \right] < 0. \qquad (A18)$$

Hence, from *(A17)*, it is clear that the sign of $\partial U^* / \partial \sigma$ is ambiguous and depends on the sign of $(p_2 q_2 e_2 - \gamma)$ (see also the main text). Combining *(A16)* and *(A18)* reveals that the sign of $\partial \pi^* / \partial \sigma$ is also ambiguous.

The social planner's solution

Substituting the Gordon–Schäfer functional forms into equations *(11)* and *(12)* of the main text yields the first-order conditions:

$$\partial(\pi + U) / \partial e_1 = (K / r)\left\{-2 p_1 q_1^2 e_1 - (p_1 + p_2) q_1 q_2 e_2 + p_1 q_1 r - c_1 r / K - (w - \gamma) q_1\right\} \leq 0, \qquad (A19)$$

$$\partial(\pi + U) / \partial e_2 = (K / r)\left\{-2 p_2 q_2^2 e_2 - (p_1 + p_2) q_1 q_2 e_1 + p_2 q_2 r - c_2 r / K - (w - \gamma) q_2\right\} \leq 0. \qquad (A20)$$

The second-order conditions are $\partial^2 (\pi + U) / \partial e_i^2 < 0$ $(i = 1, 2)$ and $\left[\partial^2 (\pi + U) / \partial e_1^2\right]\left[\partial^2 (\pi + U) / \partial e_2^2\right] - \left[\partial^2 (\pi + U) / \partial e_1 \partial e_2\right]^2 > 0$. The first of these conditions holds unambiguously, while the second one is violated since it implies $(p_1 - p_2)^2 < 0$, which is impossible, after rearrangement. We then have three possible corner solutions (see also the main text). We consider the first possibility (i). With $e_1^s > 0$ and $e_2^s = 0$, equation *(A19)* holds as an equality, while equation *(A20)* holds as an inequality. Solving *(A20)* with respect to e_1^s yields:

$$e_1^s = (r/2q_1)[1 - c_1/p_1q_1K - (w-\gamma)/p_1r]. \tag{A21}$$

Substituting for e_1^s in *(A20)* (as an inequality) yields $[r - c_1r/p_1q_1K - (w-\gamma)/p_1](p_1 + p_2)/2p_2 > [r - c_2r/p_2q_2K - (w-\gamma)/p_2]$, which holds if the price, cost and productivity conditions are favourable for the park manager. The resulting stock level is:

$$X^s = (K/2)\left[1 + c_1/(p_1q_1K) + (w-\gamma)/p_1r\right]. \tag{A22}$$

Substituting *(A21)*, *(A22)* and $e_2^s = 0$ into *(10)* yields the following overall net benefit, after some rearrangement:

$$\pi^s + U^s = (p_1rK/4)\left[1 - c_1/p_1q_1K + (w-\gamma)/p_1r\right]^2 + (c_1/p_1r)(w-\gamma). \tag{A23}$$

In case (iii), with no profitable harvesting, in which case, $e_1^s = 0$ and $e_2^s = 0$, the overall net benefit is $\pi^s + U^s = (w-\gamma)K$. This may be below or above the level implied by positive harvesting by one of the agents. It can be shown that not exploiting the stock is the best option if harvesting values are low when the net stock value, $(w-\gamma) > 0$, is substantial, which is intuitive. Otherwise, harvesting is profitable from the social planner's point of view, and in the main text, it was assumed that the park manager harvested. The difference between the stock level in this case, given by *(A22)*, and the level under the pre-ICDP market solution, given by equation *(A8)*, is as follows:

$$X^s - X^* = (K/6)\left\{\left[1 + c_1 r / p_1 q_1 K - 2c_2 / p_2 q_2 K + \left[w - \gamma(3 - 2p_1 / p_2)\right]/(p_1 r)\right]\right\}. \qquad (A24)$$

From this expression, it is clear that if w is high, γ is small, and p_1 and c_2 are not too high, the stock level in the social planner's solution exceeds that implied by the pre-ICDP solution.

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Tables

Table 1: Comparative-static results in the pre-ICDP solution

	e_1^*	e_2^*	X^*	π^*	U^*
p_1	+	–	–	+	?
w	–	+	+	+	?
γ	–	+	–	–	–
p_2	–	+/–	–/+	–/+	?
c_1	–	+	+	–	?
c_2	+	–	+	+	?
r	?	?	?	?	?
K	?	?	?	?	?

Note: A +/– implies that a reduction in e_2^* (–) is accompanied by a higher X^* (+), and vice versa. A ? implies that the sign is ambiguous.