Research Letters

Natureza & Conservação
Brazilian Journal of Nature Conservation

Natureza & Conservação 8(2):177-183, December 2010

Handling Editor: Rafael Dias Loyola
doi: 10.4322/natcon.00802012

The Opportunity Cost of Conserving Amphibians and Mammals in Uganda

Federica Chiozza, Luigi Boitani & Carlo Rondinini*

Department of Biology and Biotechnology, Sapienza Università di Roma, Viale dell'Università 32, 00185, Roma, Italy

Abstract

Despite substantial conservation efforts, biodiversity continues to decline and further conservation action is needed. This imposes significant opportunity cost on local communities, particularly in developing countries where livelihood depends strictly on land use and agricultural activities. Incorporating socio-economic data into methods for the identification of conservation priorities can reduce conflicts between socio-economic development and biodiversity conservation. We present a systematic selection of priority sites for the conservation of 353 Ugandan mammals and amphibians. We used the suitable habitat as an estimate of the area potentially occupied by each species inside its geographic range, and estimated the opportunity cost based on data on agricultural profit. We used the software Marxan to identify the sites that need to be added to the existing protected areas (IUCN categories I-IV) to conserve Ugandan mammals and amphibians at a minimum cost. In addition to the existing protected areas, covering *ca.* 17,100 km^2, *ca.* 57,500 km^2 of land should be protected to achieve the conservation target for amphibians and mammals, bringing the coverage to *ca.* 38% of the country. The sites that are irreplaceable for the target achievement occupy *ca.* 32,800 km^2, are mostly located in the Western and Eastern regions and overlap with the Eastern Afromontane hotspot and the Albertine Rift. The yearly agricultural profit from these sites amounts to *ca.* 540,700,000 US$, or 16,524 US$/km^2 (2008 value).

Key words: Conservation Planning, Conservation Priority Setting, Conservation Conflict, Agriculture, Habitat Suitability Model.

Introduction

Despite substantial conservation efforts, biodiversity continues to decline (Hoffman *et al.* 2010). Further conservation action is thus needed, but this imposes a significant opportunity cost (the income and other benefits from land use, investment and development opportunities precluded or diminished by the need to maintain biodiversity (Emerton & Muramira 1999) on local communities. This is particularly true in developing countries, where livelihood depends strictly on land use and agricultural activities (Norton-Griffiths & Southey 1995).

Opportunity cost varies substantially across sites (Adams *et al.* 2010, Naidoo *et al.* 2006, Polasky *et al.* 2001), and this is reflected in variable cost-effectiveness of alternative conservation plans. It has been demonstrated that conservation plans that consider or not consider opportunity cost can protect similar numbers of species, but the former are much cheaper (Naidoo & Adamowicz 2006). The biggest limitation in incorporating cost in conservation plans is the scarcity of spatially explicit data, especially for developing countries. In these cases proxies of cost are used, such as human population density or the distribution of infrastructures (Williams *et al.* 2003), but in order to be effective, the surrogate measures chosen should estimate actual cost, or at least have a strong spatial correlations with actual cost (Adams *et al.* 2010).

Uganda is a global biodiversity hotspot (Mittermeier *et al.* 2004) and includes some the richest spots in Africa in terms of vertebrate species (Rondinini *et al.* 2005), but its protected area (PA) coverage is relatively low (IUCN & UNEP 2010). Rapid population growth, high population density and heavy reliance on subsistence agriculture for income and park resources for subsistence characterise areas surrounding National Parks (Archabald & Naughton-Treves 2001). Conflicts with local communities in several National Parks are still a major concern for Uganda Wildlife Authority, and a negative attitude towards conservation persists in local people (Chhetri *et al.* 2003). Consideration of opportunity cost to minimise further socio-economic conflict would provide added value to plans for the conservation of biodiversity in Uganda.

In this paper we used the software Marxan to systematically identify sites to be added to the existing PA network to protect the Ugandan amphibians and mammals, while

***Send correspondence to:** Carlo Rondinini
Department of Biology and Biotechnology,
Sapienza Università di Roma, Viale dell'Università 32,
00185, Roma, Italy
E-mail: carlo.rondinini@uniroma1.it

minimising the cost of the conservation plan. We estimated the area potentially occupied by each of 353 species of Ugandan mammals and amphibians as the area of suitable habitat inside their geographic ranges (Rondinini *et al.* 2005; Rondinini & Boitani 2006). We used data on agricultural production and net profit value derived from agricultural activities to estimate agricultural opportunity cost.

Material and Methods

Estimation of the area potentially occupied by species

We determined the geographic ranges for 377 African vertebrates (65 amphibians and 312 mammals) whose distribution falls within Uganda's administrative boundaries. To avoid planning reserves for species for which Uganda is at the edge of their geographic distribution, 24 marginal species were excluded from the analysis. These species have less than 1% of their extent of occurrence falling within Uganda's administrative boundaries and occupy less than 1% of Uganda land area.

For 341 of these species we determined the area of suitable habitat inside the geographic range (at 1 km^2 resolution) using species' habitat preferences. We obtained the data from the literature and experts (in collaboration with the IUCN Global Amphibian Assessment and the IUCN Global Mammal Assessment) and built on an existing database on large- and medium-size African mammals (Boitani *et al.* 1999). We reclassified as suitable or unsuitable the land classes of a land cover map (United States Geological Survey 2000), the elevation values from a digital elevation model (United States Geological Survey 2001), and the distances to water from a map of water bodies and water courses (Environmental Systems Research Institute 1993). For each species we used the intersection of suitable areas from the three environmental layers as the estimated area of suitable habitat. This estimation is more robust than other, more permissive estimates in terms of the prevalence of false positive errors (Rondinini & Boitani 2006), which are dangerous in conservation because they may lead to the protection of sites that do not contain the species of interest (Loiselle *et al.* 2003, Rondinini *et al.* 2006). The modeling procedure and validation of results are fully described elsewhere (Rondinini *et al.* 2005). We performed all the cartographic data processing with ArcInfo GIS 8.3 (Environmental Systems Research Institute, CA, USA).

For 12 poorly known species we were unable to collect enough information regarding species-habitat relationships, which prevented us from estimating habitat suitability inside their range. However we included these species in the analysis and replaced their missing suitable area with the estimated geographic range. This was necessary as many of these species have restricted ranges and their removal from the sample would underestimate the high conservation value of the sites where they occur.

Agricultural opportunity cost

We used total yearly net profit from agricultural activities (hereafter yearly agricultural profit) as an estimate of yearly agricultural opportunity cost, to estimate the potential benefits foregone as a result of protecting an area rather than using it for agriculture production. We obtained crop statistics from the 2002 Uganda Population and Housing Census (UBOS 2004). The census incorporates an agricultural module inquiring about household-based agricultural activities (MAAIF *et al.* 2010). Since the census included the enumeration of all households, we aggregated the data to small administrative areas (sub-county level). The crop data is supplied for various crops, including coffee and cotton that represent the two major cash crops cultivated in Uganda, in terms of number of plots for each administrative unit, where a crop plot is defined as a piece of land within the agricultural holding on which a specific crop or crop mixture is cultivated (Table 1).

To estimate the average plot size in each administrative unit we divided the total number of plots cultivated by the total cropped area within that unit (UBOS 2004). This value was used to calculate the hectares under a specific crop cultivated in each administrative unit, assuming that all plots within that unit have the same size.

In addition, we obtained data from the National Agricultural Advisory Services (NAADS 2003) on yearly net profit per hectare (expressed in Uganda Shillings) for some of the crop types surveyed by the 2002 Uganda Population and Housing Census (UBOS 2004). Net profit from agriculture indicates the revenue of farm activities and is calculated as the difference between the value of outputs and expenditures (Table 1).

Yearly agricultural profit for each administrative unit was estimated as:

$$\prod = \sum_{j=1}^{J} x_{ji} P_j + x_{ui} \overline{P} \quad (1)$$

where x_{ji} is the area under crop j in the administrative unit i; P_j is the net profit per hectare for crop j; x_{ui} is the area under crop with unknown revenue in the administrative unit i; and P is the average net profit for cultivated crops with unknown revenue.

We converted the value of the yearly agricultural profit from Uganda Shillings in 2002 to US dollars in 2008 using the inflation measured by the consumer price index (World Bank 2010), and the exchange rate.

Systematic selection of conservation priority sites

In addition to the distribution of target species and the cost of land, the analysis for the identification of conservation priority sites required two other pieces of information: 1) the conservation target to be achieved for each target

Table 1. Total number of plots (UBOS 2004) and yearly net profit (NAADS 2003) of each type of crop in Uganda.

Crop	Total number of plot	Net profit (Ushs/ha)
Beans	2 152 076	81 000
Cassava	2 101 580	414 250
Coffee	334 846	530 000
Cotton	109 961	102 700
Cow peas	64 200	225 909
Groundnuts	754 709	211 000
Irish potatoes	146 810	389 500
Millet	750 722	346 250
Onion	31 020	2 028 119
Pineapple	1 800	1 677 956
Rice	86 394	473 000
Simsim	192 504	125 050
Sorghum	763 779	174 900
Soya beans	1 454	165 508
Sweet potatoes	1 439 658	426 500
Tomato	2 980	649 194
Vanilla	9 786	9 075 000

species (Rondinini & Chiozza 2010), and 2) the boundaries of sites (Margules & Pressey 2000).

For species whose area of suitable habitat was smaller than 1,000 km^2 we set the conservation target to 100% of this area; for more widespread species, with area of suitable habitat greater than 10,000 km^2, we set the target to 10% of this area; for species with intermediate area of suitable habitat, we interpolated the conservation target between these two extremes, proportionally to the log of the area of suitable habitat. In an earlier analysis we demonstrated that the use of different targets resulted in only minor differences in the site selection outcome (Rondinini *et al.* 2005).

In order to generate a map of sites we selected the Ugandan reserves from the World Database on Protected Areas (IUCN & UNEP 2010). For this analysis only those protected areas that qualified as IUCN categories I to IV were included. We generated a grid of squares of 25 km^2 to divide the rest of the country into planning units selectable in the site selection analysis. Cells with an area smaller than 12.5 km^2, found along the country administrative boundaries or generated by the intersection of the grid with the protected area map, were removed by merging them with the adjacent ones. Uganda was so subdivided into 8,970 planning units of which 21 are represented by national protected areas with IUCN category I to IV.

We performed the site selection analysis with the software Marxan (Ball & Possingham 2000).We selected the analysis input parameters as follows: algorithm, simulated annealing; number of simulations, 10,000; iterations per simulation, 100,000; number of temperature decreases per simulation, 20,000; choice of the initial temperature and cooling factor, adaptive; and boundary length modifier, 200. Marxan simulations produced 10,000 different solutions to the conservation problem. The selection frequency of each site is therefore an estimate of the overall value of the site for the achievement of the conservation target. The sites selected 10,000 times (*i.e.* with selection frequency equal to 1) were likely to be necessary to the achievement of the target, conditional to the parameters set for the problem. Hereafter these sites will be referred to as irreplaceable. It is important to note that irreplaceability estimated through selection frequency is not absolute but conditional to the problem constraints, including the cost of sites. If for example two sites, one cheap and one highly expensive, contain the same species, the former but not the latter may be always selected (*i.e.* be considered irreplaceable).

Newly selected sites were added to the existing IUCN protected areas I-IV. We assigned a penalty factor of 100 for each species missing in the final reserve system. This way we ensured that the target was met for all species in the selected systems of reserves. To allow conservation targets to be achieved at the minimum cost, we used the opportunity cost from agriculture activities as the monetary value of each planning unit. The software and all procedural details are freely available online from: http://www.ecology.uq.edu.au/marxan.htm (accessed October 2010).

Results

The yearly agricultural opportunity cost of land in Uganda varied from 0 to 55,320 US$/km^2 with an average value of 13,733 US$/ km^2 (2008 value). Western and central regions were the ones with the highest mean values of land, with most of the high-value land concentrated along northern shores of Lake Victoria (Figure 1).

The land surface occupied by the existing IUCN protected areas of categories I to IV is approximately 17,100 km^2 corresponding to 8.7% of Uganda. In order to achieve our conservation target for 59 amphibians and 294 mammals, another 57,515 km^2 (29.1% of the country) was necessary. Of these, 32,723 km^2, corresponding to 57% of the total area selected for complementing the current Uganda reserve system, were irreplaceable.

The irreplaceable sites were mainly clustered in the western and eastern regions of Uganda (Figure 2). Those in the western region were mainly found along the administrative boundary with Democratic Republic of Congo and Rwanda, while the block of irreplaceable sites in the eastern region surrounded the Mt. Elgon Nature Reserve. Other irreplaceable sites were found along northern shores of Lake Victoria and in the northern region along the administrative boundary with Kenya.

Overall, the yearly agricultural profit from the sites that are irreplaceable for the conservation of Ugandan mammals and

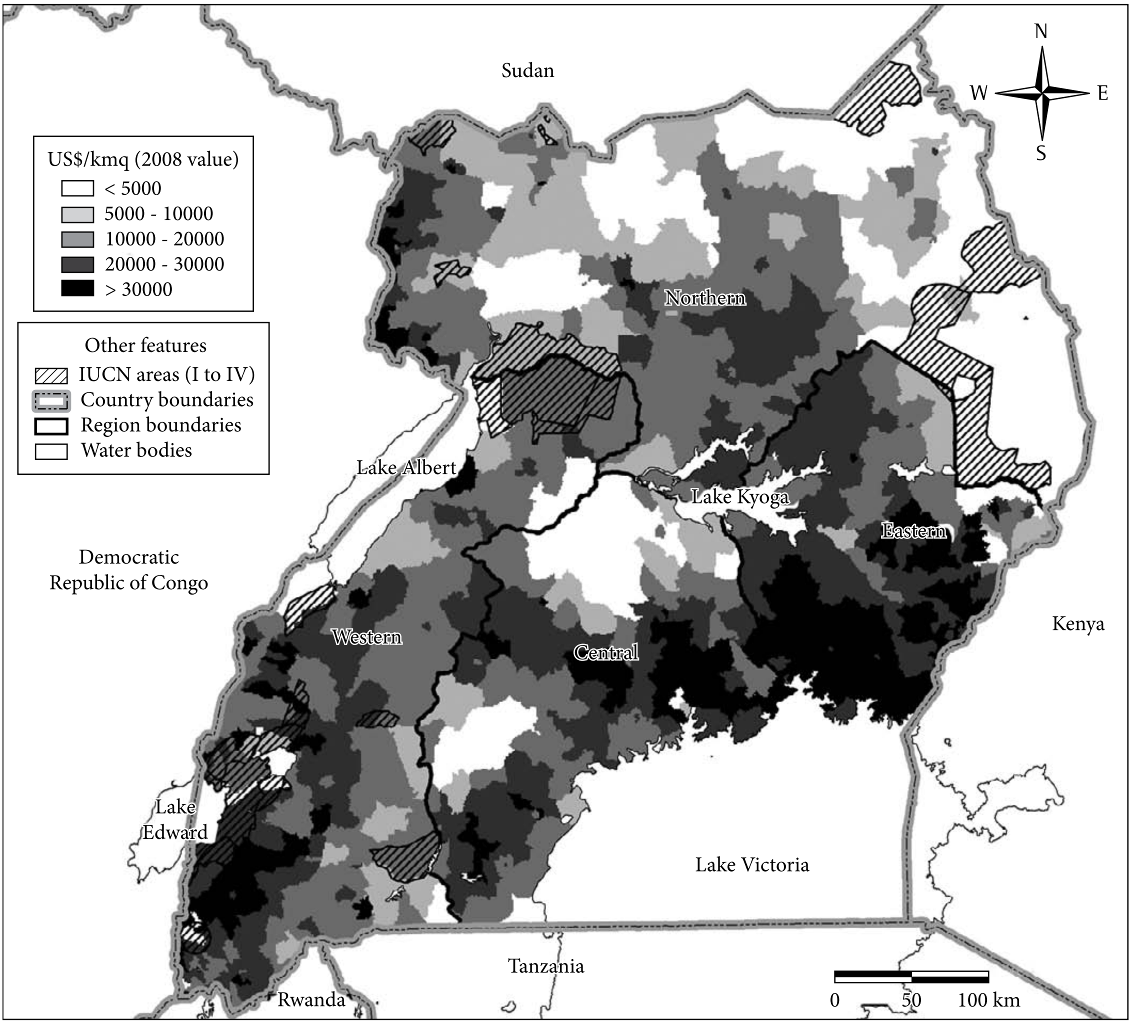

Figure 1. Annual revenue from agriculture in Uganda.

amphibians amounted approximately to 540,700,000 US$, equal to 16,524 US$/km^2. The yearly agricultural profit of the most efficient Marxan solution (including all the irreplaceable sites plus other replaceable sites needed to achieve the conservation target for amphibians and mammals) was 772,850,000 US$ or 13,437 US$/km^2.

Discussion

Our approach to estimating opportunity cost relied on a number of assumptions. We assumed that all plots in an administrative unit are the same size. We are aware that if conditions, such as rainfall distributions, soils and topography are suitable, usually the plots cultivated with cash crops are very different in terms of size to the plots cultivated with crops for subsistence farming, thus we may have somewhat underestimated the profit of each administrative unit. We only estimated the agricultural profit of land, and we assumed that productivity and profit for each crop type were even across the country. Agriculture is not the only reason for land to be valuable. Other types of land use, such as timber and mining extraction, can make land valuable and difficult to set aside for conservation. Yet agriculture plays a key role in Uganda's economic development. Uganda has put emphasis on the agricultural sector as a strategy for raising rural incomes and reducing rural poverty (NEMA 2005). For the majority of Ugandans, the agricultural sector (including crops, livestock, and fisheries) is the main source for livelihoods, employment, and food security (MAAIF *et al.* 2010). Despite its slow decline in the past years due to a number of reasons (including drought, instability, pest outbreaks, and productivity and price declines for selected crops and commodities, NPA 2010), combined with the faster growth in the services and industrial sectors, the agriculture's share of Uganda's Gross Domestic Product (GDP) was 38% in 2009 (World Bank 2010). The sector provided 73.3 percent of employment in 2005/06, and most industries and services in the country are dependent on it (UBOS 2009).

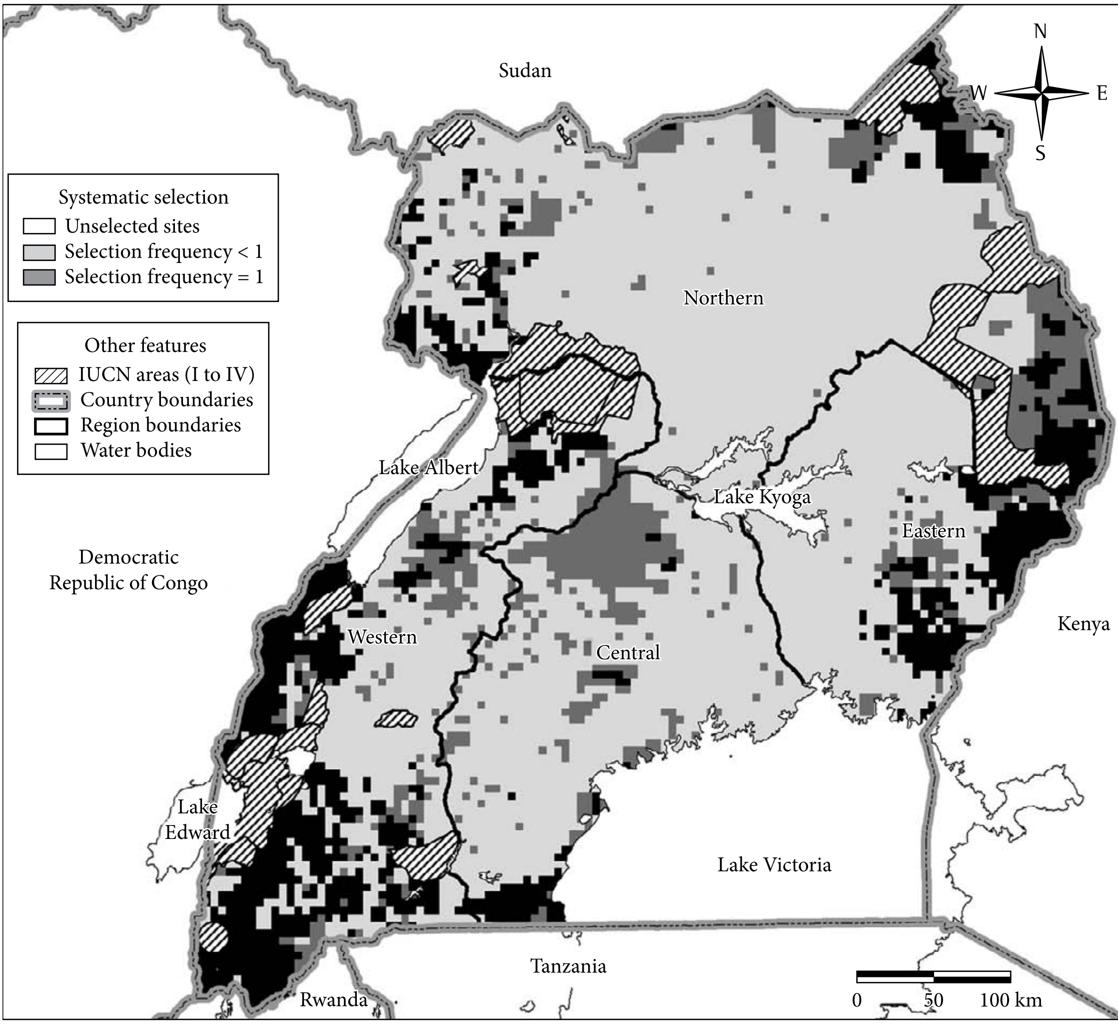

Figure 2. Irreplaceability of sites in Uganda, *i.e.* number of times each site was included in a Marxan solution that achieved the conservation target for all amphibians and mammals. Sites with selection frequency = 1 are likely to be not replaceable if the target is to be achieved.

The agricultural profit in Uganda was higher in highlands and in Lake Victoria areas. Lake Victoria shores are characterised by intensive cropping, having soils suitable for agriculture, receiving sufficient rainfall to support perennial crop production and having the most favourable access to infrastructure and markets compared to other regions in Uganda (NEMA 2005). Elsewhere, some 40% of the people in rural areas still live below the poverty line, accounting for 95% of the total number of Uganda's poor; most of them depending on agriculture as their primary source of livelihood (Fan *et al*. 2004).

More than 15% of Uganda appeared to be irreplaceable for the achievement of the conservation target for amphibians and mammals. These sites were mostly concentrated in western and eastern regions, and many of them overlapped with the Eastern Afromontane hotspot already identified as a region with exceptional levels of endemism and by serious levels of habitat loss (Mittermeier *et al.* 2004). South-west Uganda is a key component of the larger Albertine Rift, one of the richest parts of the world in terms of biological diversity (Nantamu 2005). The block of irreplaceable sites in the eastern region correspond to Mount Elgon Nature Reserve. This is a volcanic massif with high conservation and ecological value due to its rare endemic species, valuable forests and water catchment functions (Chhetri *et al*. 2003).

Many sites of the northern region overlapped with areas already identified by IUCN as protected areas with category VI and designated as Controlled Hunting Area. These areas, allowing for a sustainable use of resources, impose a lower opportunity cost than strict reserves. Category VI protected areas are managed to ensure long term protection and maintenance of biological diversity, while providing at the same time a sustainable flow of natural products and services to meet community needs. Categories V and VI protected areas have obvious relevance in the contest of rural poverty as these promote and support traditional livelihoods and cultures as well as protection of biodiversity (Scherl *et al.* 2004).

If the conservation of Ugandan amphibians and mammals were to be achieved through strict reservation, profit in excess of 500,000,000 US $ could be lost annually. Although high, this value represents a small fraction, 12.5%, of the Uganda Agriculture GDP for 2008 (4,332 billion US$, World Bank 2010). Other estimates at a national level have shown that states can incur considerable opportunity costs from the loss of agricultural land to protected areas (Howard 1996, Norton-Griffiths & Southey 1995). For developing countries as a whole, James *et al.* (2001) estimate a total opportunity cost for existing reserves in categories II, III, and IV, occupying 3.62 million km^2, of 4.9 billion US$.

The high agricultural opportunity cost of conservation in Uganda could be reduced by aiming at coexistence and conflict resolution in place of strict reservation, trading off between biodiversity conservation and poverty alleviation. The problem of poverty is acute in Uganda rural areas (Woelcke 2006). Moreover, even if parks generate an economic return, the distribution of these benefits is so skewed against poor rural people that the role of parks in local development is negligible and they neither justly compensate for lost property nor contribute to poverty alleviation (Brockington 2003). These imbalances act as a constraint to biodiversity conservation. This recognition has inspired adoption of different human-inclusive strategies guided by the philosophy that the success of conservation objectives depends strictly by the interests of the communities (Kideghesho *et al.* 2007).

Our approach to minimising conservation conflict relies on agricultural profit, therefore it does not accounts for conservation conflicts sensu Araujo & Rahbek (2007), *i.e.* the coincidence of complementarity areas and sites with high human population density. Indeed, it may be important to explore the trade-offs between minimising the cost of a conservation plan and minimising its impact on rural populations (Adams *et al*. 2010).

Even if we accounted for all reasons for land to be valuable, this would represent only a partial estimate of the economic cost of conservation. Real economic cost include acquisition cost, management cost, and transaction cost (Naidoo *et al.* 2006). Yet, by calculating opportunity cost from a substantial source of profit for a large share of the Ugandan population, our conservation plan can explicitly minimise local socio-economic impacts, reducing local poverty and displacement of communities (Adams *et al*. 2010), and providing a plausible basis for a full conservation plan.

Acknowledgments

We would first like to acknowledge the collaboration offered by Thomas Emwanu, Senior System Analyst at the Uganda Bureau of Statistics (UBOS), and the support and collaboration of Timothy Robinson and Ugo PicaCiamarra (FAO - AGAL). We are grateful to the experts involved in the IUCN Global Amphibian Assessment and IUCN Global Mammal Assessment and in particular to J. Chanson, N. Cox, W. Sechrest, S. Stuart and B. Young.

References

Adams VM, Pressey RL & Naidoo R, 2010. Opportunity costs: who really pays for conservation? *Biological Conservation*, 143:439-448.

Araujo MB & Rahbek C, 2007. Conserving biodiversity in a world of conflict. *Journal of Biogeography*, 34:199-200.

Archabald K & Naughton-Treves L, 2001. Tourism revenue-sharing around national parks in Western Uganda: early efforts to identify and reward local communities. *Environmental Conservation*, 28:135-149.

Ball IR & Possingham HP, 2000. *Marine reserve design using spatially explicit annealing*. Available from: <http://www.ecology.uq.edu.au/marxan.htm>. Access in: July 2007.

Boitani L *et al.*, 1999. *A databank for the conservation and management of African Mammals*. Roma: Istituto di Ecologia Applicata.

Brockington D, 2003. Injustice and conservation: is local support necessary for sustainable protected areas? *Policy Matters*, 12:22-30.

Chhetri P, Mugisha A & White S, 2003. Community resource use in Kibale and Mt Elgon National Parks, Uganda. *Parks*, 13:28-38.

Emerton L & Muramira E, 1999. *Uganda biodiversity*: economic assessment. Biodiversity Economics for East Africa. Nairobi, Kenya: The World Conservation Union - IUCN.

Environmental Systems Research Institute, 1993. *Digital chart of the world for use with ARC/INFO software*. Redlands: Environmental Systems Research Institute.

Fan S, Zhang X & Rao N, 2004. *Public expenditure, growth, and poverty reduction in rural Uganda*. Washington, D.C.: International Food Policy Research Institute, Development Strategy and Governance Division. Discussion paper, 4.

Hoffman M *et al.*, 2010. The impact of conservation on the status of the world's vertebrates. *Science.*

Howard P, 1996. *The opportunity costs of protected areas in Uganda*. In: *IUCN Workshop on Economics of Biodiversity Loss*. Gland, Switzerland.

International Union for Conservation of Nature - IUCN & United Nations Environment Programme - UNEP, 2010. *The World Database on Protected Areas (WDPA)*. Cambridge, UK: UNEP-WCMC.

James A, Gaston KJ & Balmford A, 2001. Can we afford to conserve biodiversity? *BioScience* 51:43-52.

Kideghesho JR, Røskaft B & Kaltenborn BP, 2007. Factors influencing conservation attitudes of local people in Western Serengeti, Tanzania. *Biodiversity Conservation*, 16:2213-2230.

Loiselle BA *et al.*, 2003. Avoiding pitfalls of using species distribution models in conservation planning. *Conservation Biology*, 17:1591-1600.

Margules CR & Pressey RL, 2000. Systematic conservation planning. *Nature*, 405:243-253.

Ministry of Agriculture, Animal Industry and Fisheries - MAAIF, Uganda Bureau of Statistics - UBOS, Food and Agriculture Organization of the United Nations - FAO, International Livestock Research Institute - ILRI & World Resources Institute - WRI, 2010. *Mapping a better future*: spatial analysis and pro-poor livestock strategies in uganda. Washington, D.C.: World Resources Institute.

Mittermeier RA *et al.*, 2004. *Hotspots revisited*: earth's biologically richest and most endangered terrestrial ecoregions. Mexico City: Conservation International and Agrupación Sierra Madre - CEMEX.

Naidoo R & Adamowicz WL, 2006. Modeling opportunity costs of conservation in transitional landscapes. *Conservation Biology*, 20:490-500.

Naidoo R. *et al.,* 2006. Integrating economic costs into conservation planning. *Trends in Ecology and Evolution*, 21:681-687.

Nantamu N, 2005. *The Albertine Rift*: a globally important endangered space harbors the majority of Africa's biodiversity. Kampala: USAID/Uganda. Environmental Brief, 3.

National Agricultural Advisory Services - NAADS, 2003. *Profitability Analysis of Agricultural Enterprises in Uganda.* Kampala, Uganda.

National Environment Management Authority - NEMA, 2005. *State of environment report for Uganda 2004/05*. Kampala, Uganda.

National Planning Authority - NPA, 2010. *National Development Plan 2010/11 – 2014/15*. Kampala, Uganda: NPA.

Norton-Griffiths M & Southey C, 1995. The opportunity costs of biodiversity conservation in Kenya. *Ecological Economics*, 12:125-139.

Polasky S, Camm JD & Garber-Yonts B, 2001. Selecting biological reserves cost-effectively: an application to terrestrial vertebrate conservation in Oregon. *Land Economics*, 77:68-78.

Rondinini C & Boitani L, 2006. Differences in the umbrella effects of African amphibians and mammals based on two estimators of the area of occupancy. *Conservation Biology*, 20:170-179.

Rondinini C & Chiozza F, 2010. Quantitative methods for defining percentage area targets for habitat types in conservation planning. *Biological Conservation*, 143:1646-1653.

Rondinini C *et al.*, 2006. Tradeoffs of different types of species occurrence data for use in systematic conservation planning. *Ecology Letters*, 9:1136-1145.

Rondinini C, Stuart S & Boitani L, 2005. Habitat suitability models and the shortfall in conservation planning for African vertebrates. *Conservation Biology*, 19:1488-1497.

Scherl LM *et al.*, 2004. *Can protected areas contribute to poverty reduction?* Opportunities and limitations. Gland, Switzerland: IUCN.

Uganda Bureau of Statistics - UBOS, 2004. *Report on agriculture module, piggy-backed onto the population and housing census 2002*. Entebbe, Uganda.

Uganda Bureau of Statistics - UBOS, 2009. *Statistical Abstract*. Kampala, Uganda: UBOS. Available from: <http://www.ubos.org/onlinefiles/uploads/ubos/pdf%20 documents/2009Statistical_%20Abstract.pdf>. Access in Oct. 2010.

United States Geological Survey, 2000. *Global land cover characterisation ver. 1.2.* Available from: <http://edcdaac.usgs.gov/glcc/glcc.html>. Access in: Oct. 2010.

United States Geological Survey, 2001. *GTOPO30*. Available from: <http://lpdaac.usgs.gov/gtopo30/gtopo30.html>. Access in: Oct. 2010.

Williams PH *et al.,* 2003. Integrating biodiversity priorities with conflicting socio-economic values in the Guinean–Congolian forest region. *Biodiversity and Conservation*, 12:1297-1320.

Woelcke J, 2006. Technological and policy options for sustainable agricultural intensification in eastern Uganda. *Agricultural Economics*, 34:129-139.

World Bank, 2010. *World Development Indicators database*. Available from <http://data.worldbank.org/>. Access in: Oct. 2010.

Received: October 2010
First Decision: October 2010
Accepted: October 2010