Elephants or Onions?

Paying for Nature in Amboseli, Kenya

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Abstract: Traditional grazing grounds near Amboseli National Park (Kenya) are rapidly converted to cropland – a process that closes important wildlife corridors. We explore the scope for introducing a "payments for ecosystem services" scheme to compensate pastoralists for spillover benefits associated with forms of land use that are compatible with wildlife conservation. Our results indicate that such a scheme likely enhances global welfare, but that leakage or slippage effects through excessive stocking rates warrant close scrutiny.

Keywords: paying for ecosystem services, PES, Maasai, elephant conservation, habitat conversion.

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1. Introduction

Ecosystems provide a plethora of services to human communities, and these services benefit people at a wide range of scales – varying from local to national and even global scale (MEA 2005). It is well known that, unless compensation takes place for ecosystem services spilling over to areas beyond their source, such services will likely be ignored by local "suppliers." The result is that too little of these services are provided, relative to the desires of the regional, national or global community – an *inefficient* outcome from an economic perspective. *Equity* concerns are relevant as well. Most of the remaining biodiversity is found in developing countries, and 1) because biodiversity helps provide ecosystem services to humans (MEA 2005), and 2) international flows of ecosystem services are not matched by (monetary) transfers flowing in an opposite direction, this implies effectively that the poorer countries are subsidizing rich countries.

The leading approach to biodiversity conservation is to create protected areas (Brandon et al. 1998; Margules and Pressey 2000; Adams et al. 2004). Protected area systems involve top-down command-and-control measures, including fencing off specific areas to restrict their use. While recent research suggests that protected areas can be effective in some cases (Bruner et al. 2001), many developing country experiences have been disappointing (Brandon et al. 1998, Adams and Hulme 2001, Western 2001). The difficulties with protected areas include: (i) their size – often parks are too small to sustain a full range of services; (ii) inadequate administrative and management capacity; (iii) limited resources for monitoring and enforcement; and (iv) denying access to local communities, especially the poor who may depend directly on the restricted ecosystem for survival. When rights and access to ecosystem services shift in ways that adversely impact local communities, poor households have little incentive to maintain or use ecosystems in a sustainable way (Barbier 1992, Tisdell 1995; Damania et al. 2003).

The limitations of protected area approaches led to efforts aimed at aligning the interests of the poor with conservation objectives through community-based resource management programs.[1] This participatory-style conservation approach, mostly driven by external donor financial encouragement, seeks to provide local communities with incentives to protect crucial ecosystems through sharing products, responsibilities and decision-making authority. However, evaluations and studies continue to raise important concerns about the appropriateness of community-based conservation efforts, arguing that positive and lasting success is elusive when development projects combine biodiversity conservation goals with poverty reduction goals (Simpson 1995, Murombedzi 1999, Hulme et al. 2001).

Other studies question the assumptions linking local communities and sustainable resource use across diverse geographic conditions and economic situations (Barrett and Arcese 1995, 1998). An analysis of community based natural resource management in Kenya concludes that it did *not*: (i) result in more equitable distribution of economic benefits; (ii) reduce conflicts; (iii) consider traditional Maasai grazing and wildlife

[1] The importance of integrating local communities into protected-area planning dates back to at least the 1982 World Parks Congress (Adams et al 2004).

movement knowledge; (iv) improve biological diversity protection; nor, (v) improve sustainable resource use (Kellert et al. 2000). The Kenya case focused on the Kimana Community Wildlife Sanctuary, an important ecological habitat severing as a wildlife corridor between two protected areas Amboseli and Tsavo. The study region of this paper encompasses the Kimana wildlife corridor.

More recently, a variety of compensation and market-related policies have gained prominence to encourage ecosystem and land managers to change behaviour. While direct financial and market incentive schemes, commonly referred to as direct payments for ecosystem services (PES), now exist in many developed countries – e.g., within the European Union there are elaborate payment schemes for the conservation of waders (meadow birds) – experiences in developing countries are limited (Landell-Mills and Porras 2002, Wunder 2005). The idea is that conservation can be promoted directly through PES in a way that is potentially beneficial for the poor as well (Pagiola et al. 2005).

To date, PES activities in developing countries most often address watershed issues where feedback loops are "tight" and where suppliers and demanders are easy to identify (e.g., Pagiola et al. 2003). Less work has been done on payments for global values, especially those *other* than carbon. This is unfortunate because such values may be large, and tapping into them could have far-reaching implications for conservation and development agendas alike.

In this paper, we explore the opportunity to establish an international payment system for non-use values – or cultural values, in the parlance of the Millennium Ecosystem Assessment – associated with wildlife (elephant) conservation near Kenya's Amboseli National Park (NP). Under current trends the long-term future of the Amboseli ecosystem (and its icon – the elephant) looks rather bleak.[2] The objective of this paper is twofold. First, we explore whether efforts to promote elephant conservation near Amboseli NP through a PES scheme represent a viable economic proposition, or not. That is; we aim to provide a rough indication of the social benefits and costs involved, and establish whether the increase in welfare from "more elephants" outweigh the costs associated with implementation of a PES scheme? The outcome of such a comparison may be used to decide whether strategies should be implemented that provide incentives for local households to sustainably manage their rangelands and share this habitat with wildlife. The second, and closely related objective, is to predict how a PES scheme affects conservation (the so-called *additionality* issue) and welfare of the Maasai. To

[2] In addition to the issue of land conversion discussed in this paper, the future of the Amboseli ecosystem may be compromised by the following three factors: (i) the upper forest line on Mount Kilimanjaro shifts down due to an increased frequency and intensity of forest fires, which may have severe repercussions for local climatic and hydrological conditions (for a discussion of the importance of this issue vis-à-vis the more conspicuous issue of the disappearing glacier, see Hemp 2005); (ii) there is a push in the group ranches to sub-divide the communally owned grazing grounds into private plots, which would adversely affect the capacity of the system to support grazing (Boone et al. 2005); and (iii) recently the government of Kenya announced that it would degazette the area from National Park to Game Reserve, and that management would be relegated from the Kenya Wildlife Service (KWS) to the district Maasai Council. An integrated, international conservation effort would presumably need to tackle these challenges in tandem. The current study provides a first step.

address the second question one would ideally use a household model, but as a fully calibrated Maasai model is not available, we resort to an approximation instead.

The study results are being used to develop a PES project, coordinated by the United Nations Food and Agricultural Organization. The outcomes of the proposed project are threefold: (i) ecosystem-wide management and the development of organizational structures for effective participation and coordination in natural resource management decision-making; (ii) significant increases in wildlife corridors, dispersal areas and habitats through established biodiversity services payments at appropriate sites throughout the ecosystem; and (iii) improved poverty alleviation and household food security outcomes.

The paper is organized as follows. Section 2 provides a brief profile of the Amboseli ecosystem. In section 3, we sketch the bare bones of the SAVANNA and PHEWS models that are used to simulate the impacts, in terms of changes in land use, income and elephant abundance, from a PES system. Section 4 presents the simulation results as well as a rudimentary social cost-benefit analysis. Section 5 concludes.

2. The Amboseli Ecosystem

The Amboseli ecosystem, an area of some 8,000 km^2, comprises part of the Ilkisongo region of southeastern Kajiado District in Kenya and the Longido region of northern Tanzania. Amboseli is typical of African arid rangelands, rainfall is low and unpredictable in time and space. At the heart of the ecosystem is Amboseli NP, the core of a UNESCO Man and the Biosphere Reserve protecting 392 km^2 (about 5%) of the wildlife dispersal area. Amboseli's swamps are fed by subsurface water that percolates though volcanic rock from the forested catchment of Kilimanjaro rising spectacularly to the south. Nearly four decades of ecological monitoring and research, as well as two of the world's longest studies of elephants and primates have brought Amboseli international scientific and conservation recognition (FAO 2005).

Amboseli NP is fundamental to Kenya's tourist industry, typically ranking second among parks in annual park gate fees – around USD 3.5 million in 2004. In the past, the absence of wide-scale intensive agriculture and the relatively low population density encouraged and provided refuge to a magnificent array of biodiversity, including large and small mammals, birds, reptiles, insects and plants, some of which are rare or threatened. Birdlife International has named Amboseli one of the world's Important Bird Areas.

At present, market, policy and institutional incentives interact in ways that weaken the region's ecological integrity, endanger the wildlife tourism industry and threaten the long-term viability of rural households. Wildlife habitats are diminishing, migration corridors are narrowing, water resources are being degraded, livestock-wildlife competition is worsening, income inequality is increasing; and human-wildlife conflicts are mounting (Campbell et al. 2000, Reid et al 2004, FAO 2005). Human-human

conflicts are increasing too, as the interests of local communities, park managers and wildlife tourism providers increasingly clash (Hoare 1999, and Campbell et al. 2003).

The Amboseli ecosystem is home to Maasai pastoralists, whose long-practiced livestock activities are well adapted to the variable habitat, and whose land use decisions are a key driver of wildlife abundance in and around the park. However, the majority of Maasai households receive virtually no direct benefits from the wildlife tourism industry. The cash benefits are not distributed fairly nor equally to the landowners (Kellert 2000, Mburu 2003). And the indirect benefits, in the form of reduced school fees, irrigation infrastructure maintenance, livestock sales yards, and other related community goods, often fail to benefit those in most need.[3] The Maasai do bear the costs of managing wildlife habitats, including personal safety, grazing competition, investments to minimize risks, management costs, damage to crops (from eating and trampling), and damage to livestock through the spread of diseases and killing (Norton-Griffiths and Southey 1995, Campbell et al. 2002).

In contrast, the Maasai do receive direct benefits from renting out their land. It is no surprise, therefore, that they have increasingly rented out large areas for irrigated or rain-fed agriculture during the past decade. During the past twenty years, the adjacent areas to the south and east of Amboseli NP (Loitokitok Division) human populations have more than tripled, rain-fed agricultural areas expanded by 3.5 times, and irrigated area increased by 18 times, from around 250 ha to 4800 ha. (Campbell et al. 2003).

Some of the irrigated land was fenced during the late 1990s to protect onions and tomatoes from wildlife, and increasingly those protected croplands impede access to water, food, breeding grounds and to the seasonal migration of wildlife up and down the slopes of Mount Kilimanjaro, and between Amboseli and other protected areas like Tsavo NP.[4] Wildlife populations that had access to all of Amboseli's swamps until the 1970s, now have no access to one swamp and only partial access to three others (Reid et al. 2004). While cropping may be *privately* rational (the returns of cultivation dominate the private returns of wildlife management), it is an open question whether it is also socially beneficial – i.e. what happens when we include eco-services benefiting people outside the Amboseli system in the picture?

Wild elephants are greatly valued by tourists and the global community at large – both groups mainly consist of residents in the North. Yet, it is the impoverished and remote communities of Africa (and Asia) that bear the costs and depredations associated with their conservation. Half the population living in the Amboseli ecosystem is below the poverty line (Kenya Economic Survey 2005), and the United Nations Famine Early

[3] The Maasai communities surrounding the Park are themselves divided about the benefits they obtain from the park (in the form of revenue sharing and job opportunities), and are frustrated that certain beneficial policies that were promised have never been implemented, such as water boreholes outside Amboseli NP. Factions within these communities are dissatisfied with the benefits they obtain, and threaten to intensify pressure on key natural resources in the Park (mainly forage and water) unless they will receive a larger share of the Park's proceeds.

[4] In addition, albeit somewhat beside the main point of this paper, there is evidence that agricultural use of the former grazing grounds is not sustainable because of water pollution, agrochemical use and soil runoff.

Warning System frequently identifies the region. Ultimately these communities are also the main drivers of changes in local land use. Because wildlife in many protected areas, including Amboseli, depend on access to (food) resources found on private lands, the success of conservation efforts – elephants or onions? – is determined by the balance between benefits and costs as perceived by these private agents.

3. The Model

The majority of elephants and the other migrating species cannot survive without Amboseli's larger ecosystem, migrating seasonally between the Park and its surroundings. The future of much of Amboseli's wildlife lies in the hands of the people surrounding the Park. Six communally owned group ranches surround the Park. The predominant form of land use has been livestock raising, an activity that is compatible with wildlife conservation. While livestock and wild herbivores may compete for forage, and predators may occasionally kill livestock, historical grazing systems and population pressures seemed to be sustainable and allowed for the co-existence of domesticated and wild animals.

3.1 The SAVANNA MODEL

To address management and policy questions relevant to wildlife and livestock requires an integrated approach (Coughenour et al. 2002). We built upon an integrated assessment of southern Kajiado District (Boone et al. 2005; Thornton et al. 2005) that uses a process-based, spatially explicit ecosystem model called SAVANNA. SAVANNA has been applied at sites throughout the semi-arid areas of the world, but was first developed within Turkana District, Kenya (Coughenour 1985). Many subsequent improvements and applications have been described (e.g., Coughenour 1992; Buckley et al. 1993; Boone et al. 2002; Boone et al. 2004, Thornton et al. 2004; Boone 2005; Boone et al. 2005; Thornton et al. 2005; reviewed in Ellis and Coughenour 1998). A schematic outline of the model is provided in Figure 1.

<< Insert Figure 1 about here >>

SAVANNA is a series of FORTRAN computer programs that join to model primary ecosystem interactions, simulating functional groups for plants and animals (e.g., perennial and annual grasses, cattle, grazing antelopes) over periods from 10 to 100 or more years (Ellis and Coughenour 1998). The model represents landscapes by dividing them into a system of square cells, and uses a series of digital maps (GIS maps) to characterize each cell. The model predicts water and nitrogen availability to plants using rainfall and soil properties, for each cell in the map. Based upon water, light, and nutrient availability, quantities of photosynthate are calculated for each of the plant functional groups. Photosynthate is distributed to the plant parts based on established allometrics, yielding estimates of primary production. Plant populations are calculated from investments in reproductive parts.

A habitat suitability index is calculated for each cell, at weekly intervals and for each animal functional group, based upon forage quality and quantity, slope, elevation, cover, and the density of herbivores. Herbivores are distributed on the landscape based

upon these indices. Importantly for this study, where we are interested in the system's response to the presence or absence of fenced-in cropland, maps may be used to modify the distribution of herbivores. Animals will feed upon the available vegetation, depending upon dietary preferences and consumption rates. The energy gained is reduced by energy costs associated with basal metabolism, gestation, and lactation. Net energy remaining goes toward weight gain, with weights reflected in condition indices. Charts and maps are produced at monthly intervals (e.g., Boone et al. 2002).

Seven plant functional groups are captured in the case study's SAVANNA model: palatable grasses, palatable forbs, unpalatable grasses and forbs, papyrus (*Cyperus papyrus*) swamps, palatable shrubs, unpalatable shrubs, and deciduous woodlands. Nine animal groups were modeled: three livestock species (cattle, goats and sheep), and six wildlife groups (wildebeest, *Connochaetes taurinus*, zebra, *Equus burchellii*, African buffalo, *Syncerus caffer*, grazing antelope, browsing antelope, and elephants). See Boone et al. (2005) for species comprising grazing and browsing antelope groups. A variety of data sources were used to parameterize the application for southern Kajiado District, described in Boone et al. (2005), including examples of literature used. The ecosystem model was calibrated using sources such as an net primary production database (Kinyamario 1996), satellite imagery, which relates well to regional stocking levels (Oesterheld et al. 1998), and information from important literature sources (e.g., Bekure et al. 1990; De Leeuw et al. 1998).

3.2 The PHEWS Model

In an ideal world the SAVANNA model would be linked to a process-based, detailed and fully calibrated household model that captured the myriad of response Maasai may have to changing circumstances. Such a model would combine the preferences of the Maasai with respect to goods and services they consume (including their utility from leisure) with a set of constraints – a budget constraint, time constraint, production possibilities, etc. However, such a model is not available for the study area. Instead, we use an approximation of such a model, calibrated for pastoral households in East Africa, called PHEWS (Pastoral Household Economic Welfare Simulator – see Thornton et al. 2003 for details).

PHEWS is not a conventional utility maximizing model, but instead is based on a set of rules that households follow when trying to secure caloric intake. It is well known that rainfall and income from herding are highly volatile in this part of the world. PHEWS keeps track of dietary energy flows and prescribes a certain series of actions when intake falls short of a desired level. In addition to a target caloric intake, the pastoral households also have specific target levels for their livestock – preferred numbers of heads for goat and cattle stocks. Pastoralists are assumed to use livestock as a buffer in periods when household income and consumption are low, and invest in livestock (if the stock is below the target level) when income is high and caloric requirements are easily satisfied. Remaining funds are placed in a so-called "cash box" where it is stored for future use when income is low (Thornton et al. 2006).

When caloric intake from consumption of animal products, maize and sugar is insufficient to meet the threshold, the household tries to use its "cash box" (if available) to make up for the deficit. If this fails it sells a goat or cow. If all fails, the model assumes that there will be outside relief from some exogenous source. For this reason the model is not particularly useful for capturing Malthusian population dynamics, say, and we simply assume that the human population is constant.[5]

3.3 Three scenarios

We distinguish between three different scenarios, which are compared to highlight effects of different management practices. In control scenario A we consider the base case where parts of the group ranches that surround the park are converted to fenced in cropland (but note that we assume that the fenced in areas were used for cropping throughout the entire study period – from 1977 to 2000 – and that in reality fencing only started in the 1990s). We use historical rainfall patterns to simulate livestock and wildlife abundance over time and space. In the pastoral scenario B we explore the case where the fenced in area is returned to grazing ground and accessible for wildlife and livestock alike. One may think of this as a command-and-control approach to conservation, simply banning the use of fences. We simulate the impact on wildlife and livestock, but also on Maasai income. Finally, in PES scenario C we consider what happens if we compensate the Maasai for restoring the grazing grounds. That is, in return for giving up the privately profitable option to rent out land to onion growers, the Maasai are assumed to engage in an easement deal with a funding agency that offers a competitive rate of return on the land. Compared to scenario B the Maasai budget constraint is therefore relaxed, which means that households are better able to meet their target consumption and livestock levels.[6]

This approach involves comparisons between simulations where the only attributes changed were areas available for grazing and payments to Maasai. The model was parameterized to agree with current conditions to the degree possible, but the approach is not predicated on responses being absolutely correct, but rather on comparisons between simulations that are otherwise parameterized identically. Our results are not intended to provide precise predictions about how the elephant population may change in the future; too many unforeseen circumstances may affect the trajectory. Rather, we provide examples of tradeoffs associated with PES systems, and identify the direction and magnitudes of change in wild and domestic ungulates, and in Maasai well-being.

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[5] In reality of course the population is not constant. It may change because of natural population growth and mortality, but also because of migration patterns. It is possible that both replenishment and migration react endogenously to implementation of a PES scheme. While we ignore this in the analysis, this is somewhat that should be considered when actually transferring money.

[6] In reality a fourth scenario is being discussed: the case where fences are not removed but where agriculture *outside* the fences is controlled to enable a free flow of animals between areas. In theory we could readily analyse this case, but the resolution of the current model is too coarse to yield reliable results. The scenarios considered in this paper are more dramatic cases, sharply illustrating the main tradeoffs.

4. Simulation results and CBA

In this section we present the simulation results of the three scenarios, and we use these results as input in a cost benefit analysis. We try to address the question whether a PES scheme for elephant conservation is welfare enhancing at the global scale, or not. We also use the output to discuss the form that transfers from conservationists to pastoral households may take.

4.1 Returning cropland to range land

Figure 2 summarizes the impact of returning the fenced-in cropland to grazing grounds on elephant abundance. The dashed upper line reflects elephant abundance in scenario B (no fences) and the solid lower line reflects the number of elephants in control scenario A. The figure also shows the historical pattern of rainfall in the study area (light dashed line).

Not surprisingly, expanding elephant habitat translates into a larger number of elephants. However, during the first 15 years of the simulation exercise the impact is very modest – typically in the range of only 100 to 300 extra elephants per year, or a modest 15% increase in abundance. It appears as if the PES scheme is hardly worthwhile. But the situation abruptly changes after 1992, when stocking rates are rather high and a serious drought hits the area. The elephant population in the control scenario collapses to about 50% of its pre-drought level of abundance while the elephant population in the pastoral scenario increases. Considering the entire study period from 1977-2000, the *average* number of elephants in the pastoral scenario is about 500 head larger than in the control scenario. But averages tell only part of the story: the main benefit from removing fences is that the elephant population is much more resilient to changes in (environmental) conditions when it has access to a wider set of base resources.

The interpretation of these results is as follows. In times of sufficient rainfall, the swamp areas converted to cropland do not represent a key resource for elephants. Opening up these areas implies they have access to more food, so we observe a modest increase in the population. However, the picture changes in times of drought, when access to the swamps for food and water becomes necessary to support the elephants. If this access is denied, water and food become critical factors and the population crashes.

The elephant population in pastoral scenario B increases amidst the drought of the mid 1990s because it faces less competition from livestock. Faced with a drought, the Maasai have no option but to sell part of their large stock to support their families, to buy grain and more drought-resistant small stock. The loss of milk from the large stock demands more large animal sales, which in turn means less milk, etc., in the downward spiral seen here and sometimes seen in Maasai communities. In the simulation goats came to dominate herd composition. This represents a fundamental tradeoff of the command-and-control option to conservation: if it is effective at promoting elephant conservation by restricting the Maasai's use rights of the swamps, the costs of this "success" are borne entirely by the Maasai who see their herds shrink and income position deteriorate. Since most of the non-use values associated with conservation are transboundary, this is clearly unfair.

4.2 The effect of paying for ecosystem services

Figure 3 summarizes the consequences of establishing a PES system, where the Maasai lease their cropland to a conservation agency (as opposed to onion farmers), and where the restored grazing grounds and swamps are available for livestock and wildlife. The upper solid line represents the elephant population when a PES system is in place – the scenario C – and the lower dashed solid line, again, depicts pastoral scenario B discussed above, where fences have been removed but where no compensation takes place.

The first thing to notice is that a fair transfer to the Maasai did not compromise elephant conservation – the opposite is true. Key resource areas and other rangelands remained available because of the PES agreements limiting cultivation. Elephant numbers exceeded those when the entire area is pastoral because the transfer enabled the Maasai to support a livestock herd that was close to the preferred size and composition. While increasing livestock herd size is detrimental for conservation – livestock and wildlife compete for base resources – the same is not true for the changes in composition brought about by the PES system. Specifically, cattle diets overlap less with elephants than do goat diets. The PES system enabled the Maasai to gradually expand their cattle stock (towards a herd that exceeds the herd under pure pastoralism by some 4.000 heads, or an increase of some 25% relative to the pastoral scenario B), and move away from goats. In the final periods of the simulation exercise, the goat herd under scenario C is some 10.000 head smaller than in pastoral scenario B (representing a 33% reduction). Because goats and elephants have overlapping diets – they compete to some degree for food – this change in the composition induced by a relaxed budget constraint favored elephants.[7]

The main insight is that poverty alleviation and conservation may go hand-in-hand. Implementation of a PES scheme will both make the Maasai better off (in our specification: they are fully compensated for the foregone returns from leasing out their land, and as a bonus they can use the restored grazing grounds for their own livestock), and will enhance and stabilize elephant populations. The lack of a tradeoff follows from ecological interactions between species – a feature that is perhaps easily overlooked by economists. Capturing such interactions implies developing multi-disciplinary models such as the one advanced here.

4.3 First attempt at a (partial) cost-benefit analysis

The observation that the PES scheme makes elephants and Maasai better off does not necessarily imply that it is welfare enhancing, because there are costs to consider as well. How do the costs and benefits compare? A full cost-benefit analysis may account for the distributional consequences (giving extra weight to income of the Maasai) and should account for transaction costs, etc. In this partial cost-benefit analysis we ignore these issues and focus instead on a more narrow question: does the conservation value created by the PES exceed or fall short of the opportunity costs of conservation – the foregone returns to cultivating onions, proxied by the rental payments to Maasai?

[7] By the same token: Note that the change in livestock composition from goats to cattle will adversely impact grazing species of wildlife that compete for food with cows.

Upon comparing control scenario A with PES scenario C, the PES scheme produces benefits of some additional 600-700 elephants per year (average value). How much does the international community value the conservation of some 650 elephants? Answering this question is not easy. First off, we would be interested in marginal values and this information is not available to our knowledge. Second, the appreciation of elephants is income and location specific: elephants are likely a normal good (or perhaps even a luxury good) in the sense that demand for them increases with income. And geography matters because elephants are a real threat to the safety of people who live with them (41% of villagers polled in Cameroon wanted elephants removed or fenced in, and a significant minority wanted them shot – see WWF 2000). When considering the non-use value of charismatic species like elephants it is not obvious which reference population should be included in the aggregation exercise.

Because of the uncertainties that inevitably surround point estimates of the value of elephants we turn the question around: focus on the costs first, and then argue whether it is plausible that aggregate values are sufficiently large to overcome these costs or not. Needless to say we have a fairly decent handle on the (opportunity) costs of the PES scheme. Based on observations in the field we use a payment of KES 10,000 per acre per year (about $10), so multiplying the fee by the relevant area of cropland yields a total cost of $112,500 per year. Assuming constant marginal cost, this translates into a cost of some $175 per elephant per year (divide by 650).

Assuming that the marginal value of elephant conservation is constant (a strong assumption), a prerequisite for the PES scheme to be globally welfare enhancing is that households in Europe and the United States are willing to pay $0.60 per year for African elephant conservation.[8] Of course it is an open question whether households are indeed willing to pay such amounts, but evidence gleaned from contingent valuation studies into the willingness to pay for other species (for an overview, see Loomis and White 1996) suggests that this number is not excessive. One specific study aimed at valuing Asian elephants (in Sri Lanka) also produced an estimate of WTP amongst the people of Sri Lanka that would have been sufficiently high – some $12 per household per year (Bandara and Tisdell 2005). We conclude that a PES effort for the Amboseli region is likely to make good economic sense.

4.4 Exploring leakage

In this section we explore how robust these results are with respect to alternative specifications of Maasai behavior. The PHEWS model is based on the assumption that pastoralists use PES funds to re-balance the composition of their livestock herd (purchasing extra cattle at the expense of goats and sheep), and store some of the money in their cash box for future use. What happens if, instead, *all* the new funds are used to purchase additional livestock in the *same* proportion as current livestock holdings? We have used SAVANNA to explore this issue.

[8] The calculation is as follows. Current estimates of the African elephant population amount to some 500.000 head (Blanc et al. 2003). Assuming a minimum benchmark cost of $175 per elephant per year, the total benefits of elephant conservation should amount to $\$87.5\times10^6$ per year. Dividing by the number of households (150×10^6) this amounts to $0.60 per household per year.

Representative results are provided in Figure 4, depicting wildlife populations for three different scenarios: (i) PES payments going to households (solid line), which is just scenario C based on the PHEWS model, (ii) PES based on the assumption that all money is immediately converted into livestock (dashed line), and (iii) the control scenario A above (open line). The curves for scenario's A and C are different than the ones depicted in Figures 2 and 3 because they are based on an aggregate measure of wildlife – they contain, but are not limited to, elephant abundance. Two results follow from Figure 4. First, it is clear (and unsurprising) that the conservation effects of PES are attenuated when the Maasai convert all payments into livestock – the dashed curve is below the solid curve. Livestock demand for forage exceeds the carrying capacity by some 20%, and overgrazing and competition for food forces the wildlife population down. In particular smaller-bodied herbivores showed such compensatory changes in abundance in response to a rapid increase in livestock stocking (elephants are less sensitive).

Second, and more interestingly, upon comparing the new scenario where PES payments are used to buy livestock to the control scenario without PES it is evident that it is difficult to unambiguously rank the scenarios in terms of conservation effects. There are periods where the wildlife populations with PES are smaller than those occurring in the control case with farming and fences. Throughout the 1990s this situation reverses, and the conservation effects of PES are positive. The reason for the ambiguity is that PES pushes both the extensive and intensive margin of herding. The extensive margin is pushed out as more rangeland is made available, but the intensive margin shifts simultaneously as Maasai increase their stocking rates. The net effect on the availability of food for wildlife is ambiguous, but will be determined by the *relative price* of livestock. If this price is high (relative to the PES payment) pastoralists respond by modestly increasing their stocking rates, and the extensive margin effect dominates. However, as the livestock price becomes sufficiently low (or as the payments translates into a sufficiently large number of new livestock heads), the gains from extra rangeland are dissipated through the losses from extra competition for food. In the absence of information on relative prices (context-specific) and a better understanding of the pastoralists' objective function it is hard to predict the outcome of PES systems. This is an area worthy of more research.

5. Discussion and conclusion

In this paper we explored the opportunities for implementing a payment for ecosystem services (PES) scheme on Maasai group ranches near Amboseli NP. Wildlife migrates seasonally in and out of the park, and conserving wildlife in a sustainable fashion implies securing land use types outside the reserve that are compatible with wildlife. Livestock grazing is an example of such a compatible land use type. Fenced in cropping is not. Due to the many and potentially complex interlinkages between human and natural systems it is imperative to analyze these issues with a model that integrates insights from ecology and economics.

PES is an increasingly popular instrument for promoting conservation, especially in developed countries. In recent years, PES has been introduced in developing countries, in particular in the context of watershed management and carbon storage.

However there is no reason to discount the potential use of PES as a mechanism to align potentially opposing interests in the area of wildlife management or biodiversity conservation (areas where non-tangible non-use values are likely important – spilling over national boundaries). We conclude that PES may be a powerful tool in the Amboseli ecosystem because it promotes conservation and contributes to alleviation of poverty (also through stabilization of pastoral income). Moreover, and interestingly, the basic behavioral model that we employ (PHEWS) suggests that these beneficial effects seem to mutually enforce each other: there is no tradeoff between making the Maasai less poor and protecting elephants. Our analysis also indicates that the proposed PES scheme enhances global welfare. One important caveat is the potential issue of 'leakage' or 'slippage'. If we use a simple mechanical rule to describe Maasai behavior (i.e. 'use all extra funds to purchase extra livestock'), then much of the gains from habitat expansion are dissipated through extra competition for food between livestock and wildlife – this is clearly an issue that needs to be explored in more detail.

One final issue remains – how should the PES project be funded? In light of the very significant non-use values associated with elephant conservation it seems appropriate to turn to funding opportunities like the Global Environmental Fund. However, GEF only funds projects for a period of five years, and afterwards projects should be self-sustaining. This appears a shortsighted policy in the case of conserving ecosystem services for non-use values. Such services represent ongoing flows of benefits that accrue to the world population as a public good, and in the absence of sustained compensation such flows will eventually be curtailed. Unlike the case of watershed management it is hard to identify parties with a strong interest in privately 'purchasing' the service – making them available for the whole world at zero cost. The GEF could play an important coordinating role in this respect, and should strive for sustained payments in that case.

Fortunately matters need not be so complex for the case of the Amboseli ecosystem, which is a very popular tourist destination. With 200.000 tourist days a year, the PES program could be easily funded with a relatively minor increase in the Park entrance fee – from US$30 to US31 – or with the introduction of a modest bed tax. Having visitors pay for conservation implies that non-visitors are free riding, and receive their non-use values at zero cost. Clearly such free rides are not always feasible elsewhere, and we therefore recommend the establishment of a new institution – a revamped GEF or otherwise – that will be able to collect payments for nonuse values and channel them to those areas in the world where these values are supplied.

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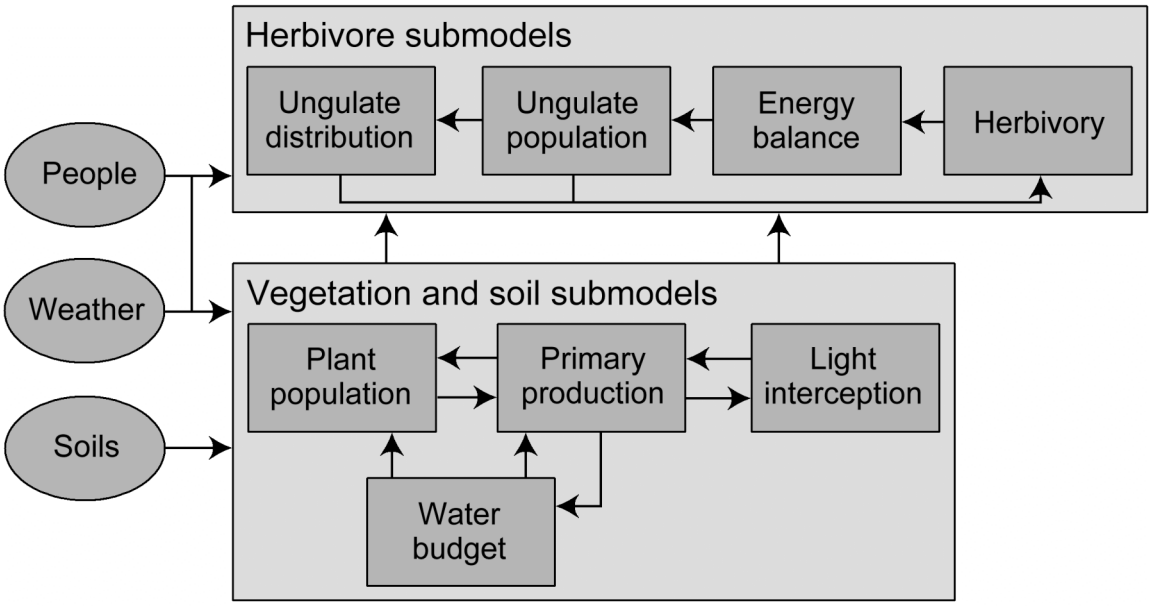

Figure 1: Schematic outline of the SAVANNA model used to simulate the impact of landuse change on wildlife (elephant) abundance.

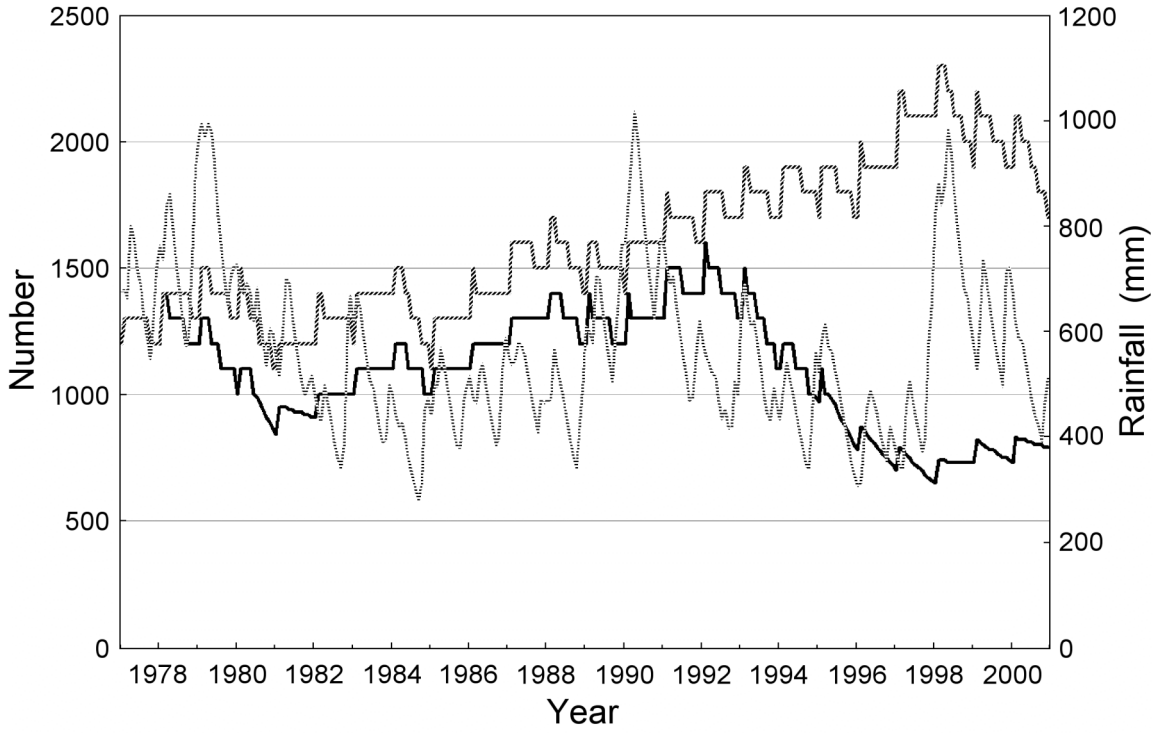

Figure 2: Elephant abundance with (solid) and without (heavy dashed) habitat conversion. Precipitation over 12 months (light dashed) is overlayed for comparison.

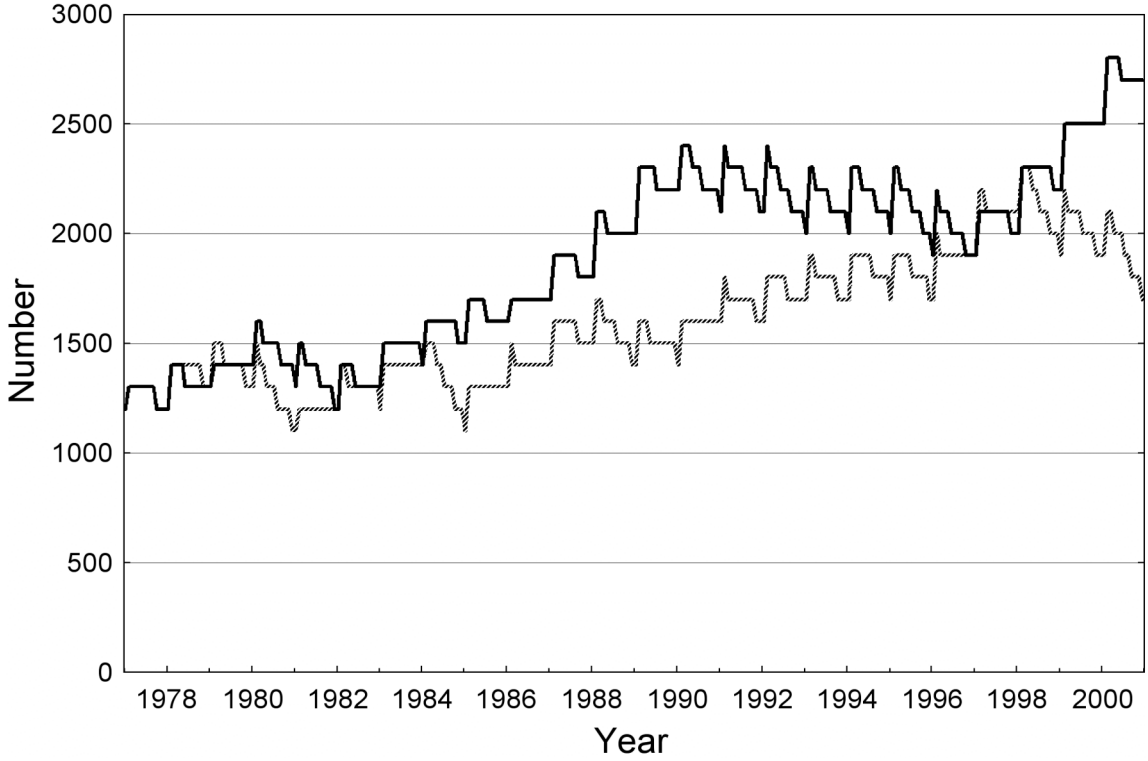

Figure 3: The effect of paying Maasai for not renting out their lands on the elephant population [a comparison of pastoral systems with (solid) and without compensation (hatched)].

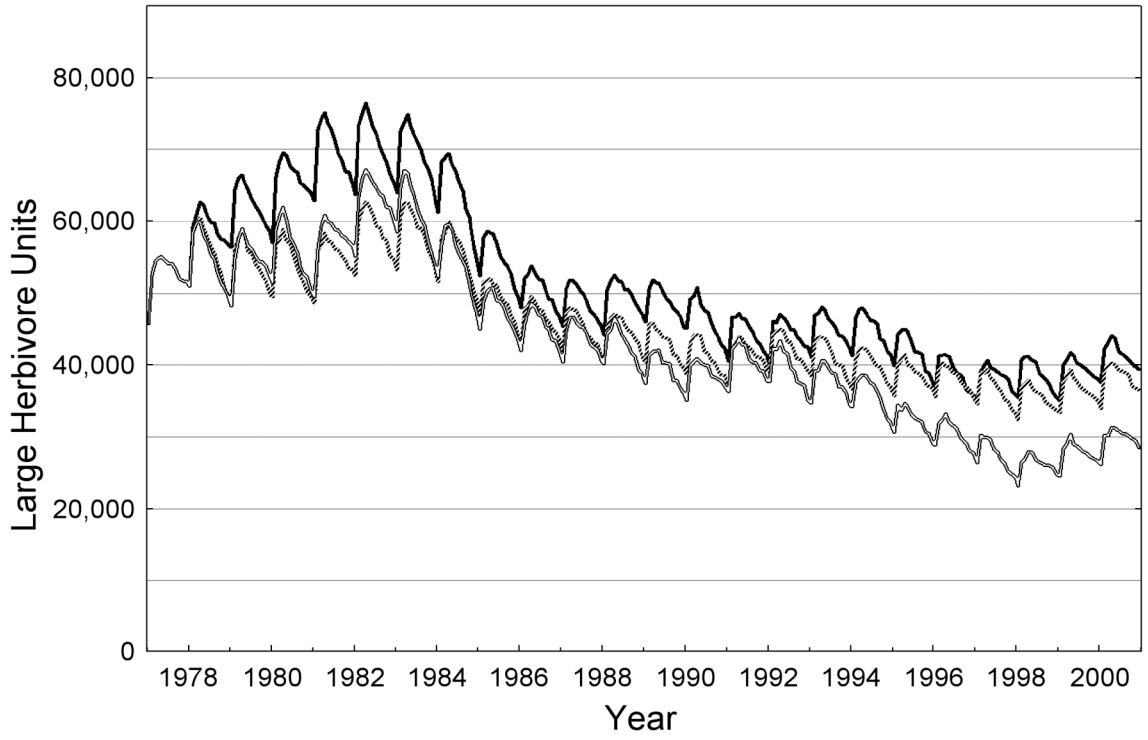

Figure 4: The Leakage effect. Wildlife stocks in the presence (solid) and absence (open) of payments for ecosystem services, as well as if payments are used entirely to purchase livestock (dashed).