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Methodological and Ideological Options

# Reconciling interests concerning wildlife and livestock near conservation areas: A model for analysing alternative land uses

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ABSTRACT

Land use decisions are central to both biodiversity conservation and rural development goals at local, national and international levels. Transfrontier Conservation Areas (TFCAs), now common in Southern Africa, present an opportunity to address these goals simultaneously. This paper proposes a theoretical spatial land allocation model that enables analysis of alternative scenarios for realising rural development and biodiversity conservation within TFCAs. The model includes socioeconomic and ecological factors such as income, fencing, connectivity, predation and disease costs and allows for clarification of opportunities and tradeoffs in land use. The model demonstrates alternative spatial options for diversification in land use, whilst accommodating the connectivity requirements and endogenous effects of wildlife on other land uses. The model is illustrated using several scenarios which include changes in key parameters, and limitations on total land allocated per land use. Illustrated scenarios show that land allocated to different land uses varies with output prices and costs such as fencing and wildlife damages, resulting in different spatial land use allocations. In addition, total revenue also changes when limitations are placed on land allocated to wildlife and tourism uses. The model can be used to reconcile interests where conservation and agricultural development activities compete for land.



## 1. Introduction

Transfrontier Conservation Areas (TFCAs) in Southern Africa represent a new approach to conservation which promotes transboundary resource management (Wolmer, 2003), whilst linking conservation with rural development objectives. The TFCA concept recognizes that sustainable wildlife conservation goes beyond boundaries of protected areas, and encourages multiple land use practices in rural areas next to protected national parks (Metcalfe and Kepe, 2008; Munthali, 2007). Agricultural and wildlife based land uses, such as wildlife ranching, ecotourism, livestock production, and cropping can be practiced in areas next to protected areas, thereby improving rural livelihoods whilst promoting biodiversity conservation (Cumming et al., 2007; Metcalfe and Kepe, 2008; Munthali, 2007). These rural areas, sometimes called 'buffer zones', are usually characterized by high levels of poverty, unemployment and environmental degradation (Munthali, 2007).

The integration of wildlife and agricultural land uses, however, often gives rise to several concerns for rural communities. These include risk of disease transmission between wildlife and livestock (Bengis, 2005), wildlife damage costs to crops and livestock (Metcalfe and Kepe, 2008; Naidoo et al., 2006), competition for grazing (Bulte and Horan, 2003), and costs of foregone opportunities when land is used for wildlife (Naidoo et al., 2006; Norton-Griffiths and Southey, 1995). In addition, several questions arise pertaining to spatial location of wildlife reserves vis-à-vis other land uses (Önal and Briers, 2003; Polasky et al., 2008), connectivity of reserves (Nalle et al., 2002; Önal and Briers, 2003; Schulz and Skonhoft, 1996), and the amount of land allocated to wildlife (Bulte and Horan, 2003; Tomlinson et al., 2002). The challenge for land use planning in rural areas adjacent to protected areas is to integrate all these factors in decision making. Such decisions would require an approach to determine suitable spatial location of various competing land uses and integrating them into already existing patterns of settlement and land use. Of additional importance is analysis of the tradeoffs of alternative spatial land uses, to achieve specific socio-cultural, economic and ecological objectives.

It has been noted that approaches to environmental planning and decision making that do not consider the ecological, socio-cultural and economic values of land, often result in single-function land use types that are not sustainable (de Groot, 2006). Spatial analysis of how wildlife related land uses can fit in with existing patterns of settlement and agricultural practices can guide land use planning in TFCAs. In the Great Limpopo Transfrontier Conservation Area (GLTFCA), straddling Zimbabwe, South Africa and Mozambique, several questions have been raised regarding the compatibility and related tradeoffs of existing and emerging land uses within buffer zones (Cumming et al., 2007; Munthali, 2007). The buffer zone, also known as the human/wildlife/livestock interface (hereafter referred to as the interface) is a mosaic of human settlement, livestock grazing, private game reserves and cultivation. Assessment of the

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tradeoffs between different land uses in respect of livelihood objectives, environmental considerations and veterinary considerations is required to guide decision making and sustainable conservation practices in the GLTFCA (Cumming et al., 2007) and other TFCAs in the region.

The need to consider spatial location of different land use alternatives arises from several factors, four of which are particularly relevant to TFCAs in Southern Africa. First, it is not clear what types of land use activities are suitable within the immediate vicinity of protected areas due to existing problems of crop and livestock damage by wildlife. Second, environmental conditions vary spatially, and so does the suitability of locations for different land uses. Third, wildlife reserve planning requires that issues of connectivity and shape are considered (Önal and Briers, 2003; Williams et al., 2005). Fourth, besides the size of wildlife reserves, border length is important as longer fences are more expensive to maintain and broaden the interface, thereby increasing the problems of human–wildlife conflict.

This paper develops a theoretical model for assessing the potential for alternative land uses at the interface, using the case of the GLTFCA. The model considers socio-economic, spatial and physical characteristics such as vertical slope and carrying capacity of the land, and enables analysis of benefits and costs of different land uses, in relation to existing geographical features. We further propose extensions to the model regarding the spatial attributes of the location of wildlife-based land use, by applying a technique to determine the location of wildlife land uses within specified connectivity constraints, and considering externalities between land uses by making disease and depredation from wildlife endogenous to the land allocation model. These connectivity issues and the endogenous nature of wildlife externalities have not, to our knowledge, previously been applied in studies on land use modelling in Africa. Although the specific case sketched in this paper pertains to TFCAs, the model developed is more general and highlights key issues to consider in integrating socio-cultural, economic and ecological concerns for conservation and rural development planning. It can be modified to suit other situations outside TFCAs where there is need for evaluating alternative conservation and agricultural land uses.

## 2. The Case Study: Competing Claims for Land in the GLTFCA

We consider the case of rural communities that lie adjacent to the north-western border of Kruger National Park (KNP), South Africa (Fig. 1). The communities are within the designated GLTFCA. The area has potential for wildlife tourism because of its proximity to the KNP. At present the predominant land use is livestock farming and dryland cropping. The area has low rainfall levels and experiences frequent droughts hence it is not suitable for dryland cropping (Thulamela Local Municipality, 2009). The Luvhuvhu River runs through the area and is part of the northern catchment area of the Limpopo River which it joins in the KNP.

Grazing land, although legally state land, is administered by a traditional authority and access is open for all members of the community. Four competing, potential and existing land uses which are in line with the broader vision of the GLTFCA have been identified from the local municipality's integrated development plans (Thulamela Local Municipality, 2009). The land uses are (i) wildlife ranches with an option for trophy hunting; (ii) livestock farming; (iii) tourism with accommodation facilities; and (iv) irrigated crop farming.

Very little wildlife currently exists on communal land. Most of the wildlife exists inside the KNP, which is currently separated from the villages only by a fence. Based on what has happened on the western boundary of the KNP, where fences were removed between the KNP and private game reserves (APNR, 2005), it would be possible to take down part of the KNP fence to allow wildlife based activities such as trophy hunting and wildlife viewing to take place on communal land. Such plans would however require a direct or indirect connection between the park and the land reserved for wildlife in the buffer zone. Other considerations to be made on movement of wildlife from the park into the buffer zone would require compliance with national regulations on disease control and movement of livestock and wildlife as set out in the amended Animal Diseases Act No. 35 of 1984 (National Department of Agriculture, NDA, 2000). It is not possible to sell live wildlife or wildlife products due to the restrictions imposed by this act. Hence, wildlife ranching revenues would mainly be generated from trophy hunting and wildlife viewing. Furthermore, fencing would be required for land allocated to wildlife. These issues are considered in the model specification in this paper.

## 3. Land Use Modelling in Conservation and Agriculture

### 3.1. Overview of Land Use Models and Wildlife Management

The land use model described follows earlier models by Bulte and Horan (2003), Schulz and Skonhoft (1996), and Tomlinson et al. (2002) but introduces novel elements that enable analysis of competing claims for land within the context of TFCAs. These models, although addressing land use decision making in wildlife/livestock systems, neither explicitly consider the spatial dimensions of land use at the interface, nor address the critical question of where to locate alternative land uses. Studies on spatial analyses of nature conservation and reserve selection have largely been conducted in western countries (see for instance Nalle et al., 2002; Önal and Briers, 2003; Polasky et al., 2008). In South Africa, reserve selection studies include Eeley et al. (2001), who considered indigenous forest reserve selection, and Freitag et al. (1996), on the species set covering problem in reserve selection for conservation of large mammals.

Connectivity has been considered in models that address both ecological and economic concerns through optimization models in general reserve selection (Groeneveld, 2010), bird migration (Williams et al., 2003) and wildlife reserve selection (Nalle et al., 2002). Williams et al. (2005) distinguish structural connectivity, which refers to the physical adjacency of reserve sites, from functional connectivity, which is related to species responses to landscape breaks. Structural connectivity is not species-specific and is an important attribute to be considered in all cases where land use decisions are made that involve wildlife. Williams et al. (2003) determine the suitability of specific sites as stopover sites for migratory birds flying over the Atlantic flyway. They proposed a set of restrictions that ensured that each stopover within the network had another new or existing stopover site to its north or south, and within a specific distance. In specifying this model, a series of restrictions are laid out based on the location and distances of the counties which are supposed to harbour the stopover sites. The model which considers both ecological and economic objectives as indicated by wetland prevalence and land costs is solved as an integer problem.

Although most connectivity studies have been built on ecological foundations, this study considers connectivity as essential in two respects: (i) wildlife ranches adjacent to the park have lower costs of getting the wildlife from the park to the communal land; and (ii) under the same wildlife ranch area, longer border length implies higher costs of fencing, maintenance, and damage to livestock. These are no ecological considerations but practical, technical spatial considerations. Such considerations build on the model formulation proposed by Williams et al. (2003).

Fencing is an important factor to consider in the development of wildlife reserves (ABSA, 2003). Fences have the potential to limit disease transmission by restricting contact between wildlife and livestock, whilst also protecting crops from wildlife destruction. One way to include the costs of fencing in modelling is to consider the boundary length, which also measures the compactness of a reserve site (Williams et al., 2005). We explicitly model the costs of fencing which are an important investment cost that is considered in converting rangeland to wildlife use whereas Schulz and Skonhoft (1996) do not consider these costs.

In this study we use an optimization approach to explicitly model land use decisions, with the intention of exploring the possibility to introduce wildlife conservation and tourism in an area that is currently used mainly for livestock. In this regard, we believe that this study