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## **Under what conditions is the management of migratory wildlife resources successful?**

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### **Abstract**

The management of fugitive resources across national boundaries possess significant challenges to organizations and policy makers. This paper investigates three key aspects areas that affect the management of migratory wildlife. The first issue is whether it is better to have a single Transfrontier park or to have several disjoint ones. We find that economically, it makes no difference, as long as the same institutional framework applies to all the disjoint areas. We however reason that from a conservation perspective, it is better to have a single transfrontier park due to economies of scale attainable from a larger reserve. We also investigate the conditions under which the local communities will cooperate with the conservation effort and the paper concludes that as long as the flow of benefits from the park authorities to the community is greater than the marginal benefit from the community's alternative source of income, cooperation will exist. Institutional setups invariably affect the success of Transfrontier park management and we discuss some of the responsibilities government and organizations have to ensure that the parks are successful. To this effect, organisations should be involved only in as much as setting up an institutional framework that allows for equalization of benefits and costs where concerned.

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## **Chapter 1: Introduction**

### **Background**

There has been a growing realisation that when dealing with natural resources, ecological boundary demarcation should take precedence over governance boundary demarcation so that management decisions have a complete effect on the ecological system. Furthermore, congruence between ecological boundaries and governance boundaries reduces the likelihood of conflicting management decisions. In dealing with fugitive natural resources such as wildlife, at an international level, this realisation has brought in its wake the creation of a good number of transfrontier national parks, examples of which include the three-nation Great Limpopo Transfrontier Park, the two-nation Maloti-Drakensburg Transfrontier Park, the two-nation Kgalagadi Transfrontier Park, the three-nation Limpopo/Shashe Transfrontier Conservation Area and the proposed five-nation Caza Transfrontier Park. Indeed the removal of fences between adjacent national parks in adjacent countries might help in the de-fragmentation of wildlife habitats, which has long been recognised as a major cause of biodiversity loss particularly in literature on large mammals.

More so, transfrontier parks provide scope for enhanced social and economic benefits to the communities in which they are established. They can be used to enhance social benefits through community participation in sustainable management of the wildlife resources in their area. Transfrontier parks also foster cooperation among regional governments, through the need for governments to work together in setting up and effectively managing the parks.

### **Motivation of the study**

The extent of enhancement of conservation under transfrontier parks will necessarily be affected by at least three factors:

- The resultant payoff matrix of conservation benefits for the participating countries.

- The wildlife migration patterns particularly those of large range and more valuable species, and
- The nature of governance institutions in each of the participating countries.

Firstly, all participating countries ought to draw net benefits from the transfrontier park if conservation is to be enhanced. Country benefits from transfrontier parks usually come in the form of benign tourism. Additional benefits may be acquired as existence values. More often than not, countries would also need to create some kind of infrastructure within or just outside their portion of the transfrontier fence such as lodges, gravel roads, viewing spots, telecommunication systems and road transfer facilities in order to enhance tourism benefits. Countries that benefit more from wildlife conservation are expected to invest more in its conservation and in infrastructure which consolidates those benefits.

Secondly, the removal of fences between adjacent national parks in adjacent countries will most likely see the re-emergence of such migration patterns particularly across political boundaries given that the quality of habitats is likely to differ in the different parts of the transfrontier park. Wildlife is likely to be concentrated along certain routes or sanctuaries within the park. Also, animal instinct could be such that wildlife tends to escape from high poaching risk areas to safe sanctuaries. As a result of the foregoing two factors, access to wildlife hot spots may not be evenly distributed amongst the participating countries. Needless to say that the benefits from the transfrontier park will consequently be affected by wildlife migration patterns but some countries might be better readily able to counter adverse wildlife migration effects by putting in place better mechanisms to navigate to wildlife hot spots than others. A classic example would be the construction of more water points. This changes the type of habitat and it would be interesting to investigate how this induces the wildlife to change their range.

Thirdly, countries tend to differ in the governance systems (rules of behaviour, ways and means of enforcing these rules, procedures for mediation of conflicts, sanctions in the case of breach of the rules, and organizations supporting transactions) they use to manage their portion of the transfrontier fence (responsibilities) and benefits. Some countries

might prefer to involve local communities as a way to reduce resource monitoring costs and increase resource protection while others might prefer to exclude local communities and use a more centralised approach to management. This centralized approach however, in the presence of ill-resourced ineffective monitoring, has historically led to collective action problems and has effectively turned their portions of the park into de facto open access areas.

Wildlife biological processes occur at small, medium and large-scales such that their effective management requires that governance systems are organised in multiple scales that are effectively linked (Ostrom 1995). Thus the governance system must be as complex as the biological process it is trying to manage. It is not uncommon to find smaller scale organisations that are nested within larger ones, each with its own distinct set of rules (Ostrom 1995). Countries that promote congruence between the governance system and the biological process in wildlife conservation have strong governance institutions. Poaching is likely to be rampant in countries with weak institutions because poachers hunt without effective restraint. Furthermore, local communities who are adjacent to wildlife are likely to support and shield poachers as a way to protest their exclusion from wildlife management. Of concern to local communities will be whether the creation of the transfrontier park will entail costs for them in the form of (i) increased human-wildlife conflict given that there is no guarantee that wildlife will not occasionally wander from the parklands into the rangelands, and (ii) loss of livelihood opportunities such as livestock farming and of traditional hunting areas, given that local parkland boundaries may have to be redrawn to effectively link the local park to the neighbouring ones. It will be difficult to establish transfrontier parks adjacent to communities who stand to suffer large losses.

In Southern Africa, the elephant is probably the single greatest species-specific factor influencing ecosystem conservation in protected areas (DNPWLM 1999). Perhaps this suggests that governance boundaries should be along the ranges of elephants and take refuge in it being both a keystone and umbrella species. Indeed the elephant range was the key consideration in the establishment of the Great Limpopo Transfrontier Park.

In some countries elephant populations are exceeding carrying capacities<sup>1</sup>. If this situation continues unchecked it will adversely affect the parks ecosystem in that other species habitats might be degraded. Furthermore, the elephant's own habitat will not be spared. In reality this situation might also affect the tourism income opportunities. In isolation, affected countries would have to take drastic measures such as culling. While such measures solve the conservation problem they may adversely affect tourism opportunities given the way in which animal rights activists campaign against them. Transfrontier parks can create an avenue through which overpopulated parks could be relieved of their excesses by finding additional carrying capacity from neighbouring parks. This is particularly the case if there is excess capacity in the neighbouring parks. In that case, everyone potentially stands to benefit by the mere creation of the transfrontier park.

Even though transfrontier arrangements are potentially conducive to sound conservation in the sense that wildlife, especially large range species, has access to more land, the same arrangements entail that a more diverse range of managers has access to wildlife and if the dominant majority of managers responds to perverse incentives transfrontier parks could actually open up more areas to biodiversity loss. In particular, given that wildlife moves across the countries participating in the transfrontier park why should any particular country make conservation sacrifices if it cannot control the other countries? The situation which might arise is, in part, akin to international free-riding and tragedy of the commons.

### **Research Questions**

- When dealing with fugitive natural resources such as wildlife, is it better to have a transfrontier park or several disjoint ones?
- Under what conditions might local communities actually cooperate with transfrontier park wildlife management?

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<sup>1</sup> We are using carrying capacity as has been historically used. Effective management capacity is used more widely but in this case carrying capacity may still be used in other areas of the park.

- What threshold of organizational involvement in the participating countries is required to guarantee enhanced conservation?

In the proposed paper we seek to build a bio-economic model for terrestrial migratory species such as the African elephant (*loxodonta africana*) in the Great Limpopo Transfrontier Park. We intend to investigate:

- i. The bio-economic perspective on the need for coordination of conservation efforts among neighbouring nations: here, we actually evaluate whether it is better to have a single large national park or several disjoint ones, and investigate how different habitat qualities affect species and how spatial dispersal helps to maintain viable wildlife populations
- ii. The benefits culminating from coordination: we reason that to ensure minimisation of opposition to the transfrontier parks, we should identify the situations in which local communities might actually gain from them
- iii. The requirements of governance organisations that guarantee increased conservation in the Great Limpopo Transfrontier Park.

### **Structure of the paper**

This paper will comprise six chapters. Chapter 1 outlines the context in which this research is made, the motivation for the study and research questions that stand to be answered. A review of the literature follows in chapter 2. The chapter seeks to expose some of the pertinent issues in inter-boundary conservation and how conservation effort has been changing through time. It also brings out some of the challenges and successes of transfrontier conservation methods. The next chapter explains the methodology to be employed. Chapter 4, the main chapter of the paper, will present the model. This chapter reviews the different animal migration patterns and determines the type that resembles elephant migration patterns in the Great Limpopo Transfrontier Park closest. This section will look at, among other things, the main types of terrestrial animal migration, documented elephant behavioural patterns and how their migration patterns will impact the model. The second section of the chapter will look at the nature of wildlife harvesting. This section discusses the incentives and costs associated with park

management and how the nature of property rights will affect conservation effort and the various equilibria. In Chapter 5, the policy implications of the results are discussed and in the last chapter, a conclusion will be given.

## **Chapter 2: Literature Review**

### **Rationale behind transfrontier natural resource management.**

Transfrontier Conservation Areas have gained popularity as methods of preserving and conserving natural resources. To this effect, a number of parks have been established in Southern Africa, and the main idea behind them is the fact that ecological boundaries do not always coincide with national/political boundaries and hence for effective conservation practices to prevail, management of wildlife should be based on ecosystem boundaries and not restricted by national boundaries. Transfrontier Parks and Transfrontier Conservation Areas effectively integrate areas previously segregated by political boundaries, to get them under a common management scheme, with the aim for better conservation effort.

Munthali, (2007) identifies some of the main reasons for creating transfrontier conservation areas as:

- i. The need to protect reserves that span across nations
- ii. The need to expand the total area that is being utilised for wildlife activities, and,
- iii. The need to re-establish seasonal migration routes Munthali (2007).

With poverty levels consistently high in most African countries, wildlife resources have also been viewed as a tool that local communities and governments can actually use for the betterment of the lives of the people around the reserves. Singh, (1998), for example, takes the view that transfrontier parks and conservation areas offer increasing economic opportunities, diminish cultural isolation and may be used for community integration Singh, (1998). Transfrontier conservation areas have also been described as vehicles which fight the twin goals of conservation and development. There seems to be

consensus among authors that wildlife, if effectively managed, may impact positively on the lives of the people around the resources.

While there is consensus and acknowledgement that transfrontier areas can have a huge impact on the livelihood of communities, how these areas have been managed or ought to be managed remains debatable. Buscher et al, (2005) argues that instead of community based conservation, the older, more excluding approach should be taken. Buscher argues that there is irrefutable evidence that African communities have failed to harness the full potential of wildlife resources, with some communities which are well endowed with natural resources and which have been given ownership failing to improve their lives. While this view cannot be disregarded, as there indeed are numerous cases of failures at community level, there are also cases of community based conservation methods that have worked quite well and have addressed both the conservation goals as well as the economic goals<sup>2</sup>.

### **Problems associated with Transfrontier Management**

Transfrontier conservation areas and parks, by virtue of their structure, are not without problems. One of the main challenges they face is the exclusion of most stakeholders in the management practices, as governments have generally assumed full ownership of the parks Munthali, (2007). While conservation is the main objective, the livelihood of the local communities should also be considered as these communities pose a threat to conservation effort should they not stand to benefit from the areas. The parks affect the communities by potentially reducing the size of area available for agricultural purposes and animals frequently destroy crops and property when they wander outside the reserves. Due to colonial history and different perceptions around access to resources and use between different communities, misunderstandings are bound to rise resulting in non cooperation Munthali (2007).

Transfrontier parks may generally face ineffective management capacities. The level of coordination needed in joint operations is higher than when dealing with individually

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<sup>2</sup> Examples the Makuleke clan in the Kruger National park which benefited from land restitutions

managed resources and in some cases management capacity for this level of coordination may just not exist. Thus, these parks may inherently suffer from collective action problems - more people have to be consulted and consensus must be reached on all key decisions. In cases where payoffs structures are different, and one sub area stands to benefit more than the others, management views and objectives regarding the way forward may be diametrically opposed.

### **Challenges faced by the Greater Limpopo Transfrontier Park**

Other than these general issues that transfrontier parks face, the Greater Limpopo Park, has its own challenges. While these have been discussed in depth by other authors, this paper will point out some of the main issues. Saayman and Saayman (2006) point out the extreme poverty levels of communities living around the park. They consider the income structure of Mpumalanga province in South Africa, showing that the province, in which the Kruger National Park is situated, is one of the poorest provinces in the country. Such a situation thus puts pressure on the management system to stop the local communities from acquiring illegal off-take from the park.

Some areas of the park have infrastructural backlogs. In the Gonarezhou Park, most roads are un-tarred, in bad shape and mostly accessible by off road vehicles (Spenceley et al, (2008). The paper also notes that the level of other tourist infrastructure such as game lodges, viewing spots and other recreational facilities are only well developed in the South African side of the park (formerly Kruger) and not so much in other areas, particularly the Mozambican side. This is an issue of concern because for as long as the level of infrastructural development is different, benefits and costs in the different areas will not be the same, and this ultimately leads to coordination problems.

The transfrontier park to date has seriously fallen short of quantifiable deliverables. Although much has been said about the potential of the project, the possible gains to the communities and gains in biodiversity enhancement, to date, not much in observable deliverables has been achieved. Sceptics of the project argue that other than the relocation

of a handful of elephants from the Kruger to the Gonarezhou, the park has perhaps not achieved anything else<sup>3</sup>.

The motives behind the establishment have also been called into question a number of times, with the suggestion that South Africa stands to gain the most and wanted to find areas to where it could translocate excess elephants from Kruger National park at low cost. The Kruger had an excessive elephant population and these had to be rid of, but without taking drastic action such as culling which would have had bad publicity and taken a toll on tourism revenues.

### **Chapter 3: Methodology**

The paper uses bio-economic modeling in a dynamic framework. Bio-economic modeling takes into account the biological process of wildlife as well as the economic incentives of people interacting with wildlife. Joint modeling of biology and economics ensures that we capture human effects on the wildlife ecosystem. The management actions of humans will affect the wildlife ecosystem and the wildlife ecosystem will in turn give its feedback by changing the economic incentive structure of humans. By formulating a plausible model that captures the biology-economics interactions one may be able to predict the effects of changing key parameters of the model. This tool can then be used to appraise, for example, different configurations of economic incentives amongst countries participating in transfrontier parks. Indeed, transfrontier park arrangement is ultimately a joint economic and biological problem.

Bio-economic models have been formulated to investigate biology-economics interactions especially for individual country situations, for example in investigating Integrated Community Development Projects (ICDPs) (see Shulz and Skonhofs (1996), Skonhofs and Solstad (1996), Skonhofs and Solstad (1998) and Skonhofs (1998). Where trans-boundary resource management has been investigated, fisheries have tended to

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<sup>3</sup> Some experts will however argue that this is not so much a numbers game but the creation of the opportunity for elephants to be able to move around and their use of resources across time and space that results in the success or failure of a transfrontier park.

dominate particularly migratory coastal fish species which move across country borders, for example Sanchirico and Wilen (2001). For terrestrial species, bio-economic models have tended to focus on investigating the effect of creating new protected areas in formerly open access lands in a particular country, for example see Johannesen and Skonhofs (2004). The proposed work will extend the discussion in the bio-economic modeling literature to include fugitive terrestrial resource management situations where countries come together to jointly manage previously isolated national parks and where wildlife migration takes place across country borders. In this work we will be helped by the experience of the Great Limpopo Transfrontier Park.

The aim of this paper is to build a model for migratory species such as the African elephant. However, given that wildlife frequently migrates across large areas it is imperative to incorporate the dynamics of wildlife migration when analysing different management regimes in the underlying sub areas. However, none of the preliminary models are explicit models of wildlife migration. The paper will therefore incorporate the dynamics of wildlife migration, growth patterns and the economic system under which the system operates to find the equilibrium steady state values and the implications these have on intervention effort.

## **Chapter 4: The Model**

### **Terrestrial Animal Migration Patterns**

There are three main types, or reasons for animal migration. The first type of migration that affects conservation technique and effort is seasonal migration. With seasonal migration, the species moves from habitat to habitat dependant on the season in search for food. In Africa, several terrestrial species show this form of migration. As an example, the wildebeest in the Masai-Mara game reserve seasonally migrate in search of food depending on the rainfall patterns (Johannesen and Skonhofs, 2004). With seasonal migration, no density effects affect the movement of the species from one habitat to the other (Johannesen and Skonhofs, 2004). Rather, when the food supply runs out in one

area, all the animals move to another area where, due to the different climatic conditions, more food is available. This kind of movement is exhibited by the wildebeest in the Serengeti-Mara ecosystem. The wildebeest stay in the protected game reserve for most of the year, but in the dry season, they all migrate outside the reserve into the surrounding environment in search of better pasture (Fryxell et al, 1995). For these terrestrial species, seasonal migration naturally takes place over vast distances, as the beasts have to migrate from one geographical location to another.

The serengeti-mara ecosystem as a whole, covers some 25000- 32000 square kilometers (Ronald et al 1989) and there is a significant rainfall gradient throughout the ecosystem, with some areas receiving only 800mm of rainfall a year and others over 2000 mm. It is this kind of vast difference that then makes it possible for seasonal migration where the species move from one area completely to the other, as the climatic conditions allow for different vegetation, nutritional value and carrying capacity per unit area.

The African elephant has been known migrate across vast distances each season. With no natural enemies, does the African elephant exhibit seasonal migration in the Great Limpopo Transfrontier Park? Although elephants move vast distances, assuming seasonal migration where the animals all move completely from one area to another solely in response to food availability ignores human interference and activities such as poaching, which have been shown to affect elephant behaviour, migration and social structure. In addition to this, the rainfall gradient within the park is not that steep.

The second form of migration discussed is symmetric density dependant migration. This form of migration occurs between two different habitats in order to equalize densities between the two habitats. Symmetric migration occurs between two habitats whose natural conditions are generally identical and the species would move between different park areas based on the densities of the areas. If one area has a higher density than a neighbouring area, the species would migrate to the neighbouring area. When the two areas have the same animal density, then the rate of migration between the areas is equal and the rate of change of stock is the same in the areas Hannesson, (1998).

Symmetric density dependant migration in a homogenous ecosystem which is sub divided two or more areas thus shows the effect of different institutional set ups that exist in the different areas. If the rate of harvesting in the one area is greater than in the other, the population in the former area will always be less. There will thus always be a positive flow of animals from the area with less harvesting to the one with more harvesting. This has profound effects on the conservation effort as it implies that as long as animals can move freely between the areas and as long as the extraction effort in the unprotected area is high enough, the species may actually become endangered as it will always move into the extraction area.

The African elephant however, is less likely to follow a symmetric density dependant migration pattern. Although physical conditions in the three different management areas<sup>4</sup> of the Greater Limpopo Transfrontier Parks are the same, studies have shown most large terrestrial herbivores, including the elephant, to be particularly sensitive to the natural dangers in their habitat (Nyakaana et al, 2001). Human activities such as culling and poaching have led to elephants congesting in areas where there is less human interference. Modeling elephant migration as symmetric would imply that the quality habitat throughout the park is identical, i.e. the quality of food is the same, human interference is identical, and thus the habitat of choice is solely determined by the amount of food available - in which case would be determined by the species' population density. In this particular case therefore, the elephants would be distributed evenly, and there would be a positive flow of animals to that area whose density becomes lower. This however is hardly practical as the geographical characteristics differ within the park and human interference is not the same. This paper therefore assumes that the African elephant will not follow a pattern of symmetric migration as this oversimplifies the natural conditions that exist in the park and ignores documented elephant behaviour.

The last type of migration this paper will discuss is asymmetric density dependant migration. With this kind of migration, there is movement in and out of the conservation

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<sup>4</sup> This refers to the area under Zimbabwean, Mozambican and South African management.

area despite the population densities being the same. For species that follow this kind of migration, the reason for migration is usually a result of different density effects between the two or more habitats that the species can live in. Here, density effects refers to the impact on the livelihood of the species due to its own density in the area and due to that of other species as well, particularly predator species. If for example one habitat allows for predator hunting and another does not, the former will be less favourable to the species as it lends the species to higher rates of predation due to the higher number of predators. In equilibrium, this habitat would therefore naturally have a lower total stock level than the second. This however is a static equilibrium, as it considers a one period flow from one habitat to the other. A multi-period analysis, allowing for the migration to happen continuously over successive periods, would suggest that asymmetric density dependant migration will lead to fluctuating levels of stock levels in the two habitats. Assuming equal population densities in the two habitats at first, and then one is allowed to minimize the number of predators affecting the species, despite the same density of species, animals will migrate to the safer habitat and will result in a higher stock level and population density than the first.

Studies show that large herbivores such as buffalo, elephant, rhinoceros and hippo are regulated by food supply and not natural predators (Fryxell, et al, 1995). Due to their size and/or social structure, these animals face minimal disruptions in their normal routines by natural enemies, and thus the presence, or absence, of predators does not have much migratory impact. In the case of the African Elephant however, poaching and human activity may induce this kind of migration.

In a transfrontier park whose monitoring is managed by different institutions, although hunting of the species may be illegal in both habitats, one institution may enforce these property rights better than the other, leading to rampant poaching in the one and none in the other. In this particular case, where poaching is consistently practiced, asymmetric density dependant migration may take place.

It is this type of migration that suits the elephant migration pattern in the Greater Limpopo Transfrontier Park the closest. There is very minimal evidence of seasonally migrating elephants, where the elephants move completely from one area to another and alternate from season to season. Symmetric density dependant migration is too simplified as it assumes conditions throughout the park are homogenous, a case that is not so. The asymmetric density dependant pattern however, seems to suit the species closest. This allows for migration to take place between different habitats, with higher densities of elephants in areas where the habitat is favourable, such as poaching free areas. This pattern also allows for density modeling, with the rate of migration also dependant on the density of animals in the area, as this affects food supply. The elephants are therefore expected to be more concentrated in sanctuaries, but this would also be limited by the food supply. In equilibrium therefore, there would be more elephants per unit area in the preferred habitat. So how is this represented mathematically?

The mathematical formulation used for this migration pattern draws from the work of Sanchirico and Wilen, (2005) and that of Skonhofs and Armstrong, (2005). The species migrates spatially across the park according to an asymmetric density dependant fashion. This means the migration pattern will have a dispersal rate,  $m$ , which is a constant value for each species. Sanchirico and Wilen, (2005) refer to this value as the coefficient of dispersal and it simply shows the intrinsic dispersal rate of a species. Species that have a very low spatial movement will have a low value and those that exhibit more dispersed migration, a higher one. As the species migration is affected by density, a coefficient of migration,  $\alpha$ , will be included. The migration rate from area 1 to area 2, denoted  $M1$  may therefore be represented as:

$$M1 = m\left(\alpha \frac{S_{1t}}{K_{1t}} - \frac{S_{2t}}{K_{2t}}\right)$$

Where :  $S_{1t}$  and  $S_{2t}$  are the total stocks of animals at time  $t$  in area 1 and 2 respectively,  
 $K_{1t}$  and  $K_{2t}$  are the respective carrying capacities of area 1 and 2  
 $m$  is the intrinsic dispersal rate of the terrestrial species.

$\alpha$  is the coefficient of migration, dependant on the relative density of area 1

This model allows for flexibility on the assumptions about migration. It allows for differing spatial movement rates between different species, through the parameter  $m$ . For any species, this parameter would be constant, and determined through empirical studies. It would however be different from species to species as different species have differing rates of movement. Species with a high degree of spatial movement will have a large value of  $m$  as opposed to those with minimal movement which would record a much lower value.

It also allows for asymmetric density dependant migration through the parameter  $\alpha$ . This parameter is the coefficient of migration with the value changing as the desirability of the area the species is in changes.

#### **The case of the Net Present Value maximising owner.**

In this model, we assume there are two wildlife areas, area 1 and area 2. Both areas are privately owned and maximize the present value of the net benefits they obtain from the park. Benefits are in the form of two main sources of revenue, the first arising directly from tourism and the other, from proceeds<sup>5</sup> from the sale of game and other game related products from the park. The costs incurred by the management authority are in the form habitat management (waterholes, fireguards, etc) and tourism infrastructure (gravel roads, viewing spots, lodges etc). Elephants, being both a keystone species and an umbrella species are the single most influential species that affects the management of the wildlife areas. They have the capacity to exploit the natural habit if they exceed the carrying capacity, but at lower numbers they can increase biodiversity and spatial distribution of other animals (Baxter, 1996). In this model, the wildlife areas will use elephant stock as their control variable for maximising the net benefits from the areas.

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<sup>5</sup> These proceeds are not off-take but in fact revenues arising from translocating animals to other parks to further their conservation effort.

This model can easily be extended to include other key species, by expanding the model to a stacked model, as used in Sanchirico and Wilen, 2005<sup>6</sup>. In an expanded stacked model, the net benefits and costs of an individual species are added to those from other species and the control problem solved simultaneously for all the required species.

### **Benefits**

Elephants benefit the park in the following ways:

i. Tourism

The African Elephant is one of Africa's "Big Five" and continues to fascinate many people. The elephant is considered an appealing animal partly due to its size, charisma and the imminent threat of danger that always comes with being close to one (Reynolds and Braithwaite, 2001). It is because of this special appeal, that tourists have continued to flock the wildlife reserves in Africa, to catch a glimpse of this species. This paper will assume that the net benefits from tourism are directly dependant on the stock of elephants that exist in the park owing to people who want to come and observe this animal in its natural habitat.

Second, as a keystone and umbrella species, elephants indirectly regulate the total stock of other species in the park. Elephants are one of the most destructive species but are also known to be instrumental in the dispersal of seeds and regulation of veld types. These activities ultimately affect the stocks of all the other animals in the park and together, these two effects will directly affect the number of tourists that are lured to the park.

ii. Proceeds

The other benefit considered is proceeds from the sale of game and any other wildlife related products that the park may produce. This parameter represents all revenues from

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<sup>6</sup> In the stacked model, the elephants would be for example species  $i$  and the model allows for  $n$  species, where  $n > 1$ . For a detailed illustration of such a stacked model, refer to Sanchirico and Wilen, (2005). This model will however not work for predator prey relations.

park activities such as the auction of excess elephants to other parks with excess capacity, revenues from trophy hunting, once off concessionary sales of ivory where permitted and game meat. The revenue stream from proceeds unlike that from tourism, will involve some form of harvesting practice<sup>7</sup>. The paper assumes the Schaefer harvest function:  $H = eES$  where  $e$  is the coefficient of harvest,  $E$  is the effort put in to harvest and  $S$  is the total stock of elephant available.

Given the above discussion, the benefit function has two parameters, the stock level,  $S$  and the level of harvest,  $H$  and the absolute level of benefit is obtained by multiplying these parameters with the going market price,  $P$ .

### **Costs**

The main cost of keeping elephants is the regulation of the size of the herd. They would need to be tracked, provided with sufficient waterholes and fenced off from human settlement areas and so forth. This cost is assumed to be directly dependant on the total stock of elephants in the park.

The other cost accruing to the park is that of harvesting. At the end of each period, the excess elephants need to be captured, either to be sold off to other parks with the capacity to effectively manage them, (this is a common occurrence within national parks and tourism facilities), or as an extreme measure, culled, within the context of compensation for damage causing animal impacts on neighbouring communities<sup>8</sup>.

### **Growth**

Migration patterns and the growth patterns have paramount importance in the analysis of equilibrium states and how these may change with time. The rate of change of the total stock in each of the sub areas, 1 and 2, will depend on the growth rate and the rate of

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<sup>7</sup> This harvest practice entails capturing the animals to be auctioned off, thus is not harvesting for consumption purposes.

<sup>8</sup> Should the elephant population exceed its carrying capacity, the species will break into neighbouring areas for food, thus costing the parks more in terms of compensation. Excess elephants also decrease the biodiversity of the park as a whole, and thus it is in the park's interest to rid of them.

migration. The growth rate of the species will follow the logistic pattern, with the rate of change of the stock size dependent upon an intrinsic growth rate, and a density dependant factor. The model assumes species homogeneity, i.e. there is no difference in the intrinsic growth rate of the species between the two habitats. This is in line with the standard definition and use of intrinsic growth rates and does not alter the set up of the problem.

The growth rate of the species is given by:

$$g = rS_t \left( 1 - \frac{S_t}{K_t} \right)$$

Where:  $r$  is the intrinsic growth rate of the species,

$S$  is the total stock level,

$K$  is the carrying capacity

Combining the growth and migration patterns together, the rate of change of the stock level in area 1 thus can be represented as follows:

$$\frac{dS_{1t}}{dt} = rS_{1t} \left( 1 - \frac{S_{1t}}{K_{1t}} \right) - m \left( \alpha \frac{S_{1t}}{K_{1t}} - \frac{S_{2t}}{K_{2t}} \right) - h_{1t}$$

Where:  $h_{1t}$  is the harvest in area 1, and all the other parameters as described before.

In a present value maximization scheme, where each area maximizes the net present value of benefits, the paper assumes that the revenues from proceeds, are linearly dependant on the level of harvesting,  $h$  and that the revenues from tourism, are also linearly dependant on the stock level,  $S$ . Given an inverse demand function for elephant related products, the proceeds would be a function of the total amount of harvest multiplied by the market price for those products. While this assumption may appear restrictive, in an expanded stacked model that allows for more than one species modeling, it is indeed the abundance and density of the main species (such as the big five) that determines the revenues from tourism.

The present value maximizing owner will thus be faced with a decision to maximize net benefits inter temporally through optimal management of the keystone species. The decision problem for each of the owners becomes:

$$\text{Maximise: Net benefits} = \int_0^{\infty} [B(h_{1t}, S_{1t}) - C(h_{1t}, S_{1t})] e^{-\delta t} dt$$

Subject to:

$$\frac{dS_{1t}}{dt} = rS_{1t} \left(1 - \frac{S_{1t}}{K_{1t}}\right) - m \left(\alpha \frac{S_{1t}}{K_{1t}} - \frac{S_{2t}}{K_{2t}}\right) - h_{1t}$$

And an initial stock level  $S(0) = S_0$

The current value Hamiltonian is:

$$H^c = [B(h_{1t}, S_{1t}) - C(h_{1t}, S_{1t})] + \lambda [rS_{1t} \left(1 - \frac{S_{1t}}{K_{1t}}\right) - m \left(\alpha \frac{S_{1t}}{K_{1t}} - \frac{S_{2t}}{K_{2t}}\right) - h_{1t}]$$

And the associated first order conditions:

$$(i) \quad \frac{\partial H^c}{\partial h_{1t}} = \frac{dB}{dh_{1t}} - \frac{\partial C}{\partial h_{1t}} - \lambda_{1t}$$

$$(ii) \quad \frac{d\lambda_t}{dt} = \delta \lambda_t - \lambda_t \left[ r - 2r \frac{S_{1t}}{K_{1t}} - \frac{m\alpha}{K_{1t}} \right] + \frac{\partial C}{\partial S_{1t}} - \frac{dB}{dS_{1t}}$$

$$(iii) \quad \frac{dS_{1t}}{dt} = rS_{1t} \left(1 - \frac{S_{1t}}{K_{1t}}\right) - m \left(\alpha \frac{S_{1t}}{K_{1t}} - \frac{S_{2t}}{K_{2t}}\right) - h_{1t}]$$

Along the optimal efficient path, the rate return from area 1 (which is also identical to that of 2) is given by:

$$(iv) \quad \delta = \frac{d\lambda_t}{dt} / \lambda_t + \left[ r - 2r \frac{S_{1t}}{K_{1t}} - \frac{m\alpha}{K_{1t}} \right] - \frac{\partial C}{\partial S_{1t}} / \lambda_t + \frac{\partial B}{\partial S_{1t}} / \lambda_t$$

How does this compare to the rate of return that can be obtained from a single transfrontier park?

A single present value maximizing transfrontier park, with carrying capacity  $K$  and stock size  $S$ , under the same conditions as above would maximize:

$$\text{Net Benefits} = \int_0^{\infty} [B(H_t, S_t) - C(H_t, S_t)] e^{-\delta t} dt$$

Subject to:

$$\frac{dS_t}{dt} = rS_t \left(1 - \frac{S_t}{K_t}\right) - H$$

The current value Hamiltonian is:

$$H^c = [B(H_t, S_t) - C(H_t, S_t)] + \lambda \left[ rS_t \left(1 - \frac{S_t}{K_t}\right) - H_t \right]$$

And solving this for Hotelling's efficiency condition gives:

$$(v) \delta = \frac{d\lambda_t}{dt} / \lambda_t + \left[ r - 2r \frac{S_t}{K_t} \right] - \frac{\partial C}{\partial S_t} / \lambda_t + \frac{\partial B}{\partial S_t} / \lambda_t$$

Comparing equations (iv) and (v) will show that from an efficiency perspective, it makes no difference whether there is a single park or two disjoint ones, as long as the institutions surrounding governance are the same. The right hand side of both equations shows that the rate of return from the resource is given by the proportionate change in the shadow price of the resource with time. This rate of change would be equal regardless of the size of the park<sup>9</sup>. In equation (iv), the next term is different from that of the single

<sup>9</sup> Assuming that the market for the resource is the same, i.e. the pool of tourists is the same and the market of proceeds is the same, then the rate of change of the shadow price with time would be the same.

park. There is an additional term due to migration, but since we are considering two areas, net migration in the steady state is zero thus the rate of the return in the small parks would be the same as that in the joint transfrontier park. The last two terms, show the proportional change in costs due to an increase in stock size and the increase in benefits due a change in stock size and these are equal under the single park and the disjoint ones. Economically, there is thus no difference between having a transfrontier park or several disjoint ones.

Solving for the explicit stock levels shows the same result for both the disjoint area and the aggregated parks and the stock level is given by<sup>10</sup>:

$$S^* = \frac{(r+\beta-\delta)KPe+rw + \sqrt{[(\delta-r-\beta)KPe-rw]^2 - 8rPe\delta wk}}{4rPe}$$

However, we can point out a number of cases in which single transfrontier park would be a better tool for conservation as opposed to several disjoint parks. The following considerations make a single transfrontier park a better conservation technique than several disjoint ones.

- In most cases, park boundaries are based on governance demarcations and not along natural habitat boundaries or ecosystems boundaries. If Area 1 and 2 are demarcated along these political boundaries, then natural migration patterns and breeding grounds are affected. Area 1 may encompass the main breeding habitat, but due to fencing off along governance lines, the species as a whole may not have adequate access to this. This ultimately affects the rate of growth as it would be lowered since migration patterns and breeding grounds are restricted. A single Transfrontier park that removes these artificial barriers, and bases management along ecosystem boundaries would have a higher total stock level.
- A transfrontier park if effectively managed will result in lower running costs due to the scale effect. In the case of a present value maximizing owner, a larger park

<sup>10</sup> See Appendix 1 for specific functional forms assumed.

will have lower overhead costs per person who visits the park, as the owners take advantage increasing returns to scale on revenues and proceeds. Instead of incurring the same overheads, overheads are split among the different areas proportionately and this increases the net benefits available for distribution, either to the owners for more conservation benefit or to the local communities.

Considering this scale effect, a single transfrontier park, we conclude from a conservation perspective, is better than several disjoint ones. A park managed along estuarine and ecosystem boundaries will have fewer disruptions to animal migratory and breeding patterns, allows for natural spatial dispersal of species and thus will result in more biodiversity and a higher stock of animals.

### **Conditions for cooperation**

One of the key issues that impact the success or failure of conservation effort in is the involvement of the local communities. Communities may disrupt conservation effort because it denies them access to the land. Extension of conservation areas may involve relocating people to other areas or reducing the size of their farmland. Damage causing animals also destroy their crops and in cases without well defined property rights communities may have distaste for any governance system imposed on them, with regards to how they may or may not interact with the wildlife around them subject to a sense of ownership, or a lack thereof. It is therefore crucial that in transfrontier park management, the local communities are involved to the extent that their objectives and those of the conservation authorities are synchronised. Without this synchrony, the conflict of interest that would result may cause the conservation objectives to fall short of their potential.

In the case of transfrontier parks, this problem poses a bigger challenge than internally contained reserves as due to their size, there could be significant populations to consider. As in the case of the Greater Limpopo Transfrontier Park, these people actually belong to different countries and the nature of benefits and costs they face from the park would be

different. Management authorities have to find a way to deal with this possible threat to conservation and this section gives insight into the necessary conditions that should prevail before the locals may be expected to cooperate.

The general consensus in the literature is that local people will cooperate with conservation effort as long as they stand to benefit from the cooperation (see Swanson and Babier 1992; Mangel. et al 1996; Johannesen and Skonhøft, 2004). What is this level of benefit that they require to cooperate?

Local communities are considered to be those people who live within and or around the boundaries of the transfrontier park. The paper assumes that they engage in two main activities, agricultural production and wildlife hunting. It is also assumed that the individual community members have the same preferences and production capacities and thus can be collapsed into one representative agent. (These are the same assumptions applied in Johannesen and Skonhøft (2004))

This representative community has two sources of subsistence, it can work on the land for agricultural produce or may hunt game from the park for food. As the paper wants to establish the minimum conditions for cooperation, initially assume that property rights solely belong to private owners of the resource. These private owners are pure profit maximizers, i.e. economic profit is their sole priority. Tourism revenues and revenues from the park are directly linked to the stock of animals, level of biodiversity and thus their goal is to have the largest stock of animals permissible and as much bio-diversity as possible. To this effect, the pure profit maximiser has the same objectives as the conservist, as the revenue stream is directly dependant on the stock of game and biodiversity. The profit maximiser maximizes inter-temporal profit and the rate of return obtained from the park is as in equation (v).

With no property rights, all forms of hunting are illegal, but due to the size of the park area, it is impossible for the private owners to exclude the community completely. Net benefits for the community come from the agricultural productivity and illegal hunting.

Costs come in the form of productivity costs and hunting costs. With this simplification, the community will make economic decisions based on this net benefit function specified as follows:

$$(vi) NB = PA(E) + PH(E, S) - C(E_a) - C(E_H)$$

Where:  $NB$  is the net benefit.

$P$  is the price of agricultural produce and harvest<sup>11</sup>

$A(E)$  is the output from agriculture

$H$  is the amount of harvest from hunting

$C(E_a)$  is the cost of agricultural effort

$C(E_H)$  is the cost of harvesting effort

Agricultural productivity varies from season to season, depending on variables such as rainfall and natural disasters, the area under cultivation, fertilizer and pesticides and the level of effort used. The paper assumes all other factors, except the level of effort, to be constant. This makes the net benefits from agricultural productivity a function of the level of effort only.<sup>12</sup> With no property rights, there is no guarantee for lifetime benefits from hunting, thus the community makes decisions on how to allocate effort between the two sources of livelihood intra-temporarily, in this case seasonally.

The problem of the community is thus to maximize equation (vi) with respect to effort, subject to the total level of effort that is available in a season. The conditions for a maximum are:

$$\frac{dNB}{dE} = PA_E + PH_E - C_{E_a} - C_{E_H} = 0$$

<sup>11</sup> The community makes decisions based on a quantity of produce that costs the same as some known quantity of wildlife harvest.

<sup>12</sup> This assumption allows us to focus on impact of the community on the game reserves and given in most of these communities the production methods are labour intensive anyway, the amount of time spend working on the land, i.e. effort, is the largest determinant of final output.

This can be expressed alternatively as:

$$PA_E - C_{E_a} = C_{E_H} - PH_E$$

When maximizing seasonal benefits, the community will attribute extra effort to hunting until the marginal net benefits between hunting and agricultural activity are the same

During each season, the community ensures that the marginal benefit from agricultural productivity,  $(PA_E - C_{E_a})$ , is equal to the marginal loss from harvesting<sup>13</sup>,  $C_{E_H} - PH_E$ .

As long as the owner can produce a flow of net benefits per season equal to the marginal productivity of agriculture, then the community will be maximizing welfare. This flow of benefits should impose an effort cost equal to the cost of agricultural effort.

In conclusion to this section, as long as the flow of benefits from the park to the community in each time period is greater than the marginal net benefit from their alternative source of livelihood, the community will be maximizing welfare and from an economic incentive point of view, has no reasons to disrupt conservation effort.

This however has interesting implications to the management of transfrontier national parks. The minimum flow of benefits for a community to cooperate to the conservation effort should be equal to the marginal productivity of the community's alternative source of income. As such transfrontier parks should be cheaper to manage in areas whose communities face very limited production possibilities as compared to communities who have wider possibilities.

## Chapter 5: Policy implications

The institutional framework surrounding the management of transfrontier parks is crucial to the success of the park. Given that the present value maximizing model can will lead to

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<sup>13</sup> Since  $PH_E$  is greater than  $C_{E_H}$  the marginal loss will be a negative value therefore it would represent a marginal benefit.

an optimal utilization of resources, this paper argues that the role of government and organisations should be limited to institutional development that aids and promotes private ownership, but with a profit sharing scheme that ensures the cooperation of the local people. What are these roles and responsibilities therefore?

Governments should primarily ensure congruent legislation between countries involved. Disparities in legislation give rise to unequal benefit schemes and this would result in an imbalance of benefits from the park. In cases where this has not been done effectively, local communities have benefited unequally and this has led to a breakdown in cooperation. In the case of the African elephant, governments should ensure that all legislatures pertaining to the species is the same in all the three countries. Rules pertaining to the movement, control and export of the animals have to be aligned such that there is a common base for operation between the countries involved.

Of particular importance are the rights and responsibilities of the local people and their constitutional rights. In cases where constitutions state that the local people may not be moved, complex implications may arise where the area under management has to be increased for greater conservation, for example.

Well defined property rights are essential. Without well defined property rights, benefit schemes are affected and disputes over rights and privileges are rife. The owners of the resource should be known and so should be their rights and responsibilities. To this effect, organisations should ensure an effective policing mechanism that will be responsible for bringing to book those who infringe any of the rules.

Governments should seek to restore natural ecosystem boundaries and equalize management capacity between the different countries. Between the three countries involved in the Greater Limpopo Transfrontier Park, infrastructural differences are huge and this affects the conservation effort in two main ways. Firstly, it results in habitat quality differences which in some cases will result in lower stock levels. Using the migration functional form assumed in this paper, a habitat which allows for restraint of

poachers will have a higher stock of animals. This will lead to less harvesting costs and increased tourism revenue for the park authorities. The area will thus gain at the expense of the other and a breakdown of the relationship may follow.

Governments should ensure that the management capacity of all the different management authorities is the same, to the extent that they may be able to carry out agreed instructions and within the required timeframes. With equal management capacity, and habitat homogeneity, the net benefits accruing to all member stakeholders are structurally the same, and it should be easier to achieve coordinated activity.

Government should align conservation goals between countries. Conservation ideas and approaches vary and this may lead to conflict when the goals of the transfrontier park are different between countries. A country whose elephant population is thriving may be concerned more about efficient extraction of benefits and less about preservation. In such cases there would be conflict and conservation effort will stall. To this effect government should ensure identical park management regimes, and this paper would advocate the present value maximizing regime. Governments should ensure that all park authorities in the three countries take this view in their management. The same management regimes will ultimately align cost structures and benefit flow and this will result in cooperation.

## **Chapter 6: Conclusion**

The paper begins by an analysis of whether it is better to have a single park or several disjoint ones. Economically, it makes no difference, when operating under the same institutional environment. However, from a conservation perspective, a single transfrontier park is better, as it introduces a scale effect, with potentially higher growth rates of species, due to habitat preservation and maintenance of seasonal patterns and breeding grounds. This ultimately increases conservation and biodiversity.

Local communities are an important stakeholder in this conservation effort, without whose support conservation may be difficult, fail to achieve its full potential or merely be a failure. Local communities will thus have to be included in the benefit stream and the paper shows that as long as the stream of benefits from the park authority is greater than the stream of benefits from the alternative source of income, they would cooperate as they face an opportunity cost for not cooperating.

Lastly, the paper discusses the threshold of organisational involvement that is required to make management of fugitive natural resources. In this regard, organisations are responsible for setting up an institutional framework that ensures a mutual goal in managing the park and that allows for equalising the benefits between the different management authorities to keep the end objectives the same.

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## Appendix

### Appendix 1

$$\text{Maximise PV} = \int_0^{\infty} [B(H_t, S_t) - C(H_t, S_t)] e^{-\delta t} dt$$

$$\text{Subject to } \frac{dS_t}{dt} = rS_t \left(1 - \frac{S_t}{K_t}\right) - H$$

$$\text{And initial stock level } S(0) = S_0$$

$$H^c = [B(H_t, S_t) - C(H_t, S_t)] + \lambda \left[ rS_t \left(1 - \frac{S_t}{K_t}\right) - H_t \right]$$

#### FOC

- i.  $\frac{\partial H^c}{\partial H} = 0 = \frac{dB}{dH_t} - \frac{\partial C}{\partial H_t} - \lambda_t$
- ii.  $\frac{d\lambda_t}{dt} = \delta \lambda_t - \lambda_t \left[ r - 2r \frac{S_t}{K_t} \right] + \frac{\partial C}{\partial S_t} - \frac{dB}{dS_t}$
- iii.  $\frac{dS_t}{dt} = rS_t \left(1 - \frac{S_t}{K_t}\right) - H_t = 0$

Solving for the steady state stock levels.

$$\text{Assume: } B(H_t, S_t) = P(H + \beta S), C = wE, \text{ and } H = eES$$

$$H^c = P(H + \beta S) - \frac{wH}{eS} + \lambda \left[ rS - \frac{rS^2}{K} - H \right]$$

$$\text{From i, } P = \frac{w}{eS} + \lambda$$

$$\text{From ii, } 0 = \delta \lambda - \lambda \left[ r - \frac{2rS}{K} \right] - \frac{wH}{eS^2} - P\beta$$

$$\text{From iii, } H = rS - \frac{rS^2}{K}$$

Solve the three simultaneous equations to get

$$S^* = \frac{(r + \beta - \delta)KPe + rw \pm \sqrt{[(\delta - r - \beta)KPe - rw]^2 - 8rPe\delta wk}}{4rPe}$$

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