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Abstract: Poaching remains a sensitive and controversial issue, especially amidst a diversity of combined political upheaval and economic turmoil when biodiversity is being lost at an accelerated rate resulting in some of charismatic species becoming plummeted amidst the wave of illegal offtake caused by a number of factors acting in concert. Overall, defaunation and habitat encroachment viewed largely as a function of human action were the two major factors that caused contraction of
large herbivores in both the Kahuzi-Biega and Virunga National Parks. These two show pieces of conservation areas are still grappling with ever-growing population growth in a region where conflict over ownership and control of land and its natural resources poses daunting impediments to community-based development making it more difficult to secure sustainable solutions. This research work seeks to shed light on illegal activity patterns and trends as well as law enforcementeffort implications using a wide range of GIS analysis applications with a focus on the hotspot analysis. Analysis carried out here typically answers four fairly key questions, (i) what is the illegal resource use? (ii) Where is the best illegal activity location? (iii) Who extracts resources illegally? and (iv) Why does illegal resource use occur on recurrent basis? The thesis highlights practical issues which must be addressed to improve the effectiveness of conservation strategies.

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Monitoring Law Enforcement Effort and Illegal Activity in Selected Protected Areas: Implications for Management and Conservation, Democratic Republic of Congo

Leonard Mubalama Kakira, MSc

Promotor: Prof. Dr. Philippe De Maeyer **2010**

Proefschrift ingediend tot het behalen van de graad van Doctor in de Wetenschappen: Geografie

Submitted in accordance with the requirements for the degree of Doctor of Science: Geography

To my parents

In love and gratitude

"*Respect your father and mother" is the first commandment that has a promise added: "so that all may go well with you, and you may live a long time in the land*" **Ephesians 6, 2-3**

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EXECUTIVE SUMMARY

Poaching remains a sensitive and controversial issue, especially amidst a diversity of combined political upheaval and economic turmoil when biodiversity is being lost at an accelerated rate resulting in some of charismatic species becoming plummeted amidst the wave of illegal offtake caused by a number of factors acting in concert. Overall, defaunation and habitat encroachment viewed largely as a function of human action were the two major factors that caused contraction of large herbivores in both the Kahuzi-Biega and Virunga National Parks. These two show pieces of conservation areas are still grappling with ever-growing population growth in a region where conflict over ownership and control of land and its natural resources poses daunting impediments to community-based development making it more difficult to secure sustainable solutions.

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I examined the spatial distribution of wildlife crime incidents in both parks using ArcGIS software, including the hotspot spatial analysis technique. The primary objective was to examine whether patterns existed in the spatial distribution of wildlife crime and to explore the relationship of patterns to other geographic features while making allowances for registering all spatial data layers to common spatial projection to facilitate reliable comparisons between all data layers. The research investigation provided insight into the magnitude of wildlife crime impacts on park management unit level. Predictive understanding of either poaching patterns or wildlife occurrence remains a challenge as both hunter and hunted are elusive. I assessed the spatial scale of illegal wildlife use against target species distribution, habitat types, and patrol effort using the state-of-the art GIS applications. In short, the striking finding to emerge from the study indicates a clear tendency towards threats and wildlife clumping into both hot and cold spots areas. One major management implication is how to best direct wildlife crime prevention and mitigation resources. Decisions support efforts should include identifying places where illegal activity is prevalent and

determining where crime types occur with greatest frequency. In this regard, GIS through spatial analysis can provide a pathway for managers to better understand the relationship between natural resources and crime occurrence. Poaching phenomenon still shows no sign of fading away, hence, the thesis results point out to several avenues of further research where modeling can contribute more to the understanding rule-breaking behavior in conservation, including which factors influence the hunting sustainability and determining the hunting index of catchability.

Although wildlife Acts exist as a global conservation tool for the protection of species, most remain unenforced, especially during wartime when human resources and funding are inadequate to monitor illegal activity and enforce existing wildlife law. The study findings show how fragile is national park to poaching, particularly if surrounded by a hungry human population that receives limited benefits from the presence of the park. The long-term sustainability of conservation efforts depends on the social and political context within which they take place, thus for a better monitoring systems, both law enforcement and socio-economic are an integrated part of adaptive management, suggesting a need to blend them into the management perspectives. Future efforts could examine geographic profiling, crime prediction, and the spatial displacement of offenders as a means to mitigating wildlife crime. More sophisticated wildlife crime analyses using space-time accessibility approach might address causality in relation to protection efforts.

Rules, and the measures to enforce them, are at the heart of conservation. Wildlife Act by itself cannot deal with all known anthropogenic threats; on-the-ground complementary actions are needed to back up legislation. Although there was no evidence for the effectiveness of wildlife protection laws aimed at preventing the overexploitation of large mammals, but looking back over ten years of war, I learned that the three crucial factors in mitigating the effects of conflict on biodiversity were the continuous on-the-ground well trained field staff, continuous law enforcement information flow, and secured funding. They are as crucial now as they were at the height of the spiraling war if these parks are to survive. To all intends and purposes, protected areas must be cleared of both unchecked government soldiers and militia gangs before major progress are possible in the framework of ongoing wildlife agency restructuring. Only so, can we express the hope to put an end to current pernicious effects of the tragedy of the commons within the parks.

SAMENVATTING

Stroperij blijft een gevoelige en controversiële aangelegenheid, in het bijzonder in een context van politieke omwentelingen en economische onrust. Biodiversiteit gaat in versneld tempo verloren, en sommige karakteristieke soorten sterven uit als gevolg van een aantal samenlopende factoren. Het uitsterven van soorten, en de aantasting van hun habitat, grotendeels ten gevolge van menselijk handelen, zijn meestal de twee belangrijkste factoren die het in aantal afnemen van grote herbivoren in de nationale parken van Kahuzi-Biega en Virunga veroorzaken. Deze twee voorbeelden tonen aan dat gebieden van natuurbehoud nog steeds worstelen met continu toenemende bevolkingsgroei, en dit in een regio waar conflict over eigendom en controle van land en zijn natuurlijke hulpbronnen een serieuze hindernis vormt voor *community-based* ontwikkeling. Duurzame oplossingen zijn hierdoor moeilijker te realiseren.

Dit onderzoek wil licht werpen op illegale activiteitenpatronen en trends en op de gevolgen van inspanningen die gedaan worden rond ordehandhaving, daarbij gebruik makend van een breed spectrum aan GIS analyse toepassingen met focus op *hotspot* analyse. Het voorliggend onderzoek wil antwoord geven op vier kernvragen, (i) wat is de toestand m.b.t. het illegale gebruik van hulpbronnen? (ii) wat is de beste locatie voor illegale activiteiten? (iii) wie boort hulpbronnen aan op illegale manier? en (iv) waarom is illegaal gebruik van hulpbronnen een terugkerend verschijnsel? Het proefschrift toont aan dat een aantal praktische kwesties aangepakt moeten worden, wil men de effectiviteit van strategieën voor natuurbehoud verbeteren.

De ruimtelijke verspreiding van stroperij in beide parken werden onderzocht door gebruik te maken van ArcGIS software, o.a. de *hotspot* ruimtelijke analyse techniek. De voornaamste doelstelling was te onderzoeken of er patronen waren in de ruimtelijke verspreiding van stroperij en het verband na te gaan tussen deze patronen en andere geografische kenmerken. Er werd voor gezorgd dat alle ruimtelijke datalagen in dezelfde ruimtelijke projectie geregistreerd werden, zodat betrouwbare vergelijkingen tussen alle datalagen mogelijk waren. Het onderzoek heeft inzicht verschaft in de omvang van de impact van stroperij op niveau van parkbeheer. Het ontdekken en begrijpen van patronen in stroperij en in de aanwezigheid van in het wild levende dieren blijft een uitdaging; zowel jager als prooi zijn immers moeilijk te vinden.

Met behulp van geavanceerde GIS toepassingen werden de ruimtelijke schaal van illegale stroperij in verhouding tot de verspreiding van soorten, habitattypes, en controle-inspanningen beoordeeld. Opvallende vaststelling die uit het onderzoek naar voor kwam is een duidelijke neiging naar concentratie van zowel wild als bedreigingen in *hot* en *cold spots*. Een van de belangrijkste uitdagingen voor het beheer is de vraag hoe preventie van stroperij en verlies van hulpbronnen het best kunnen gestuurd worden. Inspanningen moeten zich onder meer concentreren op het identificeren van plaatsen waar illegale activiteiten wijd verspreid zijn en op het onderzoeken waar misdaden het vaakst voorkomen. In dit opzicht kan GIS, via ruimtelijke analyse, een leidraad verschaffen voor managers om het verband tussen natuurlijke hulpbronnen en de aanwezigheid van misdaden beter te begrijpen. Er zijn geen tekenen dat het fenomeen van stroperij afneemt, en de resultaten van het proefschrift brengen verschillende mogelijkheden voor verder onderzoek naar voor; modelleren kan hierbij bijdragen tot het begrijpen van regelovertredend gedrag, en van de factoren die de duurzaamheid van de jacht beïnvloeden en de vangstindex van jacht bepalen.

Hoewel *Wildlife Acts* bestaan als algemeen instrument voor de bescherming van soorten, blijven de meeste niet afdwingbaar, in het bijzonder gedurende oorlogstijd wanneer er te weinig mensen en financiële middelen beschikbaar zijn om illegale activiteiten te monitoren en bestaande *wildlife* wetgeving af te dwingen. De resultaten van het onderzoek tonen aan hoe kwetsbaar nationale parken zijn voor stroperij, vooral wanneer in de omgeving een hongerige bevolking woont die weinig voordelen heeft van de aanwezigheid van het park. De duurzaamheid op lange termijn van inspanningen voor natuurbehoud hangt af van de sociale en politieke context waarin ze plaatsvinden. Monitoringsystemen, zowel uitvoering van wetten als het sociaal-economische onderzoek, zijn een volwaardig onderdeel van het leerproces en mogen niet los van de managementdoelstellingen ontwikkeld worden. Toekomstige inspanningen kunnen zich richten op het onderzoeken van geografische profilering, misdaadpreventie, en de ruimtelijke verspreiding van overtreders als middel om stroperij tegen te gaan. Meer geavanceerde analyses van stroperij, die gebruik maken van tijdruimtelijke toegankelijkheid, zouden licht kunnen werpen op oorzakelijkheid in relatie tot beschermingsmaatregelen.

Regels, en de middelen om ze af te dwingen, vormen de kern van natuurbehoud. De *Wildlife Act* kan op zichzelf alle antropogene bedreigingen niet opvangen; complementaire acties op het terrein zijn nodig om de wetgeving te ondersteunen. De effectiviteit van beschermingsmaatregelen die de preventie van stroperij tot doel hadden, kan niet bewezen worden, maar terugkijkend naar 10 jaar strijd, stelden we vast dat er 3 cruciale factoren zijn die de effecten van conflicten rond biodiversiteit kunnen verminderen: de voortdurend aanwezige en in de praktijk getrainde veldwerkers, continue informatie over ordehandhaving, en stabiele financiering zijn. Willen de parken overleven, dan zijn deze factoren nu even cruciaal als ze waren op het hoogtepunt van de nog steeds voortdurende oorlog. Sowieso moeten beschermde gebieden gezuiverd worden van niet gecontroleerde regeringssoldaten en bendes; dan pas is ernstige vooruitgang mogelijk in de continue herstructurering van *wildlife* instituten. Enkel op die manier kunnen we hopen een einde te stellen aan de recente en voor het algemeen belang nadelige gevolgen van de tragedie in de parken.

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ACKNOWLEDGEMENTS

This thesis presents the remarkable day-to-day struggle of Congolese professionals in service for the protection of biodiversity in selected Democratic Republic of Congo’s protected areas through the spiraling civil war that has buffered the parks and surrounding areas. It would not have been possible without the involvement of many individuals and institutions. Foremost among them is Professor dr Philippe De Maeyer, who kindly accepted to coach me in order to carry out a this study. Carrying out a PhD research has always been a dream of mine for so long since I completed my MSc degree in Conservation Biology at the Durrell Institute of Conservation and Ecology (DICE) at the University of Kent at Canterbury in the United Kingdom, but it has become a reality only when I left the Wildlife Conservation Society and rejoined the ICCN to coordinate the SYGIAP unit in 2005. Professor dr. Philippe De Maeyer originally encouraged me to submit my research proposal to the Department of Geography at Ghent University in the framework of a collaborative agreement with the ICCN towards the implementation phase of the Système de Gestion de l’Information des Aires Protégées (SYGIAP). His expertise and foresight guided me through my studies while at the same time he provided opportunity for grants to cover a great chunk of my academic fees and my life at Ghent University. Indeed, without his guidance and personal support this final stage would never been reached. If I had known what writing a PhD would entail at the time when Philippe asked me, I do not know whether I would have started at all! But now I have and for your support, I would like therefore to express my heartfelt gratitude to you as the Wind that steered my course beneath the Wings!

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The success of the work, which culminated in the preparation and completion of this thesis, was possible due to the talents and commitment of many other people. As the saying goes, “A man never gets to this station in life without being helped, aided, shoved, pushed and prodded to do better”. I take this opportunity to acknowledge those who served in various capacities for the event and subsequent activities that provided the basis for this dissertation. The Executive Director of ICCN, Mr Cosma B. Wilungula was equally supportive. I particularly owe thanks to him, for having allowed me to take some of the work time to commute between Belgium and DRC in order to complete with my studies. I am also grateful to Mr Benoit Kisuki Mathe, who has since left ICCN for Conservation International (CI) and Dr Guy Mbayma Atalia, ICCN Technical Director for their immense contribution and extensive field experience in helping me to craft the research topic while I struggled to kill two birds with one stone. All the partners working in the two national parks provided input at different levels in supporting the field work leading to the law enforcement data collection. Their tremendous contribution brought me to cope with costs related to the field work. WWF offered sets of SPOT image for both the Virunga and Kahuzi-Biega National Parks. Both KBNP-GTZ and WWF-PCKB simultaneously welcomed me to use office space in Bukavu for data analysis and dissertation writing. I am particularly thankful to Yalolo M. Bisidi, Radar B. Nishuli and Sylvie Ouellet in this regard.

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ABBREVIATIONS

ACF	African Conservation Fund/UK
ADF	Alliance Democratic Fund
ANOVA	Analysis of Variance
AR	Albertine Rift
BEGO	Building the Environment for Gorilla
BELSPO	Belgian Science Policy Office
CAR	Central Africa Republic
CBC	Community-Based Conservation
CBD	Convention on Biological Diversity
CBFP	Congo Basin Forest Partnership
CCC	Community Conservation Committee
CEA	Cost Effectiveness Analysis
CF	Congolese Franc
CITES	Convention on International Trade in Endangered Species of wild Fauna and Flora
CMS	Convention on the Conservation of Migratory Species of wild Animals
CNDP	Congres National pour la Défense du Peuple
COPEVi	Coopérative de Pêcheurs de Vitshumbi
CPUE	Catch per Unit Effort Index
DFGF	Dian Fossey Gorilla Fund
DRC	Democratic Republic of Congo
DSRP	Document Stratégique sur la Réduction de la Pauvreté
EBA	Endemic Bird Area
ECDO	European Commission's Development Office
ECOFAC	Programme utilisation rationnelle des écosystèmes forestiers en Afrique centrale
ED	Enforcement Disincentive
EIA	Environmental Investigation Agency
ESRI	Environmental System Research Institute
EUV	Exceptional Universal Value
FAO	Food and Agriculture Organization
FARDC	Forces Armées de la République Démocratique du Congo (Congolese National Army)
FDLR	Forces Démocratiques pour la Libération du Rwanda
FZS	Frankfurt Zoological Society
GEF	Global Environment Fund
GIC	Gilman International Conservation
GIS	Geographic Information Systems
GPS	Global Positioning System
GSM	Global System for Mobile communications
GTZ	The Deutsche Gesellschaft fur Technische Zusammenarbeit/German Technical Cooperation
HCR	United Nations High Commissioner for Refugees
HIPC	Heavily Indebted Poor Countries
IBA	Important Bird Area

ICCN	Institut Congolais pour la Conservation de la Nature
ICDP	Integrating Community and Development Project
ID	Internally Displaced
IDP	Internally Displaced Persons
IDPE	Innovation pour le Développement et la Protection de l'Environnement
IGC	Institut Géographique du Congo
IGCP	International Gorilla Conservation Programme
IPNCB	Institut des Parcs Nationaux du Congo Belge
IRScNB	Institut Royal des Sciences Naturelles de Belgique
IUCN	International Union for Conservation of Nature – The World Conservation Union
IZCN	Institut Zaïrois pour la Conservation de la Nature
HCR	United Nations High Commissioner for Refugees
KBNP	Kahuzi-Biega National Park or PNKB: Parc National de Kahuzi-Biega
LATF	Lusaka Agreement Tusk Force
LEM	Law Enforcement Monitoring
MBIFCT	Mgahinga and Bwindi Impenetrable Forest Conservation Trust Fund
MEA	Millennium Ecosystem Assessment
MENCT	Ministry of Environment, Nature Conservation and Tourism
MIST	Management Information System
MRAC	Musée Royal d'Afrique Centrale/Royal Museum of Central Africa
MONUC	Mission de l'Organisation des Nations Unies au Congo or United Nations Organization Mission for the Democratic Republic of the Congo
MONUSCO	Mission de l'Organisation des Nations Unies pour la Stabilisation au Congo or United Nations Organization Mission for the Stabilisation in the Democratic Republic of the Congo
NALU	National Army for the Liberation of Uganda
NGO	Non-Governmental Organization
OPJ	Officier de Police Judiciaire
PA	Protected Area
PARECO	Patriotes pour la Reconstruction du Congo
PCKB	Programme pour la Conservation du Kahuzi-Biega
PDI	Probability Detection of Illegal Intrusion model
PI	Preference Index
PMU	Park Management Unit
QENP	Queen Elizabeth National Park
RAMSAR	Convention on Wetlands of International Importance especially as Waterfowl Habitat
RBM	Ranger-Based Monitoring
RHD	Rutshuru Hunting Domain
RIMC	Regional Inter-Ministerial Committee
RS	Remote Sensing
SADC	Southern African Development Community
SDM	Strategic Deployment Model
SNEL	Société Nationale d'Electricité
STDEV	Standard Deviation

SYGIAP	Système de Gestion de l'Information des Aires Protégées
TNC	The Nature Conservancy
UNARCO	Union des Associations pour le Reboisement Communautaire
UNDP	United Nations Development Programme
UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environmental Programme
UNESCO	United Nations Organization for Education, Science and Culture
UNHCR	United Nations High Commissioner for Refugees
UTM	Universal Transverse Mercator
VHF	Very high frequency
VNP	Virunga National Park
WCED	World Commission on Environment and Development
WCPA	World Commission on Protected Areas
WCS	Wildlife Conservation Society
WCH	Wildlife Crime Hotspot
WHC	World Heritage Committee
WHL	World Heritage List
WRI	World Resources Institute
WWF	World Wide Fund for Nature
ZSL	Zoological Society of London

DISCLAIMER

This dissertation is the result of my own work carried out as part of a PhD program of study at the Department of Geography, Ghent University in Belgium and includes nothing which is the outcome of work done by or in collaboration with others, except where specifically indicated in the text.

THESIS OUTLINE

This thesis is organized in two major parts covering the two study sites, one representing a forest and another one a savanna habitat. Apart from the general introduction which consists of setting on the scene on which the study has been undertaken, the study comprises five other chapters. The reminder of this dissertation is structured as follows.

Chapter 1 covers the detailed account of the geographic, biodiversity and human populations in the study sites, thus providing the background and problem statement and rational for a good understanding of the general discussion of the findings of the research that led to the production of this research work. Details provided therein are from different sources, including some results from current work as well as a review of the existing literature in the field of law enforcement and protected areas. Relevance of classical academic research and its practicability for management and conservation is discussed on the basis of two specific case studies and building upon fairly comprehensive data-gathering that stand up to rigorous scientific scrutiny.

Chapter 2 provides thorough background on materials, methodology outlying a suite of methodological approaches and analytical framework applied in this thesis, thus exploring both statistical and spatial analyses and modelling. In sum, illegal use of natural resources is a threat to biodiversity, but research on illegal activities has methodological challenges. Methodological framework is mostly copied from previous experiences where survey and modelling methods were used that originate from the time when scientific research was more the goal of a conservation project than it was a means to achieve effective management. It basically emphasizes how predicting threats occurrence using a modeling approach based on a Geographic Information System (GIS) represents a new methodological tool which can be used to endorse conservation policies, on condition that models are tested for reliability. Moreover, I argue that the hotspot analysis has the advantage of being fast, effective and cost effective method for scientists, conservation managers and financiers and will assist in allocating their efforts (in terms of personnel and money) where the potential benefit per species and threat places is greatest.

Chapters 3 & 4 will explore the quantification of law enforcement effort and illegal activity in both the Kahuzi-Biega and Virunga National Parks with emphasis on detection effort; the Catch per Unit Effort Index (CPUE Index) relating illegal activity to patrol effort; Convention patrols versus investigations; law enforcement expenditure; optimizing resources allocation and management and conservation implications. Study area, data and results provide details on the study area, data and the results of several spatial applications. The results presented here underline the importance of a global perspective on the mechanisms driving spatial patterns of illegal activity, and the key role of anthropogenic factors in driving the current poaching crisis, thus suggesting that they represent one of the highest-resolution analyses of human impacts on both KNBP and VNP biodiversity currently available to inform conservation policy. Many aspects in these chapters have explored either the scientific or the ethical dimensions of the poaching-biodiversity related controversial issues. More generalized findings are highlighted in chapters three and four and thoroughly summarized in the chapter 6 on discussing conclusions.

Chapter 5 deals with the validation of the law enforcement monitoring using the socio economic data. This chapter gives insight in the importance of integrating socio-economic and ranger-based monitoring data in a research designed to in-depth investigation of the illegal exploitation of natural resources and its cascading effects in protected areas under a wartime political and environmental context. The importance of monitoring wildlife use, based on a bushmeat practical example is discussed and shows the relevance of the link between socio-economic development and conservation of threatened species in the framework of DRC world heritage sites in danger.

Chapter 6, finally, summarizes all the discussions of the study achievements in the global context of the conservation a world heritage site in peril and challenges ahead in protecting their biodiversity. Lessons are drawn from the experience on monitoring law enforcement efforts and illegal activity patterns in parks wracked by political strife and economic hardship, and then make some practical advice for on-the-ground management and conservation implications. A brief section of chapter 6 discusses the limitations of the methodological framework and concludes with a critical outlook on the future. The results on the basis of 2 specific case studies provided in chapters 3 and 4 are combined and analyzed whether they compare and reinforce each other and also pave the way for the use and practicality of classical long-term research.

CHAPTER 1

GENERAL INTRODUCTION

The conservation of natural resources is the fundamental problem. Unless we solve that problem, it will avail us little to solve all others.

—Theodore Roosevelt, October 4, 1907 —

1. Background and Problem Statement

1. 1. 1 Background

1. 1. 1. 1 Biogeophysical and Ecological Overview

The Democratic Republic of Congo (DRC) is one of the most important countries in Africa for the conservation of biological diversity, with more species of vertebrates than any country on the continent. Indeed, it is the only megadiversity country on the African mainland, and is also wealthy in natural resources, being rich in minerals and ranking third in the world for its amount of closed tropical forest (McNeely *et al*., 1990). The DRC contains huge contrasts of scenery and biology and is home to a wider variety of species of animals and boasts the highest diversity of mammals and appears high on the global list, being fourth highest in mammals (415 species of which 28 are endemics) with the eastern part of the country containing several forest refugia, areas of the planet with remnant populations of more ancient species, many of which are found nowhere else. Among the wildlife of these refugia are globally important species like the okapi (*Okapia johnstoni),* the northern white rhino (*Ceratotherium simum cottoni)*, the mountain gorilla (*Gorilla beringei beringei),* the eastern lowland gorilla (*Gorilla beringei graueri*), the aquatic fishing genet (*Osbornictis piscivora),* and the Salonga monkey (*Cercopithecus dryas*) and birds (1094 species of which at least 23 are endemic of which the Congo peacock (*Afropavo congoensis*). Another forest endemic species is the bonobo (*Pan paniscus),* a man's closest living relative. Reptiles (268 species, 33 endemic) and amphibians (80 species, 53 endemic) are poorly known; it stands to reason that much remains to be discovered about the true extent of their diversity. Freshwater fish diversity is also high with almost 1,000 species. More than 1,300 species of butterflies, the highest for Africa, have been described, and new species are discovered every year. More than 11,000 species of higher plant are known for the DRC, of which 3,200 are endemic. Only South Africa rivals the DRC in numbers of plants species, and the number is expected to increase as more exploration takes place (Aveling *et al*., 2004).

With seven recognized phyto-geographic zones (White, 1983; Inogwabini *et al*., 2005b), the general context of the DRC is one that of a country whose extensive geography has imposed a diversification of biodiversity habitats (Sayer, 1992). Astride the Equator and climbing from the mangroves on the Atlantic coast to the snow covered Rwenzori Mountains (5,119 m) and Virunga volcanoes in the east, the DRC is the biological heart of Africa (Aveling *et al*., 2004). Its waters are pumped through two major watersheds, the Congo and the Nil. Spanning 22 degrees of latitude north and south of the Equator, the Congo River drains the second largest watershed in the world after the Amazon. It contains the entire Congo River, the largest share of the Congo basin and over 50 percent of Africa's moist tropical forests. Forest covers some 70 percent of the country, comprising a wide variety of forest types with the evergreen forests in the mountainous area of the Albertine Rift showing marked patterns of altitudinal zonation (Aveling *et al*., 2004). However, very little undisturbed montane forest remains in Africa as it is generally the most highly prized land for agriculture and ranching. In the DRC, this type of forest is found in the east along the Albertine Rift, but they are under immense pressure from burgeoning human populations.

Apart from the evergreen forests, the vegetation of the DRC's savannas and woodlands to the north and south of the central forest differ in floristic composition and have been influenced by centuries of the fire. The *Brachystegia* "miombo" woodlands in the south are the example of a fire adaptation region. These savanna and woodland are inhabited by a number of familiar African wildlife which, in the past, were present in high numbers, but which are now severely depleted as a result of decades of uncontrolled exploitation (Fa & Peres, 2001). Rather than producing an inexhaustible supply of bushmeat, which is a common misconception, the forests of the Congo Basin are actually not very productive in terms of wildlife (Fa & Peres; 2001; Aveling *et al*., 2004). As a result, wildlife is rapidly dwindling and the forest becomes empty (Redford, 1992) when the rationale for hunting shifts from feeding a few local families to feeding many more urban consumers. African elephants in the DRC, which constituted perhaps 20% of the continent population, are believed to have been severely affected by recent civil wars and migrations of refugees into PAs (Said *et al*., 1995; Hart & Hall, 1996; Hall *et al*., 1997; Plumptre *et al*., 2000).

Not only is the DRC biologically the richest country in Africa but it also can boast the highest diversity of mammals (Aveling *et al*., 2004) and the longest history of conservation and biological research dating back to the early part of the twentieth century. Albert National Park (now Virunga National Park) was created on 21 April 1925 and is the oldest National Park in Africa, and the most threatened (Pierce, 1994; Languy & de Merode, 2009a). In the early days, the parks were managed by the Institut des Parcs Nationaux du Congo Belge (IPNCB), created in 1934, setting the stage for a long and distinguished record of protected areas (PAs) management that continues to this day under the Institut Congolais pour la Conservation de la Nature (ICCN).

ICCN is one of the few specialized wildlife authorities in Central Africa, and in this respect it has long been ahead of the field in PAs (henceforth "Parks") management among the Central African nations. The economic and social difficulties experienced by the country over the past two decades have, however, left their mark on the Institute, especially during the recent civil wars when general insecurity and lawlessness in the area led to suspension of all external funded conservation projects. Not only has it had to operate without any kind of meaningful budget for many years, but perhaps more seriously, almost no recruitment and training of young staff to replace "old park guard" has been possible for over a decade. As a result, although PAs theoretically cover 223,973.3 km^2 over 10.47 percent of the country, many of them now receive little or no active management are referred to as "Paper parks". The exception is the set of World Heritage Sites (WHS), now classified as World Heritage Sites in Danger (96,300 km^2), including the Virunga National Park (VNP) and the Kahuzi-Biega National Park (KBNP) that received support from the international conservation organizations throughout the recent war years with funding from the United Nations Foundations (UNF) through UNESCO and continue to enjoy support from international non government organizations (NGOs).

The effects of the recent wars upon conservation in the area are still fresh and a great loss too. Substantial efforts have been made by numerous conservation organizations to maintain a conservation presence in the DRC, even under the most difficult of conditions (Draulans & van Krunkelsven, 2002). It is not an exaggeration to say that if it had not been for the timely intervention of the UNESCO/UNF-financed project and substantial efforts made by numerous NGOs, little would probably remain of these globally important PAs. However, cost of recovery program will be enormous yet not everything lost may be recovered. The nature resource-based capital lost in terms of individual wildlife species and related revenue should be an eye-opener to the relevant authorities to protect the region more adequately than before for prosperity. According to MacKinnon *et al*. (1986), there is no foolproof management prescription to protect parks under circumstances of warfare. However, given that the pie of funding for biodiversity protection is sadly small, there is a critical need of public support, more condensed international linkage and monitoring and adaptive management approach if this region is to be protected.

The nature of modern park management requires a wide range of skills. In the particular context of the DRC, these skills include surveillance techniques, including military-style operations; patrol-based law enforcement monitoring, bio-monitoring, and community conservation. With the exception of anti-poaching, these are essentially new skills that are being added to ICCN's institutional capacities. In the immediate post-war period, it is essential that ICCN recovers full control of its entire PAs before precedents are set and the current illegal occupation of certain sites becomes the *status quo*. With the war coming to an end, it was crucial to evaluate thoroughly the conservation status of the sites by determining how far poaching has taken a turn for the worse, their integrity and the impact of the conflict on the values for which these sites were inscribed on the UNESCO's World Heritage List.

1.1.1.1.1 Global Aim of the study

The need for both qualitative and quantitative measures of biodiversity outcomes in protected areas is underscored by the Millenium Development Goals on environmental sustainability (MEA, 2005), and by the Convention on Biological Diversity (UNEP, 2002). Given the high investment that has been made in protected areas as the cornerstone of conservation efforts but their performance in maintaining wildlife populations in the midst of political instability remains poorly understood, it is crucial therefore to document how effectively law enforcement is performing in selected protected areas in DRC. Hence, the global aim of the study is to better understand spatial and temporal distribution patterns in different types of illegal wildlife use using CartoGIS applications and provide insights on how to optimize law enforcement operations through optimizing both resource allocations and the level of deterrence thus, reducing illegal offtake of natural resources to acceptable levels while making allowances for the community-based conservation approach.

1. 1. 1. 2 Legal Basis for Legislation to Conserve Species

> In democratic societies people may think that their government is bound by an ecological version of the Hippocratic oath, to take no action that knowingly endangers biodiversity. But that is not enough. The commitment must be deeper-to let no species knowingly die, to take all reasonable action to protect every species and race in perpetuity. Insofar as biodiversity is deemed an irreplaceable resource, its protection should be bound into the legal canon. **Wilson, E. O. (1992).**

1. 1. 1. 2. 1 Definition

Using the law to ensure the conservation and sustainable use of the Earth's biodiversity is a complicated matter requiring clear definitions – both scientific (what and where biodiversity is, what threatens it?) and legal (who has national jurisdiction, who is the injured party when biodiversity is lost, who is entitled to benefit from its use? While recent works by ecologists is looking where biodiversity is concentrated, lawyers and policy-makers pinpoint the importance of a standardized classification of the words used. In fact, simplicity of language is a desirable feature of wildlife legislation; it should be comprehensible and provide a source of reference, not only for lawyers and courts but also for members of the conservation managing agency who implement the laws. To that end, I provide the set of key words used in this dissertation as follows:

Enforcement: is defined as the system comprising detection, apprehension, prosecution, and conviction of lawbreakers. Therefore strengthening enforcement is a mean to an end, not an end in itself. The end goal of improving enforcement is to eliminate illegal activities or to reduce them to acceptable levels – in other words, to improve compliance. Enforcement contributes to that goal by directly suppressing criminal activity and by creating a deterrent effect (Akella & Cannon, 2004).

Law: Laws may be defined as a body of rules that enjoin or prohibit certain actions, and can be considered as the practical instrument for implementing policy. They are basically of two kinds, one written in statutes enacted by a legislative assembly, and the others often unwritten and acting by custom (Leader-Williams, 1996). Laws also operate at various levels ranging from local by-laws, to national laws, to international treaties. First steps towards conceptualizing the field of law have unearthed two major dichotomies: first, whether law is to be characterized in formal or functional terms; and, secondly, whether law is to be characterized in morally neutral or moral terms (Adams & Brownsword, 1992). Arising from this, the concept of law may be formulated in one of the four ways as follows:

(i) A formal morally neutral concept of law; for example, law may be conceptualized as a regime of rules, the rules having no necessary connection with morality.

(ii) A functional morally neutral concept of law: for example, law may be conceptualized as an order seeking to perform various functions required for group life, the order having no necessary connection with morality.

(iii) A formal moral concept of law: for example, law may be conceptualized as a regime of rules, the rules (as natural lawyers insist) having a necessary connection with morality.

(iv) A functional moral concept of law: for example, law may be conceptualized as an order seeking to perform various functions required for group life, the order (as natural lawyers insist) having a necessary connection with morality.

Legislation is the body of statutory law which controls the management and use of wildlife resources. It represents the legal expression of government policy (**Boxes 1.1 & 1. 2**). Statutory law is usually two-tiered, comprising primary legislation, produced by the legislature and subsidiary legislation, which is usually promulgated by a government minister.

Monitoring is a follow up system designed to reveal long-term changes – or the absence of change – at the heart of ecosystems and their component communities. The observation and analysis of these changes is necessary in order to gain a basic understanding of natural areas, in order to ensure coherent and effective conservation programs. When applied to natural ecosystems 'monitoring' (or ecological monitoring') is a necessary tool on which managers should base many of their conservation actions (Brashares & Sam, 2005; Gray & Kalpers, 2005a). It is really no more than repeated resource and/or threat inventory and process measurement over time.

Poaching is the illegal hunting, killing or capturing of wildlife. This can occur in a variety of ways. Poaching can refer to the failure to comply with regulations for legal harvest, resulting in the illegal taking of wildlife that would otherwise be allowable. Examples include taking without a license or permit, use of a prohibited weapon or trap, taking outside of the designated time of day or year, and taking of a prohibited sex or life stage. Poaching can also refer to the taking of wildlife from a gazetted wildlife sanctuary, such as a national park, game reserve, or zoo. However, it is important to note that hunting, under specific regulations, is in fact often permitted in designated game preserves (Magelah *et al.*, 2007). This raises the wildlife management implications which are discussed below. Killing or capturing of plants is also considered.

Protected Area (PA): The International Union for Conservation of Nature (IUCN, 1994) defines Protected Area as "areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means".

Box 1.1
Legal basis for state control of land and natural resources in DRC-1

Definitions of PAs as designations, as legislated, together with authorities responsible for their administration.
Title: Ordnance-Law No. 69-041 relative to nature conservation
Date: 22 August 1969
Brief description: Provides *inter alia* strict nature reserves and national parks.
Administrative authority: Institut Congolais pour la Conservation de la Nature (ICCN)

Designations:
Reserve naturelle intégrale (Strict nature reserve): An area in which it is forbidden to enter, traverse, camp or stay
It is forbidden to introduce dogs, traps, arms, or to transport or export living wild animals, skins or hides or non-cultivated vegetable products.
Prohibitions on entry do not apply to certain stipulated people.
It is prohibited to disturb in any manner wild animals, even harmful ones, except for cases of legitimate defense, or to remove, or to harm eggs and their nests.
If an animal is killed or harmed in the cause of legitimate defense, this must be declared within a stipulated time.
It is prohibited to: damage non-cultivated plants; introduce any species of animal or plant; undertake any form of excavation, prospecting or drilling, or remove any material or any activity modifying the land or vegetation.
It is prohibited to: block rivers, remove or pollute directly or indirectly the water, fish of any sort; fly over at an altitude lower than 300 m.
Tourism is permitted in designated sections, entry and camping being under the control of any appropriate agency.
Penalties for infraction of the law are stipulated and include prison sentences of one to ten years for killing specific species.

National Parks. Comprise strict nature reserves within the meaning of this Law. Also governed by special texts.

Within which customary rights other than those specially stated are not permitted.
Under Law 75-023 dated on 22 July 1975 (Under Articles 11, 12 & 13), and Ordnance law 85/035 dated on 3 September 1985 (Article 10), park guards are allowed to carry and make use of weapons; territory competence of the *Officer of Judiciary Police* in pursue of illegal activity is 50 km from the park physical limit. Park guards should assist park warden in preventing and searching and reporting illegal activities in protected area in line with Law 69-041 dated on 22 August 1969, the legislation on hunting, fishing and jurisdictional forestry regime.
Under Article 13 of Law 75-023, park guard can make use of firearm when offenders are caught red-handed provided that he makes three warning calls to stop dead in their track.
Source: Original legislation in French.

Box 1. 2
Legal basis for state control of land and natural resources in DRC - 2

Title: Law No. 82-002 (hunting law) dated on 28 May 1982

Date: 1982

Brief description: Provides *inter alia* for faunal reserves

Administrative authority: Institut Congolais pour la Conservation de la Nature (ICCN)

Designations:
Réserve totale de faune (Total faunal reserve): Hunting and all other human activity is prohibited, thus the same level of protection is provided as is found in national parks

Réserve partielle de faune (Partial faunal reserve): Exploitation of wildlife is permitted subject to regulations, thus protection equals that found in hunting domains.

The hunting legislation is unclear, largely as a decision by the *Conseil Exécutif* to suspend sport and commercial hunting in 1982. While this ruling is unambiguous with regards to commercial and sport, it is more difficult to define the legal status of traditional hunting (IUCN, 1988). However, the Decree N° 014/CAB/MIN/ENV/2004 dated on 29 April 2004 has since provided the implementing set of measures of the Law 82-002 dated on 28 May 1982.

Source: IZCN, 1991

1. 1. 1. 2. 2 Wildlife Policies and Legislation in the Democratic Republic of Congo

Whatever the legal status of wildlife, the State is always entitled, in the general interest, to exercise its police powers by enacting legislation to prohibit or control the exploitation of any species of fauna and flora. Such conservation measures are usually embodied in an Act of Parliament or equivalent legislative instrument, which specifies the categories of species or taxonomic group to which it potentially applies and lays down rules for the conservation of those species which are expressly listed for that purpose. This is the basis upon which hunting and fishing legislation was developed over the years in the DRC and throughout the world. The Rio Convention affirms national sovereignty over biodiversity resources (de Klemm & Shine, 1993).

Formerly a Belgian colony, the DRC (then called the Belgian Congo) achieved independence in 1960, the name being changed later in 1970. Prior to this period, each PA was established by a Royal Decree of the Belgian monarch, under a general decree passed in 1937

(UICN, 1992). The Institut des Parcs Nationaux du Congo Belge (IPNCB) is the ancestor of the Congolese PAs Institute - hereafter referred to as ICCN. It successively took the name of Institut des Parcs Nationaux du Congo (Ordnance-law No. 67-514 of December 1, 1967) and then ICCN following the Ordnance-loi No. 69-041 of August 22, 1969 (**Box 1. 1; Annex 1**). In 1960, some politicians attempted to attract popularity by claiming it was necessary to get rid of national parks by taking the law into people own hands, as these represented the last vestiges of the colonial epoch. Hunting laws are deeply entrenched in colonial land and natural resources management, including wildlife colonial governance (Schuylenbergh, 2009). Encouraged by this attitude and by the profit to be made in selling skins and trophies to adjacent countries some villagers purposefully gave free rein to poaching. With the succession of the Mobutu regime (Second Republic), the National Parks agency was attached to the office of the Head of State, a sign that the fauna of the country was to be treated seriously (Nzana-Ndoni, 1986).

With respect to the legislative structure and institutional resources affecting conservation in DRC, the government has demonstrated by word and action that it is one of the most aware and concerned countries in Africa despite no formal statement of policy on wildlife at this period of time. There are several principal national wildlife laws comprising the basic DRC legislative framework relative to conservation and management of tropical forests and biodiversity. The first and perhaps most important of these, the Ordnance-law No. 69-041 of 22 august 1969 relating to the conservation of nature which defines the conditions herein portions of the national territory may be established as ‘integrated national reserves’ and determines the jurisdictional regime applicable to such reserves and to a certain extent the authority charged with their management (**Annex 1**). This piece of legislation was modified by Decree of 22 July 1975 and Ordnance No. 78-190 which establishes the Congolese National Parks Institute under the title Institut Zaïirois pour la Conservation de la Nature (IZCN, 1991). The Law of 22 July 1975 (No. 75-023) establishing IZCN now ICCN defines the rationale for ICCN and establishes the objectives that the legislature assigns to this state enterprise. Those objectives include management of integrated and quasi-integrated natural reserves, particularly the national parks and related reserves. A related Ordnance Law (No. 75-231, 12 July 1975) completing Ordnance Law No. 69-041 of 1969 and establishing the Ministry of the Environment, Conservation of nature and Tourism (MECNT). More recently the Forest Code No. 011 of 29 July 2002 (RDC, 2002) replacing the out-of-date Forest Law of 11 April 1949 was enacted. Under the 2002 Forest Code, land is divided into protected forest, classified forest and permanent production forest (RDC, 2002). As I’m completing this thesis, the government has issued a new decree No 10/15 dated on 10 April 2010 and establishing the status of the ICCN as a public institution in charge of both *in* and *ex situ* conservation (RDC-Primature, 2010). The latter was not taken into consideration in the thesis law enforcement interpretation.

The Law of 28 May 1982 (No. 82-002) 'Regulating hunting in the country and establishing the conditions under which hunting is permitted, the documents required for hunters, animals for which hunting is permitted, and animals for which hunting or trapping is prohibited (**Box 1. 2**). Strongly influenced by the CITES Convention, this law includes two annexes listing species totally or partially protected and also defines the opening and closing of hunting seasons for each region of the entire country.

ICCN is the principal management and protection body currently responsible for national parks and game reserves. It is used to be under the financial aegis of the Ministry of Porto folio, and the MECNT where technical aspects are concerned. Owing to the new decree No 10/15 of 10 April 2010 quoted above, ICCN is from now on only under the MECNT (DRC-Primature, 2010). ICCN is a public institution with its own law enforcement personnel and independent financial standing, and thus enjoys a degree of autonomy that is unusual for African conservation organizations (WCPA-IUCN, 1999).

ICCN is a public technical and scientific institution. The wildlife Act No. 69-041 (RDC, 1969) specifically spells out the mandate of ICCN as to (i) assure the protection of fauna and flora in both strict and quasi integral natural reserves of the country; (ii) promote in these areas scientific research and tourism in accordance with the fundamental principles related to the conservation of nature; (iii) manage breeding/capture stations inside and outside the reserves (**Annex 1**). It is headed by an Executive Director and has a mandate to generate revenues. The institution has its own law enforcement personnel and independent financial standing, including 1,896 employees of which 1,524 are guards and/or park wardens (ICCN-DG, 2010) in the national parks with paramilitary standing and a mandate to assure protection of the parks and natural reserves.

To guarantee the effectiveness of this conservation mission, the legislation by means of Law No. 75-023 (République du Zaïre, 1975), provides for ICCN to hire park wardens (Officers of Judiciary Police) and park guards. The latter have the following terms of reference (Article 12):

- ❖ To foresee, seek out and report to the park wardens any violation of the present law (Law creating the IZCN), any violation of the hunting and fishing legislation and any violation of the forestry legislation,

- ❖ To identify or, failing this, to bodily apprehend and take before the competent authority any person caught violating the law on nature reserves and hunting reserves, as well as those found in possession of items that prove their guilt, in particular, weapons, instruments, plants, animals, skins or trophies,
- ❖ To prevent any person from suppressing material traces of infractions.

The DRC is a signatory to or is in the process of becoming a signatory to virtually all major multi-and bilateral international treaties and regional agreements of direct and germane relevance to conservation and management of tropical forests and biological diversity. It has signed amongst others the Convention on International Trade in Endangered Species of wild Fauna and Flora (CITES) on 18 October 1976, the Convention on Wetlands of International Importance especially as Waterfowl Habitat (usually referred to as the RAMSAR or Wetlands Convention) on 15 September 1994; the Bonn Convention or Convention on the Conservation of Migratory Species of wild Animals (CMS) on 5 September 1994; and the Convention on the Biological Diversity on 15 September 1994. DRC ratified the Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) on 17 December 1975, under which four national parks and one faunal reserve have been inscribed, including the VNP in 1979 and the KBNP in 1980. Last but not least, the country has ratified the 1968 (Algiers) African Convention of Nature and Natural Resources signed on 13 November 1976, which provides definitions of strict nature reserves, national parks and special reserves. The country is member of the IUCN- The World Conservation Union which brings together States, government agencies and a diverse range of NGOs in a unique world partnership.

While these facts are in and themselves extremely important, there are nonetheless specific weaknesses in certain of the legislative and institutional arenas whose improvement could significantly facilitate the attainment of long-term conservation objectives. This fact is exemplified by the ICCN statement indicating that legislation concerning PAs is ambiguous often leading to confusion (IZCN-DG, 1991). To give a few examples, current frustration of local people is heightened by somewhat unclear provisions within the Wildlife Statute and local government Act leading to uncertainty over who should deal with confiscated pets; not to mention some reluctance of the part of ICCN to consider the option of culling animals (Blomley *et al.*, 2010). Legislation remains the means by which society imposes its collective will upon itself. Only legislation that corresponds adequately with that collective will is practical, enforceable and viable in the long-term where wildlife exploitation can go undetected (Clarke & Bell, 1984).

1. 2 Problem Statement and Rationale

Poaching of wildlife is a major threat to conservation efforts all over the DRC protected areas network. Yet, anti-poaching campaigns remain largely ineffective for multiple reasons. First, the areas to be protected are vast and the manpower to protect these vast areas is often insufficient for the job with limited resource allocations available for these activities. Additionally, conventional patrols launched to cover broad areas of wilderness are often in the wrong place at wrong time. Even with tips from local community or informants of poaching activities, park guards often arrive on the scene after the slaughter of wildlife, too late to save species lives. Poaching remains a primary reason for loss of biodiversity and unless effective anti-poaching operations are instigated and strengthened, we will continue to see loss of life- including those of endangered species (SUN, 2007). The lack of relevant information on the dynamics of the illegal wildlife use over entire conservation areas makes this situation even more acute and appalling. As Harris points out, "we can never buy, own, or totally control enough land to preserve everything." Second, the proliferation of weapons in wrong hands has contributed to the poaching plague, hence undermining the exceptional universal value for which these sites were inscribed on UNESCO WHS List. Indeed, the post conflict period was the moment to make the threat assessment and design robust decision-making process (Shambaugh *et al*., 2001).

Wildlife is an important source of protein for the rural peoples in tropical forests and its sale is an important source of cash (Redford & Robinson, 1987; Redford, 1993). However, harvesting of natural resources has become more widespread, especially under most depressed economic conditions (Arcese *et al*., 1995) and in areas where people have been evicted from their land to make way for a PA resulting in their overexploitation due to high poverty levels and generated resentment towards the PA (Hough, 1988; Leader-Williams & Albon, 1988; Van Schuylenbergh, 2009). Overall, the crisis affected both the guards' government salaries and the income generating activities (de Merode, 1998). The importance of insufficient investment as a constraint to conservation across Africa has been emphasized by Leader-Williams & Albon (1988). How PA managers and local communities' cooperation strategies can be achieved remains an open question given the benefits driven from illegal hunting (Hofer *et al*., 2000).

Law enforcement has been identified as one of the most important factors in making parks work (Brockelman *et al*., 2002). Biodiversity conservation efforts are more and more severely compromised by poor enforcement. In the absence of enforcement, both traditional and innovative solutions for countering biodiversity loss may not be successful. Despite the efforts of conservationists over time, the quality and effectiveness of enforcement still fall far short of wildlife managers' expectations. This however requires appropriate manpower and adequate funding (Bell & Clarke, 1984). Our glaring failure has been in treating the symptoms of wildlife conservation problems rather than their root causes (Pletscher & Schwartz, 2000). Studies show it is common for wildlife to provide 20-30% of rural peoples' income in developing countries (Vedeld *et al*., 2004). Understanding the importance of bushmeat as component of the local economy is paramount to devise effective strategies aimed at reducing levels of illegal hunting.

The illegal harvest of wildlife (hereafter broadly known as poaching) is perhaps the least documented but most far-reaching threat to the loss of global biodiversity (Meffe & Carroll, 1994; Primack, 1994). Indeed, coupled with the trade in bushmeat, it is believed to involve more people than any other wildlife activity and to have the greatest impact on wildlife populations in PAs. Growing evidence suggests that illegal wildlife use is expanding and having an increasingly negative impact on wildlife populations throughout the PAs network where park staff armed with bolt action rifles often come across poachers armed with semi-automatic weapons and often heavy machine guns at the height of the civil strife. Under the pressure to address this conservation dilemma and faced with diminished resources, wildlife authorities are often unable to shift management priorities before the key wildlife species or PAs become critically affected. Resource use remains a major threat to conservation in protected areas thoughout the DRC, yet determining the extent of illegal resource use is challenging (Leader-Williams *et al*., 1990).

One aspect of human warfare that has not changed appreciably over the past few decades is the need for human populations and isolated military forces to 'live off the land' by foraging indiscriminately for food, shelter, and material good. Local people undergoing food and fuel shortages in lawless landscapes exact heavy toll on wildlife and habitats (Pech, 1995). Military and militia forces lacking established or secure lines or supply often subsist partly or entirely on wild animals and plants. Large mammals when available are often an important source of food for isolated military groups operating within war zones and disputed territories (Plumptre *et al*., 1997). Therefore overexploitation of natural resources is primary concern for PA managers as many endangered species, more and more, find their last stronghold in natural reserves (Leader-Williams *et al*., 1990; Bruner *et al*., 2001; Struhsaker *et al*., 2005). Few PAs in DRC at present have an institutionalized monitoring and evaluation system, although some progress has recently been made in this respect (Blom *et al*., 2004; Brashares & Sam, 2005) in both the two sites.

Following the overall neglect of Wildlife Act during the spiraling wartime followed by widespread poaching resulting from the free-for-all access to natural resources, each pursuing his own best interest in a society that believes in the freedom of the commons (Hardin, 1968) and given the fact that guards' actions were far less precise because the areas to control were typically too vast for effective concentrated patrolling (Sherman, 1997), I null hypothesized that the spatial pattern of key anthropogenic pressure types was ubiquitous given the free for all access to natural resources that prevailed in each war-torn protected area. An understanding of the location of these human pressures and factors determining them was essential for successful and cost effective law enforcement activities. Understanding the geographic distribution of poaching risk and its causes are key challenges and central to determining spatial priorities for the focus of conservation responses. With accurate measures of illegal activities, managers could monitor success of conservation efforts allowing them to design more efficient interventions (Davies 1996; Hockings *et al*., 2000). With appropriate methods, illegal resource use may be detected before it has biological impacts and, thereby, provide early warning of threats to biodiversity (Pitcher *et al.*, 2002). Nevertheless, the illegal nature of the activities poses unique methodological challenges. The latter prompted the need to focus the research topic on four fairly central questions that research on illegal resource use should answer: (i) what is the illegal resource use (e. g., what species and what extraction techniques)? (ii) Where is the best illegal activity location (e.g., are areas of high wildlife species/human threats turnover more important, and should such areas be prioritized for protection)? (iii) Who extracts resources illegally? and (iv) Why does illegal resource use occur on recurrent basis (e. g., behavioral incentives)?

To answer these questions, researchers must gather more spatial data on illegal resource use as well as on identities of resources targeted, techniques used to procure resources illegally, locations of illegal activities, identities of violators, and incentives driving illegal resource use. In addition, answers to the target questions must account for the magnitude of illegal resource-use problems and the frequency of illegal activity. This list of questions and associated data requirements may not be exhaustive, but I do believe that it represents the majority of information needed to assess conservation challenges posed by illegal resource use in current DRC post conflict period. None of these questions is easy to answer. Illegal resource use is mostly covert, and significant incentives exist for informants to withhold information. Although no method is a panacea, emerging combination of different techniques is poised to tackle these basic questions and similar others related to the optimal management of selected PAs in DRC.

Biodiversity monitoring was claimed to be ineffective at integrating information into decision-making and insufficiently relevant to the needs of land and resource managers (Danida, 2000; Sheil, 2001; Danielsen *et al.*, 2005). The provision of science-based information to enable

PAs managers to better manage conservation sites within DRC protected areas network has been proved to be a major shortfall in supporting management authorities to manage the sites through financial support for the basic operating costs, planning, training, monitoring and research programs. The process of decision-making needs reliable information as an important input for various managerial tasks (Harmon, 1994). Information is a vital component of the organizational functioning; just as our body depends on air, water and food for survival, we also depend on information (Oka, 1996). Optimal decision-making tools can be used to indicate the best allocation of limited resources and budgets to achieve conservation goals. The more the limited the resources, the greater the desire should be to use those resources as wisely as possible (Mackenzie, 2009). Thus, getting the right kind of information available at the right time is very important for immediate management action to support biodiversity conservation in PAs.

For many rural and urban people in African moist forest, meat from wild animals (known as "bushmeat" throughout the region) is highly valued product (Fa *et al*., 2005). Conservation legislation has created a new class of illegal activity, the illegal harvest of wildlife, and has swept progressively more forms of wildlife use into it, all else being equal, most are illegal, thus creating a conflict of interests and value system between the wildlife authorities and the general public. As a result, a high proportion of all conservation effort in terms of staff and expenditure is being devoted to law enforcement in PAs (Bell & Clarke, 1984). In the majority of DRC protected areas network, the importance of a properly planned and executed law enforcement program, in combination with monitoring of both the protection effort and illegal activity using SIG and Remote Sensing (RS), has always been highly underrated despite widespread wildlife poaching, consequently, the overall shortage of reliable data on law enforcement resource allocation and related levels of illegal activities generally results in the limited availability of feedback mechanisms for improving law enforcement operations. Available field evidence lends support to the overall picture described above in the entire DRC protected areas network where most law enforcement programs in the country are ad hoc in nature, not conducted cost-effectively, and very little attention is paid to differential resource allocation to optimize field operations (Jachmann, 1998). Therefore such programs have been criticized for being insufficiently relevant to the needs of managers and ineffective in integrating information into decision-making. To that end, continued importance of illegal activity and law enforcement in conservation areas requires a system to monitor the quantity of illegal activity and law enforcement effort on a timely temporal and a spatial basis for identifying and quantifying spatial relationships and distributions of wildlife crime patterns.

Large-bodied species are vulnerable to overexploitation. They are important “habitat landscapers” (Fa & Peres, 2001) playing a key role in the structuring and functioning of the forest ecosystems. Given that the majority of large mammals in tropical forests are frugivores (including frugivore-granivores, frugivores-herbivores and frugivore-omnivores), these species are important in seed dispersal and predation (Wright *et al*., 2000), therefore they disserve our close monitoring attention. Ranger-based monitoring (RBM) program presented here concentrate on large mammals and human traces, as it is assumed that large mammals are good indicators for trends associated with hunting and other human activities (Barnes *et al*., 1991; 1993; 1995). As such, they provide an appropriate indicator for the effectiveness of the protection program carried out in the parks. I have limited this study to large mammals for several reasons. First, because of their ecological impact, hunting potential, and conservation attention, indeed, there are numerous existing repeated population estimates of many populations of large mammals in both study sites (**Tables 3. 15. 8 & 4. 5. 1. 1; 4. 5. 3. 1; 4. 5. 5. 1**). Second, among all wildlife taxa, large herbivores are the most prone to hunting by humans. Their relatively large meat yields and commercially valuable by-products such as hide, horn, and bone, make large mammals attractive targets for hunters. On the other hand, biological traits of large mammals – their inherent low densities, large dietary requirements, and home ranges, slow rates of growth and maturation, small litter sizes, long life-spans and generation times – also render them vulnerable to extinction from stochastic factors related to demography, environment, and genetics. These biological traits also render them vulnerable to extinction from deterministic factors such as hunting. Third, justifiable or not, large mammals receive a disproportionate share of attention in conservation activity and research (Young, 1994). The death of these larger species has a domino effect on other species, since they structure the whole ecosystem. They are the only animals capable of dispersing some big tree seeds. They may also keep dominant plants down, leaving room for other species; in such way, they encourage diversity (Harrisson, 1992). Thus, understanding the impacts of human hunting on large mammals is of critical importance in planning realistic strategies for their conservation (Madhusudan & Karanth, 2002).

The legal text stating the park boundary limits dates back to 1935 (the VNP legal text was modified a further three times) and, in many cases, is based on physical characteristics that have either disappeared/ modified, or have local names that are no longer clearly understood. In the case of the KBNP, the official boundaries as described by the baseline data of the ordnance No. 75/238 dated July 22, 1975 (**Box 1. 1, Annex 5**) which set up the park boundary misquoted some of the geographic landmarks. This loophole in the legal text and its implementation led to several interpretation and confusion among conservationists and local communities on the ground. In such context, it is worth stressing that occasionally during demarcation of the park boundaries serious arguments between park staff and local community often led to shots being fired into the air to scare population. This dual problem was a major challenge for the park's managers, particularly when it came to enforcing the integrity of the park boundaries in the midst of ever-growing human pressures (Languy *et al*., 2009e).

Countries contracting to the Convention on Biological Diversity (CBD, 2007) are obliged to monitor biodiversity (Article 7.c – *identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity and monitor their effects through sampling and other techniques*-). PA is the cornerstone of conservation efforts but the latter performance remains poorly documented.

To ensure that effective and active measures are taken for the protection, conservation and presentation of the cultural and natural heritage situated on its territory, each States Party to this Convention shall endeavor, in so far as possible, and as appropriate for each country to develop scientific and technical studies and research and to work out such operating methods as will make the State capable of counteracting the dangers that threaten its cultural or natural heritage for the protection and conservation of this heritage (UNESCO, 1972). However, because of they great value, wildlife resources attract unauthorized and unsustainable uses, thus prompting recurrent conflicts between the government policies and the wish of people over natural resources use. Park staff usually carries the brunt of this conflict, since its members form the interface between government and the public. This situation subjects them to strong social pressures, and frequently, to physical danger, the intensity of which is proportional to the value of wildlife resources at stake. Such conflict makes the forest guards's job a dangerous one (Robinson *et al*., 2010). This thesis aims to reviewing the conditions of service of park staff in order to suggest means by which the wildlife may be managed in conformity with government policies and international laws and at the same time, to reduce the conflict between the government and the public, and to protect park staff when conflict is inevitable (Bell, 1984d).

This dissertation is thus written as a contribution towards fulfilling the above mentioned conservation and management needs. This research topic is a goal worth striving for on which to base the present academic case by integrating the State-of-the art GIS applications in predicting areas highly prone to poaching, thus helping to optimize the design of better day to-day all-round surveillance has never been done in any DRC site grappling with an ever-growing human population.

CHAPTER 2

MATERIALS AND METHODS

> *Predicting species occurrence using a modeling approach based on a Geographic Information System (GIS) represents a new methodological tool which can be used to endorse conservation policies, on condition that models are tested for reliability*
>
> — **Ottaviani *et al.* (2004)** —

2. 1 Methods

Key points for the development of the LEM data base and related base map, which provide PAs management with up-to-date information, are: (i) Management information needs determining data collection, analysis and outputs; (ii) standardization of data collection and outputs; (iii) processing of all data relevant to management; (iv) use of geo-referenced data for planning, decision-making, monitoring and evaluation; (v) timely and accurate data entry; (vi) site-based central information system (database maintenance and integrity); and (vii) access for all partners users in concerned PAs.

2. 1. 1 Management Information Needs determine Data Collection, Analysis and Outputs

At the beginning of the LEM pilot study, several meetings were held with park wardens to identify the kind of information they needed for day-to-day decision-making. The information needs determined what types of data to be collected, the methods of statistical and spatial analyses and the types of output. The management of the two parks defined their information needs, building upon ecological and illegal activities data as described below. It is noteworthy to mention that important criteria were taken into consideration for the development and design of data sheets (**Annexes 7, 8 & 9**), including data which could be processed into information relevant to local conservation and management requirements (Sheil, 2001); data recorded needed to be easy and fast; handling of data sheets in the field (e.g., not too many sheets) without sacrificing details required by managers (e.g., details on authorization form, including names and number of guards on patrol, date and identification of any particular patrol). Data quality was an important consideration in dataset development. On the whole, basic data sheets (**Annexes 7; 8 & 9**) have been developed and modified in conjunction with site-based personnel and tested at some of DRC protected areas including current study areas.

2. 1. 2 Standardization of Data Collection and Outputs

Since the inception of both parks as a strict nature reserves, park wardens and guards at both study areas have routinely compiled monthly reports on different types and trends of illegal activity as well as the number of individuals arrested while hunting illegally in the park. Data were also available for a variable fraction of all years on the number of wire snares and weapons collected and the number of animals' carcasses found killed, fuelwood collection and charcoal events, etc. However, a few studies have addressed the efficiency of enforcement techniques and the minimum levels of funding required protecting key wildlife populations in the parks under consideration here. No LEM baseline and up-to-date field data on wildlife and illegal activities were available when the project started. At this period of the time, the parks had neither the manpower nor the necessary money to carry out a systematic monitoring program, and thus ICCN decided to use the RBM for patrol data collection. Starting with selected species (gorilla). This provided the opportunity to establish a standardized procedure for natural resource offtake monitoring which could be applied in other parks as well.

Only recently, standardized patrol forms were introduced to keep records of the numbers of staff on patrol, the exact duration, the area traveled, types, quantities and locations of illegal activity encountered. All spatial data collected were geo-referenced using the Global Positioning System (GPS). For each sighting, GPS waypoints, mammals species or types of human signs were identified, indicators of species presence (sight, carcass, tracks, dung, or nest), number of individuals identified, and the management area where the species or sign were detected were noted accordingly (Mubalama & Mushenzi, 2004). Human signs that were recorded whenever encountered included (snares and traps, camps, felled tree, bamboo cutting, poacher sign, footprint, charcoal burning, cattle sign, pit saws, encroachment, burned areas, etc..). It stands to reason that any traps or snares discovered during the reconnaissance patrol were dismantled and vegetation type mentioned on regular basis (**Annexes 8, 9**), hence, minimizing double snare counts. GPS Garmin devices used were capable of spatial accuracies within 10 m or less, even while operating underneath dense forest canopy. However, occasional failures caused by simultaneously pressing a combination of buttons when starting the GPS were the only problems encountered to date on the ground.

Under standardized conditions, a patrol was considered as a sample count, using a strip with a variable width that among others depended on vegetation density and the number of field staff scanning the strip, to determine the relative quantity of illegal activity. Since I required a measure of law enforcement effort that was easy to interpret for management purposes, and closely related to the minimum standard that was set at 15 effective patrol days per staff per month for all PAs in DRC as defined by ICCN management requirements. The duration of an effective patrolling day was preferably standardized to 6 hours (Jachmann, 1998) for both sites.

A Law enforcement monitoring workshop was held in order to harmonize and dovetail the approaches, prepare basic patrol maps and contribute to the finalization of the training program. This was followed by a training of trainers workshop aimed at training park wardens, monitoring supervisors and patrol guards from each site in the principles of applying and using the standardized method. The latter included refining the data collection, adequate debriefing carried out at the end of patrol exercise by monitoring, staff analyzing and reporting program based on their input. Field application of the methods, accompanied by *in situ* follow-up from the training unit was developed to assure standardized collection and reporting of LEM information as a measure of levels of protection to conservation of the site. With such standards in place long familiarization periods and retraining were no longer necessary when staff were transferred in other park management unit. Furthermore, standardized procedures also lessen the negative effect if individuals were to leave the organization, because enough people with knowledge remained to train new staff.

The outputs from routine data collected by law enforcement patrols consisted of maps of observations and patrolled areas and reports on performance indicators, indices of key mammal species and indices and number of illegal activities. Indices provided measures of relative density and could be used in comparisons for monitoring without the need for expensive baseline data; they were basically used to evaluate the success or failure of anti-poaching measures (Schmitt & Sallee, 2002). Methods for data gathering and analysis stood up to rigorous scientific scrutiny.

2. 1. 3 Law Enforcement Monitoring Data Sheets

2. 1. 3. 1 Law Enforcement Authorization Form

RBM has been advocated as an effective means of gathering a variety of data for natural resource management, including both poaching signs and encounters with species of interest (Arcese *et al*., 1995; Gray & Kalpers, 2005). As such, they are seen as potenatial source of information for learning about rule-breaking behavior with encounter data derived from the reports of rangers patrolling protected areas. The reporting forms consist of a *Bulletin de service* (Authorization form) describing related patrolling itinerary and the number of staff involved in a patrol (**Annex 7**) as well as the observations form providing data collected on target species and poaching signs.

2. 1. 3. 2 Law Enforcement Observation Form

On a daily basis, an animal and illegal activity observation sheet was completed by the patrol secretary (**Annexes 8, 9**). This gives the start and end points and times of patrols walked each day. In addition, the sheet gives the number, dates and coordinates of all poaching camps old, recent (occupied less than 1 week ago following developed metadata), positions of armed contacts, poaching groups, gunshots, tracks of poachers, or frequently used poaching trails, bushfires, ivory and/or snare collected, dead animals and wildlife sightings (live or dead). In addition, a detailed record book of ivory is maintained, with accession numbers, dates, weights, whether single or paired, conditions, cause of death and collector.

Under cover information on poachers and other illegal activities was also occasionally provided by informers in the areas surrounding the park as poachers continued to strike a blow to wildlife Act. This was collected and rewarded on a more informal and personal basis to the chief park warden or wildlife officer in charge of intelligence unit. At present, this type of information is not collected on a formal, systematic data sheet basis. The development of computerized database will give some structured indications on intelligence data collection in the future.

2. 1. 3. 3 Law Enforcement Basic Assumptions

The monitoring system and more specifically the resulting CPUE indices of the different types of illegal activity can be used as an adaptive management tool. However, the use of CPUE indices in LEM was based on the following assumptions:

(i) Patrol reports must be reliable account of the activities of the field staff, both in terms of technical precision and in terms of being a true account of events. Any modification of the facts will have a major impact on the chain of events. Experience on the ground is that, in general, guards' reports are highly reliable in this respect. However, in order to keep the focus on observations made and not interpretations of observations, the debriefing taken as an information gathering process was a critical step in LEM data gathering. The objectives of patrol debriefing were:

Verification (to ensure that the information on the daily patrol form is correct and correctly recorded); *amplification* (to add additional information for selected observations based on interviews with patrol secretaries and other patrol members); *communication* (to help transmit information from the patrol to the PA managers), and *on the ground training* (to improve accurate reporting of key information on the patrol report form).

(ii) Illegal activities are only recorded once and are of known age.

(iii) There must be a more or less constant relationship between the actual quantity of illegal activity and the rate of encounter per unit effort and catch probability should remain more or less constant over space and time to give a more or less constant relationship between what is actually happening in the field and what is being expressed in terms of indices. The basic assumption can be represented algebraically as follows:

$$\mathbf{CPUE = K \times I}$$

Where **C** = the "Catch" e.g., the number of encounters with illegal activity per unit area per unit time;

E = the "Effort" i.e., the index of patrolling effort per unit area per unit time;

K = the "Capture constant" which defines the relationship between catch per effort and the quantity of illegal activity per unit area per unit time; and

I = the quantity of illegal activity per unit area per unit time.

The equation should strictly refer to individual classes of illegal activity. For example, the capture constant, **K**, for gunshots, which can be heard over several kilometers, is obviously higher than the carcasses; which can only be seen at the range of a few meters. The equation should, therefore be written:

$$\mathbf{Ci/E = Ki \times Ii}$$

Where the subscript refers to the ith class of illegal activity.

2. 1. 3. 4 Recording Illegal Activity

According to the wildlife Act governing the national parks (**Annex 1**) besides activities related to park management and photographic tourism, there should be no human activities. In the VNP and the KBNP where people live inside the park, this makes it difficult to bind by the provisions of the law. When recording illegal activity using the daily-patrol form (**Annexes 7, 8 & 9**), the first major distinction was made between Serious Offences, which directly relate to the illegal killing of wildlife (Arrest, firearm, snare, keystone species killed, gunshots, armed group) and Minor Offences (footpath, camps, and foot print) which may or may not be related to poaching. On arrest of a poacher, various items may be confiscated such as axe, machete, pick and cutlass, which come under the category Secondary Serious Offences. A further distinction can be made between Encounters in the field, such as arrests of poachers and gunshots heard and indirect observations or Indicators of violation (burning, ashes, cartridges, cut stems and tree stumps). On return from patrol, the patrol leader and the secretary patrol who kept the records were debriefed to ensure that patrol routes were correctly inferred from reports and that all necessary information has been entered in the daily-patrol form.

Guard numbers and the numbers of patrols conducted per month or annum were used to quantify law enforcement effort. Taking all the above into account, the most convenient and simplest measure of effort used was the Effective Patrol Man-Days per unit area (entire conservation area, sector, or grid square for conventional patrols) or EPMD/Km^2 per unit time. This measure of effort has two major disadvantages (Bell, 1984a), Firstly, an effective patrol day should represent a more or less constant quantity of patrolling effort. This, however, may vary widely according to conditions in the field. To counter this effect, effective patrol day was standardized to approximately 6 hours of patrolling per day. Walking at an average speed of about 3 km per hour in flat terrain and about 2 km in undulating terrain, this gives between 12 and 18 km of patrol per day. Secondly, this measure of effort does not lend itself to breakdown by area, except for relatively accessible large areas. Therefore I used a 5 x 5 Km UTM grid map for the total number of grid squares patrolled per unit area per unit time as the patrolling effort (Bell, 1984a). This method was relatively accurate given the GPS waypoints recorded and the high level of proficiency in navigation by patrol leaders and secretaries. Only grid squares covered by the patrol were counted. The number of grid squares patrolled in a specific area and or/sector in a specific time was used as a measure of effort (**Figures 3. 5. 2 & 4. 2. 2**).

2. 1. 3. 5 Measuring Law Enforcement Effort

Being fully aware of the limits of precision inherent in the method described here; the index of rates of illegal activity was admittedly crude. However, the alternatives measures of law enforcement effort which I have applied building upon the law enforcement basic assumptions above mentioned give the advantage of providing an increasingly close estimate of actual amounts of illegal activity; bringing them closer to the requirements of formal a string census.

Quantification of law enforcement effort started with the categorization of the activities of the field staff according to the likelihood of encountering illegal activity, with off-day, time lowest, stand-by time (day-time spent at base, but not actively involved in any of the patrolling activities) and non-patrol activities intermediate, and patrol time highest (Bell, 1983; Bell, 1984a). Patrol time was divided into placement days (the time spent traveling from the base to the location where the patrol starts and back), and the effective patrol days (that is days spent actively patrolling on foot and/or boat or engaged in investigations). For manpower management monitoring system, I referred to 9 classes by wildlife management field staff below:

1. Day Patrol Effective: actual time spent actively patrolling in the field.
2. Long Field Patrol Effective: actual time spent patrolling in the field for more than one day.
3. Control Duties: time spent on crop activities or the destruction of individual animals that pose a threat to human life. Relatively little time was spent on this activity and all the park staff were normally available for anti-poaching operations.
4. Escort Duties: time spent escorting clients for tour operators, and various other escort duties, including conservators' body guards. From this prospect, analysis of law enforcement effort included escort guards in the case of tour operators, but analysis of guard force efficiency only included escort guards the periods when they were available for conventional or investigation patrols.
5. Guarding Duties: time spent guarding offenders, property or park entrance gates. Analysis of guard efficiency did not include guard manning the gates.
6. Research Duties: time spent on research-related activities, such as large mammal surveys, and monitoring botanical plots. Most of the field activities of research guards contribute to the deterrence effect of regular anti-poaching operations. In this regard, they were included in the overall guard density, but not in the analysis of scout efficiency.
7. Road-Block: time spent on road-block activities usually carried out in response to information obtained through the informers system. To that end, they were part of investigation operations.
8. Stand-by: duty-time spent at base, but not actively involved in any of the above activities.
9. Base-Time: free time, not spent on duty implying a very low frequency of encounter of illegal activity.

2. 1. 3. 6 Use of Geo-referenced Data for Planning, Decision-making, Monitoring and Evaluation

Park guards recorded LEM location data using GPS devices. LEM spatial data collected were geo-referenced using user-friendly, hand-held unit with an in-built antenna and providing GPS waypoints (coordinates, date and time). GPS readings by guards' patrols were taken at each relevant observation and at least every c. 30 minutes (though not on a regular basis). This enabled calculation of the distance covered by each patrol with reasonable accuracy, which in turn allowed the calculation of distance-related indices. Indices provided measures of relative density and were used in comparisons for monitoring without the need for expensive baseline data. An index such as snares collected per kilometer patrolled showed changes in relative hunting pressure over time without knowing actual number of poachers and of animals killed. Periodic monitoring with indirect observation can document short- and long-term trends in illegal activity (Jachmann & Billiouw 1997). Nevertheless, none of the indirect observation methods indicate who violators are or why illegal behavior occurs although, debriefing provided decision support system feedback opportunities.

Park staff' patrols did not systematically cover the entire park area. They were deployed based on law enforcement requirements; areas patrolled recently, and sometimes intelligence information etc. It was therefore essential to stratify (sub divide) each PA into strata (management sector) which were similar in terms of patrol intensity. Basically, stratification of the park into management sectors which had a high chance of being patrolled at similar intensity over time helped to address the issue of patchy and unsystematic patrol deployment.

2. 1. 3. 7 Analysis and Processing of Patrol Index Data relevant to Management

Estimates of animal abundance for the regulation of management purpose were collected through cost-efficient index techniques, for example patrol index, where sightings of key species were related to patrol effort. Here, the goal was to monitor the effect on levels of illegal offtake of changes in law enforcement patterns, such as patrolling effort and efficiency, and the international legislation, such as the CITES ivory ban. In this regard, estimates were precise, but not necessarily accurate and obtained with high level of consistency in methodology applied (Jachmann, 2001).

Monitoring can cover a multitude of different types of data. Amongst all the possibilities, choices were made to streamline data collection efforts in relation to the needs and the management objectives of a particular PA (Sheil, 2001; Liebenberg, 2003). While conventional statistical methods offered a reliable way to test data sets, it was necessary to first ask what type of information was required for management purposes. In fact, often management decisions (for surveillance, tourism, etc.) don't require statistically significant results (Sheil, 2001). Park managers need a steady flow of information which is delivered without disruption, and a management decision can often be taken based on a less scientifically rigorous approach.

I analyzed data from 16,443 patrol forms generated by patrols conducted from 2004 to 2008 for the VNP, and 14,143 .patrol forms for the KBNP. Most of the information presented in this thesis was derived from patrol reports that were assumed reliable accounts of the activities of the patrol staff, both in terms of technical precision and in terms of being a true account of events while building upon the debriefing. Since patrol frequency is a key determinant of the successful protection of large mammals (Arcese *et al*., 1995), I used it into the measure of protection effort.

Patrol movements were unpredictable by nature and potential outliers were visually identified and removed from the dataset, therefore this method of screening data helped minimize non normality. This further enabled to optimize the impact of LEM and to enable statistical inference from monitoring data. Because the layout of patrols does not follow a statistical sampling design, information on illegal activity will often be biased. Inference to a larger domain can only be made when using a design-unbiased approach. However with good coverage of the site by patrols and systematic and reliable data collection (**Figures 3. 5. 2 & 4. 2. 2**), a model-based and/or assumption based may be attempted, taking into account covariates influencing illegal killing (Jachmann & Beyers, 2003). Three variables were used to calculate direct measure of protection effort: Coverage, Personnel and Time (Hart & Hillman-smith, 2001). At both sites the layout of patrol had a strong element of randomness with repeated patrol coverage of the study conservation areas, using a more or less random design. We shall look at all these variables in the next chapter.

Sightings of all events were reported to park headquarters following a debriefing session to ensure that all necessary information on the daily report form was correct and correctly recorded, thus giving a ‘big picture’ of the controlled area by minimizing omission and/or falsification. To compare encounter rates of illegal activity and key wildlife in the Park Management Units (PMU) with different conditions, a standardized measure of patrolling effort was required. EPMD/Km^2 measure of effort does not include time spent on placement and preparations, but rather effective patrol time that is time spent actively in pursuit of illegal activity. An important feature of the monitoring system is the relationship between illegal activity encountered on patrol and law enforcement effort expressed in term of catch per unit effort (CPUE) index. Encounter rate per effective patrol man-day per km^2/unit time was used as the standard unit of patrol effort to make the encounter rates equivalent to CPUE index as an index of the number of infractions committed (Bell, 1984a; Jachmann, 1998).

I determined the patrol efforts for each PMU, here after referred to as management sectors (Northern, Central, Eastern, Rutshuru Hunting domain and Southern sector for the VNP and the highland and Nzovu for the KBNP), by working out the number of persons carrying out patrol, numbers of hours worked and the number of days patrolled in a month or year. Patrols were undertaken over the month and year and were of different sizes and lengths. Thus, for each patrol, independent of its duration, the number of patrol hours was divided by the minimum required of 6 hours, and multiplied by patrol size to give effective-patrol man-days (Jachmann, 2008a). Analysis of the strength of the deterrence capacity only included staff on duty. Patrol coverage was calculated using Arc GIS 9.3 extension tools (ESRI, 2006). The study area was large in geographic extent. It prompted me to grid the area into equal size (5km x 5 km) portions (quadrats) and compared them. Quadrat analysis splits the area into equally portions and summarizes the number of wildlife crimes occurring in each portion (Eeck *et al*., 2005).

Apart from the sites management reporting quoted in this thesis, different LEM site reports were analyzed to complete the summary law enforcement in each study site including Kujirakwinja *et al.*, 2005; Kujirakwinja *et al.*, 2006a & 2006b; Kujirakwinja *et al.*, 2007; Kujirakwinja *et al.*, 2008; Kujirakwinja *et al*., 2009; IZCN-DG, 1980; IZCN-DG, 1982; PNVi-ICCN, 2007; PNKB, 1998; PNKB, 2000; PNKB-LEM, 2004; PNKB, 2005; PNKB-LEM, 2006; PNKB-LEM, 2007; PNKB-LEM, 2008; PNKB, 2009; PNKB-LEM, 2010; and PNKB-Nzovu, 2006.

2. 1. 4 Statistical Analyses

The analyses were performed using Statview 5.0 (Statview, 1998). As both biological and LEM data were not normally distributed, non-parametric tests were applied. I used χ^2 contingency test and Kruskall-Wallis test to analyze the effect of strata on wildlife species and the most common severe threat density and the relationship between habitat types, wildlife species and the major threats. Comparison of wildlife species occurrence between two habitats was analyzed using nonparametric Mann-Whitney *U*-test. The Mann-Whitney *U* test for comparison of ranks (*U*) was used to determine the significance of all continuous variables. Logistic regression analysis was conducted using the backward stepwise selection of factors. All analyses were conducted at the 0.05 level of significance. Cross-tabulations, reported as log likelihood chi-square (χ^2), were used to determine the significance in case of binominal variables.

These non-parametric tests were preferred because of their robustness in cases where sample sizes are small (Zar, 1984), and do not require many underlying assumptions. I performed regression test to examine the effects of distances from the park boundaries and patrol effort on threat densities. To examine the influence of resources allocation, park ranger performance, human settlement densities, relative densities of keystone species, and habitat type on the incidence of illegal activity, a stepwise multiple linear regression analysis was performed using Statview version 5.0 package software. Results were considered significant if $P < 0.05$.

The number of encounters with large keystone species/ km^2 was used as a measure of relative wildlife density. The number of encounters with offences per /EPMD/ km^2 was used as the response variable while the budget/km^2 ($US) was used as a measure of resources allocation to law enforcement. Predictor variables without a significant association with illegal activity were omitted from the regression analyses. The number of encounters with large keystone species/ km^2 was used as a measure of relative wildlife density. Spearman rank correlations were used to investigate the relationship between signs of human disturbance and signs of large mammals on one hand, and between amongst human threats on the other hand. Again, results were considered significant if $P < 0.05$.

The most common habitat selectivity was used to measure habitat preferences by illegal wildlife users in the ranges designated as wildlife preferred habitats (Jacobs, 1974). Vegetation or habitat types were selected as sample sites. The number of illegal sightings in a particular area and the habitat type offenders preferred were recorded. Habitat used by offenders was inferred from preference indices (PI). The proportions of sightings of offenders' presence in each vegetation type were monitored, and these were taken as the dependent variable. The different vegetation categories were interchangeably used as habitat type for offenders. The range of human wildlife use was delineated by kernel analysis at 95% and 50% of occupied plots using the Arc View 3.3 program (ESRI, 2003) with a focus on the spatial"core area" (distribution delineated by the kernel analysis at 50% probability). I then compared the abundance of individual habitat types in the range of their availability in the study area using Jacobs index of preference (Jacobs, 1974):

$$\mathbf{PI_i} = \quad [(X_1/Y_1) - (X_2 Y_2)] \; / \; [X_1/Y_1) + (X_2/Y_2)]$$

Where PI is the preference index, X_1 is the surface of the i^{th} habitat type included in the range, Y_1 is the whole surface of the range, X_2 is the surface of the i^{th} habitat type included in the study area, and Y_2 the whole surface of the study area. The index ranges from -1 to +1, taking positive values if the usage of the i^{th} habitat type is greater than its availability and negative values if the usage is less than availability. To test the reliability of the Jacobs indexes, I re-sampled 1,000 times the random points in each of the study area considered by the bootstrap method (Dixon, 1993) I then calculated the Jacobs index of preference for each bootstrap sample and for each habitat. Finally, I checked for the normality of indices distribution and I tested for significant deviations of the index values from 0 (neutral selection) by the one-sample student's t test (Hesterberg *et al*., 2005). A Chi-square test (χ^2) was used to investigate differences between dry and wet season use of habitats.

2. 1. 5 GIS Data Modelling and Spatial Analysis

Spatial analysis techniques have been defined as those ‘whose results are dependent on the locations of the objects or events being analyzed’ (Goodchild *et al*., 1992). Geostatistical methods have been widely used in natural-resource management and remote sensing (Burrough, 1990; Curran & Atkinson, 1998). I used both hotspot analysis tool and Ordinary kriging represented by the spherical model. The hotspot analysis tool calculates the Getis-Ord Gi* spatial statistic for each feature in a dataset. The resultant Z score tells us where features with either high or low values cluster spatially. To be a statistically significant hotspot, a feature will have a high value and be surrounded by other features with high values as well. Specifically, I aimed to test these predictions and show that patrol effort determines the distribution of illegal activity as well as species distribution using Arc GIS 9.3 geo-statistical analysis tools (ESRI, 2006).

The hotspot analysis: Getis-Ord local statistic is given as:

$$G_i^* = \frac{\sum_{j=1}^{n} \omega_{i,j} x_j - \overline{X} \sum_{j=1}^{n} x_{i,j}}{S \sqrt{\frac{n \sum_{j=1}^{n} \omega_{i,j}^2 - \left(\sum_{j=1}^{n} \omega_{i,j} \right)^2}{n-1}}} \qquad \textbf{(1)}$$

Where x_j is the attribute value for feature $x_{i,j}$ the spatial weight between features *i* and *j*, *n* is equal to the total number of features and:

$$\overline{X} = \frac{\sum_{j=1}^{n} x_j}{n} \qquad \textbf{(2)}$$

$$S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - \left(\overline{X} \right)^2} \qquad \textbf{(3)}$$

G_i^* Statistic is a z-score so no further calculations are required

The Gi* statistic returned for each feature in the dataset is a Z-score. For statistically significant positive Z-scores, the larger the Z-score is, the more intense the clustering of high values (hotspot). For statistically significant negative Z-scores, the smaller the Z-score is, the more intense the clustering of low values (coldspot). In order to reject the null hypothesis, one must make a subjective judgment regarding the degree of risk he/she is willing to accept for being wrong. The degree of risk is often given in terms of critical values and/or confidence levels. Z-scores are measures of standard deviation. Hotspot analysis tool assesses whether high or low values (number of illegal incidents) cluster spatially (Mitchell, 2005).

To create a continuous surface of the phenomenon, predictions were made for each location, or cell centers, in the study area based on the semivariogram and the spatial arrangement of measured values that are nearby. The spatial variation was quantified by the semivariogram. The variance was calculated based on the average variance of all point pairs within each interval of the cell size. The variogram was then fit to the variance points using the Levenberg–Marquardt Method (Cressie, 1988) of nonlinear least squares approximation. Kriging was then fit as a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. It weights the surrounding measured values to derive a prediction for an unmeasured location. The general formula for both interpolators is formed as a weighted sum of the data:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

Where:

$Z(s_i)$ = the measured value at the i^{th} location.

λ_i = an unknown weight for the measured value at the i^{th} location.

s_0 = the prediction location.

N = the number of measured values.

To make a prediction with the kriging-based interpolation method, three tasks were performed: (i) Make an assessment of the appropriateness of LEM data for use with the kriging technique; (ii) uncover the dependency rules and (iii) finally make the predictions. To realize these two last tasks, kriging goes through a two-step process: (i) It creates the variograms and covariance functions to estimate the statistical dependence (called spatial autocorrelation) values that depend on the model of autocorrelation (fitting a model) and (ii) it predicts the unknown values (making a prediction). The following sections of this work presents the outcome the mapping prediction surface related to the park poaching hotspot (threatened areas most affected by high rate of illegal activities) and coldspot using GIS kriging wizard. A random pattern indicates that there is a low probability of geographic influence on spatial distribution while a systematic pattern is one that occurs at regular intervals (Sherman & Weisburd, 1995).

2. 1. 6 Spatial Data Analysis: Hotspot Analysis Approach

Carrying out analysis followed a logical and systematic approach. Visually identifying a hotspot can inappropriately affect input parameters, such as the size of the search radius, because analysis for example, an analyst might be looking at too many observations at one time. As a result, the presence of clusters of illegal activity could be exaggerated or could remain undetected if too few observations are used. Conversely, a statistical approach can only examine the observations that are selected without considering environmental factors, and thus require human interpretation to make sense of the results of analysis. I therefore used statistical tools in conjunction with my understanding of an area to give the analysis a solid foundation for stating where hotspots actually are occurring. This process scientifically determined that a hotspot is indeed an actual cluster of events that are not occurring at random. In this regard, Gesler & Albert (2000) point out that with availability of GIS and other spatial data analysis softwares we often did side-step an important element of analysis. That element in hotspot analysis is the understanding of the underlying spatial and social processes contributing to the presence or absence of illegal activity in an environment. I made the assumption that places have unique characteristics that affect the distribution of illegal activity over space (e.g., spatial processes) and temporal distributions. Social and spatial processes are not stationary; illegal activity is affected by the variation of demographics and other social aspects that change across space (Haining, 2003). This leads to a premise that has long been championed in geography – place matters. Haining (2003) and Gesler & Albert (2000) note that observations change from place to place, which is an indication that the underlying spatial and social processes are different, and thus the method used for carrying out analysis will need to be adjusted to detect those processes.

To detect the presence of hotspot, the strength of spatial relationship between incidents was established. This strength is known as dependence and is based on Waldo Tobler's "First Law of Geography," where everything is related to everything else, but closer things are more related (National Institute of Justice, 2008). Given the fact that a spatial process can change across space, the threshold distance of influence between incidents to guide the selection of bandwidth type and size when analyzing for clusters was determined. Statistical techniques were used to find spatial dependence based on the distribution of points, such as variograms or nearest neighbor indexes. These formulas helped to measure the spatial distribution of points against a set of randomly distributed points to determine if clustering is chance or not. These formulas simply state that given a number of incidents, clustering would occur based on the amount of area in which they are present. Though no common definition of the term hotspot of wildlife crime exists, the common understanding is that a hotspot is an area that has a greater than average number of criminal or disorder events, or an area where wildlife have a higher than average risk of victimization. This suggesting the existence of coldspot- places or areas with less than the average amount of crime or disorder and that some hotspot may be hotter than others; that is, they vary in how far above average they are (National Institute of Justice, 2008).

I used both hotspot analysis tool and Ordinary Kriging represented by the spherical model. The ArcGIS 9.3 hotspot analysis tool calculates the Getis-Ord Gi* spatial statistic for each feature in a dataset. The resultant Z-score tells us where features with either high or low values cluster spatially. Kriging (ESRI, 2006) was then fit as a mathematical function to a specified number of points, or all points within a specified radius, to determine the output value for each location. It weights the surrounding measured values to derive a prediction for an unmeasured location. I used ArcGIS 9.3 to harmonize projections, cell size, and extend across datasets in carrying out all further analyses in determining hotspot poaching and other related outcomes. Once hotspots or ‘coldspots’ of illegal activity were identified, I examined factors around the hotspots that contributed to crimes and developed strategies for prioritizing their protection. First order clusters are more likely to identify crime hotspots (Mitchell, 2005).

2. 1. 7 Habitat Mapping

2. 1. 7. 1 Land Cover Classification

The method as proposed by Lillesand & Kiefer (1994) was used in this study. Land cover classes are typically mapped from digital remotely sensed data through the process of a supervised digital image classification (Campbell, 1987). The overall objective of the image classification procedure is to automatically categorize all pixels in an image into land cover classes or themes (Lillesand & Kiefer, 1994). The maximum likelihood classifier quantitatively evaluates both the variance and covariance of the category spectral response patterns when classifying an unknown pixel so that it is considered to be one of the most accurate classifier since it is based on statistical parameters. Supervised classification was done using ground checkpoints and digital topographic maps of the study areas. The areas were classified into different classes using ENVI 4.7 software (ENVI, 2009). Description of these land cover classes is presented. Then accuracy assessment was carried out using 150 points from field data and 50 points existing topographic maps dated back to 1980 and land cover map from 1985. The location of the 150 points was chosen using random stratified method to represent different land cover classes of the areas. In order to increase the accuracy of land cover mapping of the images, ancillary data and the result of visual interpretation was integrated with the classification result using GIS in order to improve the classification accuracy of the classified image. The outcomes of the unsupervised classifications which were spectral classes are compared with some form of reference data (e.g., maps or ground truthing) to determine the identity of the spectral classes.

2. 1. 8 Socio-Economic Data Gathering

At the outset, however, it should be emphasized that the socio-economic environment is difficult to quantify. Surveys are capable of obtaining information from large samples of the population. They are also well suited to gathering demographic data that describe the composition of the sample (McIntyre, 1999). Surveys are inclusive in the types and number of variables that can be studied, require minimal investment to develop and administer, and are relatively easy for making generalization (Bell, 1996). Surveys can also elicit information about attitudes that are otherwise difficult to measure using observational techniques (McIntyre, 1999). In general, questionnaires are useful, where the researcher cannot observe the phenomenon directly or is impractical to do so. It allows the researcher to reconstruct the phenomena through the experience and perceptions of the participants who have observed the phenomena.

It is important to note, however, that surveys only provide estimates for the true population, not exact measurements (Salant & Dillman, 1994). McIntyre (1999) notes that a survey design - through the data collection process of asking questions, provides a quantitative or numeric description of some fraction of the population e.g., a sample which can be in turn generalized to the population from which the sample was drawn. In order to make a useful prediction of the socio-economic effects of an action and to develop indicators for this purpose, an assessment team was assembled, and given the task of learning a great deal about the local communities likely to be affected. The process of gathering the required socio-economic information has been called *social profiling*.

Apart from the socioeconomic surveys data collected during the study period, considerable and invaluable information has been drawn from a variety of sources including different reports related to the VNP and KBNP including Kofimoja (1987); Murhula *et al*. (2001); Plumptre *et al*. (2003b); Mulangala (2004); Bush *et al*. (2006). These data and related geographic information gathered allowed completing the hotspot model on hunting probability pattern at both sites (**Figures 3. 15. 3. 1 & 4. 5. 5. 4**). Demographic data were drawn from local government public services (Division Provinciale de l’Intérieur, Décentralisation et Sécurité-Sud Kivu 2004; 2005; 2006; 2007 and 2008; Division Provinciale du Plan Nord Kivu (2007-2008) and the Ministère du plan (2005a & 2005b).

2. 1. 9 Data Sources

The law enforcement and socio economic data sets used for the study included the following:

Table 2. 1. 9. 1 *Data Sources of the Base Map for PA Network*

Data sources **Theme**	**Satellite Data**	**Cartographic Data**	**Tabular Data**	**Field Data (GPS)**
Access network	Road network	Road network		Paths, road conditions, passer by frequency, bridges, etc.…
	River network	River		Passer by frequency, (swamp, etc.)
	Other	Airport etc.		Direct observations
Human occupations	Cities, villages	Cities, villages	Demographic Data	Human settlements and demographic data
Socio-Economy and administration	Mining sites, plantations, gardens et fallows	Concessions Villages	Demographic, social and economic data	Direct observations at site level and report human settlement locations (Map) Bushmeat
	Natural limit (Rivers, hills, etc.)	Territory entity limit Zoning, etc.	Legal texts	Delimitation of boundary on the ground
Threats and protection	Natural limit (Rivers, hills, etc.)	PA boundary	Legal texts	Gazetment of PA
		Protection infrastructure (patrol post, etc.)	Protection infrastructure (patrol post, etc.)	PA infrastructure, direct observations at site level
		Patrol Map	Patrol reports Patrols from other projects	Patrol observations and coverage (« way points and limited sets of track logs »)
Habitat and flora	Hydrology	Hydrology		Direct observations
	Supervised classification SPOT image (10 and 30 m resolution), Landsat-Thematic Mapper	Classification of habitats	Classification of habitats	Ground truthing
Fauna		Map of distribution of the fauna	Reports	Direct observations

2. 1. 10 Enforcement Economics: Theoretical Underpinnings

In the **Box 2.1**, I provide a model of the economics of wildlife crime, namely the enforcement economics: theoretical underpinnings. This model allows study rational offender decision-making about entering into illegal activities. Probability and size of punishment, attitudes towards risk, gains from crime and income were the main variable influencing the results of individual behavior. The relationship of the theory of optimal law enforcement was also taken into account in understanding law enforcement and illegal activity. Overall, the rational behind the enforcement economics is that all enforcement can be considered 'effective' only if it generates an enforcement disincentive that is larger than the financial incentives motivating the illegal behavior, particularly in current most depressing economy context.

Box 2.1
Enforcement Economics: Theoretical underpinnings

Economists focusing on the question of enforcement have suggested that the economic deterrent "value" of an enforcement regime can be determined as follows:

Enforcement disincentive = $P_{d} \times P_{a/d} \times P_{p/a} \times P_{c/p} \times Fine \times e^{-rt}$

Where:

P = Probability
d = detection
a/d = arrest given detection
p/a = prosecution given arrest
c/p = conviction given prosecution
e = a mathematical constant, the exponential function of 1
r = interest rate
t = time of detection to fine

In this model, the frequency and intensity of illegal behavior are assumed to be proportional to the net profits from illegal behavior. If the gross profits of illegal behavior are greater than the expected value of the enforcement disincentive – that is, if violators of environmental laws believe that their profit will be greater than what they will have to pay for breaking the law – then the net profits of illegal activity are positive, and violators will choose to commit the crime. By the same token, if the expected value of the enforcement is high enough to make the net profits of illegal activity negative, they will decide not to commit the crime.

As shown in the equation above, the value of the disincentive to commit an environmental crime is equivalent to the probabilities of each step in the legal process happening, multiplied by the amount of the fine, and discounted for the time between detection and paying the fine. According to this logic, an enforcement disincentive (ED) that is larger than the financial incentives (profits) motivating the illegal behavior. For this analysis, "effectiveness" will be defined as such.

This model offers four particularly interesting insights into enforcement systems:

- If the probability – or even the perceived probability- of any one of the elements in the enforcement chain is zero, then the value of the entire chain is reduced to zero. The enforcement regime presents no disincentive to breaking environmental laws
- By this logic, enforcement systems are holistic in nature and must be conceived of and dealt with as such. The disincentive value generated by an enforcement regime relies not only on how well the agencies responsible for each element of the enforcement chain do their individual piece but also how well those agencies work together as a system. The system is only as strong as its weakest link.
- An element-by-element elimination of the enforcement system will help pinpoint exactly where in the process-and within which agencies-weaknesses are being generated
- The time element is an important one, because discounting for each year between detection and payment of the fine will significantly reduce (a) the value of the fine to the violator, (b) the overall value of the disincentive provided by the enforcement regime, and (c) the disincentive to commit an environmental crime.

Source: Akella & Cannon, 2004

CHAPTER 3

MONITORING LAW ENFORCEMENT AND ILLEGAL ACTIVITY IN THE KAHUZI-BIEGA NATIONAL PARK

We live in challenging times. Global warming is upon us. Ecosystems have been degraded to the point that many no longer contribute life-preserving functions. In a considerable number of places, biodiversity is in freefall. It is almost a cliché to note that each of these challenges stem from human behavior—from our efforts to meet our needs and desires. In our quest to satisfy ourselves, we have dramatically degraded the health of ecosystems and in doing so we have put our own health at risk.

- William Sullivan, 2010 -

3. 1 Introduction

Over-hunting of wildlife induced by growing human population has been highlighted as the central reason why species are currently threatened in many tropical regions (Fa *et al*., 2002; Robinson & Bennett, 2002). Recent research argues that the greatest threat to biodiversity conservation in Central African forests is not deforestation, through logging and conversion to agriculture, but defaunation (Lahm, 1993; Hennessey, 1995; Muchaal & Ngandjui, 1995; Walkie *et al*., 1999). While efforts taken to stop illegal hunting are noteworthy, these efforts often seem futile as park rangers who pursue the poachers are frequently out manned and outgunned (Magelah *et al*., 2007). As a consequence, wildlife is being extirpated across its ranges, and in turn, people who depend on wildlife meat for food and income suffer (Robinson & Redford, 1994; Robinson & Bennett 2002). Even in PAs, encroachment is widespread (Hamilton, 1984; Howard, 1991). Quantifying the relationship between the distributions of species and their ecosystem has a long history in ecological research. While understanding where species-related threats occur is fundamental ecological requirement, prediction of species occurrence is essential for conservation and population management (Rushton *et al*., 2004).

Yet against this background, a few comprehensive studies have addressed the efficiency of law enforcement monitoring and the allocation of resources for conservation purposes (Bell 1983; Bell 1984; Leader Williams *et al*., 1990; Milner-Gulland & Leader Williams 1992; Leader-Williams 1996; Jachmann & Billiouw 1997; Jachmann, 1998; Jachmann 2008a; Jachmann 2008b). In this context, ecologists, conservation biologists and GIS cartographers have become increasingly concerned at the accelerated loss of the world's natural resources and regard PAs as a core component of conservation strategies (Leader-Williams *et al*., 1990;

Bruner *et al*., 2001) and the cornerstone for biodiversity protection (Oates, 1999 Myers *et al*., 2000; Struhsaker *et al*., 2005).

Many poaching reports are collected accidentally, and may be indirect as both hunter and hunted are elusive (Sanchez-Mercado *et al*., 2008). Only recently, a RBM using GIS and remote sensing techniques was established following the observed shortage of reliable data on law enforcement effort and related illegal offtake of natural resources in the PAs network in DRC. The case in point of the KBNP upland and lowland sectors (**Figure 3. 2. 1**) was not an exception to the rule. The study area was patrolled several times each year with patrol intensity being frequently directed towards areas with both high and low incidences of illegal activities, thereby reducing bias. The study demonstrates the crucial need to have as much accurate and up-to-date law enforcement data as possible from which to draw sound management decisions.

Our purpose here is to present a framework to employ Law Enforcement Monitoring (LEM) data to understand spatial patterns of threats to wildlife species. The stimulus of this study was to determine spatial factors driving key large-bodied mammals poaching and identify illegal activity incidents that are clustered around a particular place of interest within the study area. I investigated the anthropogenic factors on defaunation as well as the spatial patterns of illegal activities against target wildlife distribution, habitat types, and distance from the park limit in order to provide park managers with information that prompts appropriate responses to threats (Gray & Kalpers, 2005a). We shall look at these key factors in the next two chapters.

3. 2 Study Area

This study encompassed a 2,596-Km² of the park known as the Highland-Nzovu complexe located between 2º 4’ 15’’ and 2 º 45’ S and 28 º and 28 º46’05 E. Area of critical conservation concern, the Park highland sector (600 km^2) consists of two geomorphic units: rift valley volcanic mountains and Congo basin low highlands. The high mountain range is dominated by two extinct volcanoes, Mounts Kahuzi (3,308 m) and Biega (2,790 m). The Mounts Kahuzi and Biega, the two extinct volcanoes after which was named the park are symbols of the conservation of humid tropical mountain forest and of the wildlife species living there. The protection of the heavily poached gorillas (*Gorilla beringei graueri*) was the prime reason for the institution of the KBNP in 1970 (Mühlenberg *et al*., 1995). The park was first declared a Game Reserve by the Belgian colonial administration in 1937. It then became a National Park in 1970 following the Ordnance 70-316 of 30 November 1970 (**Annex 4**) and covering the mountain sector (600 km²). In 1975, the park was extended (5,400 km²) under the ordnance 75-238 dated on 22 July 1975 (**Annex 5**) to include both the upland and lowland sectors which are interconnected by a 11 km-strip of land (Von Loenbenstein *et al*., 1993; ICCN/PNKB, 2000). The connecting belt between the two zones is in rolling terrain.

In the high eastern mountains, there are six primary vegetation types varying with elevation: mountain rain forest, bamboo forest, swamp forest, high-altitude rain forest, sub-alpine heather and peat bog (**Figure 3. 6. 2**). The western mountain section is lowland equatorial rain forest between 700 and 1,200 m, with transitional forest between 1,200 and 1,500 m.

The mountain rain forest grows between 1,000 and 2,000 m. From 900 to 1,350 m co-dominants are: *Michelsonia microphylla* and *Gilbertiodendron dewevrei* and from 1,350 to 2,000 meters *Pentadesma lebrunii* and *Lebrunia bushaie*. After disturbance the latter becomes open *Hagenia abyssinica* and *Neoboutonia macrocalyx* forest with *Hyparrhenia* savanna and *Imperata* meadows. Other dominant species are *Albizia gummifera*, *Parinari excelsum* and *Chrysophyllum gorungosanum*. The highland rain forest growing above 2,000 m is characterized by *Podocarpus usambarensis, Chrysophyllum longipes, Ficus sp., Parinari sp., Carapa grandiflora* and *Symphonia globulifera*. Clearings are invaded by *Lobelia gibberoa*. Swamp forest grows in poorly drained areas, dominated by *Syzygium rowlandii*, *Podocarpus usambarensis, Agauria salicifolia*, and *Anthocleista grandiflora*. Bamboo *Sinarundinaria alpina* forest grows between 2,350 and 2,600 m. It has spread by colonizing cleared land and covers approximately one-third of the original eastern park zone.

On level land between 2,000 m and 2,400 m swamp and peat bogs occur. They are dominated by *Cyperus latifolius* with *Cyperus aterrimus* or *Hypericum lanceolatum*, *Alchemilla cryptantha*, *Anagallis angustiloba* and *Jussiaea repens*. The peat-bog is formed of *Juncus effusus* with *Spagnum rugegense*. Above the tree line at about 2,600 m, the vegetation is subalpine. Heather *Erica rugegensis* is characteristic, with *Vaccinium stanleyi* and *Breutelia* spp. on the summit of Mount Biéga. On one summit of Mount Kahuzi *Hedythrsus thamnoideus* and *Disa erubescens* grow; on its main summit, between 3,200 and 3,308 m, *Erica* spp. grow with *Senecio kahuzicus*, *Helichrysum mildbraedii*, *Huperzia saururus* and *Deschampsia flexuosa*. 48 species with 2 unknown and 24 endemic species are found in the park. The western lowland equatorial forest can be characterized as *Michelsoni* - *Gilbertiodendron* forest below 1,350 m and *Pentadesma* - *Lebrunia* forest above it (UNEP-WCMC, 2008; Mühlenberg *et al*., 1995).

Towards the west, the mountainous massifs have a reduced altitude: mount Bituzi (1,842 m), Mount Kamani (1,700 m), Mount Makasa (950 m), Mount Kitumba (943 m) and Mount Kivene. The main Rivers in the park are the Luhoho, Lubimbe, Lugulu and the Luka (**Figure 3.**

12. 1). The park acts as watershed for these rivers that are actually tributaries of the Congo River either through Lake Kivu in the south or through the Lowa and Ulindi Rivers in the north-west.

Throughout the park there are surficial deposits of gold, cassiterite (a tin ore) and 15% of the world's mined coltan (columbite-tantalite) ore of a high grade which, in 2000, fetched very high prices as a component of computer and mobile phone capacitors (UNEP-WCMC, 2008). The rainfall regime near Tshivanga is 1200 ± 3000 mm and mean monthly temperature is 20.2ºC. The climate is punctuated by two dry (January-February and June-August) and two wet (March-May and September-December) seasons (Bultot & Griffiths, 1972; Wils *et al.*, 1976; Yumoto *et al.*, 1994). Owing to its fascinating biodiversity, the park became a World heritage Site in 1980 (IUCN, 1992) and so far, down listed as a World heritage Site in danger since 1997 following escalating wars that have laid waste to it (Mubalama & Bashige, 2006), uncontrolled invasion by miners and militia, the destruction of wildlife, especially gorillas and elephants, for bushmeat and ivory, and the burning and cleaning of forest. Overall, the park was declared World heritage site in danger in 1997 following growing human-induced threats to the park (UNESCO, 2001). The park straddles the Maniema, North and South Kivu provinces and 6 territories (**Annex 14**).

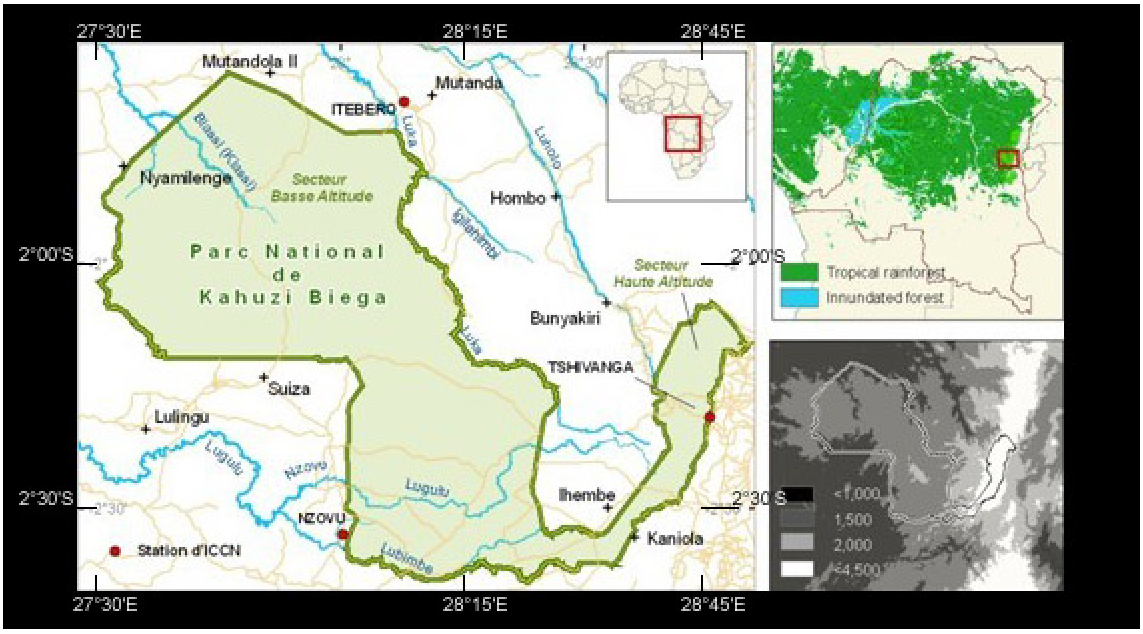


Figure 3. 2. 1 *Kahuzi-Biega National Park, Democratic Republic of Congo (Source SYGIAP, 2006a)*

3. 3 Biodiversity Value of the Kahuzi-Biega National Park

The KBNP is known for its exceptional biodiversity ranking as one of the key sites within the Albertine Rift region, which itself is one of the most biodiverse ecoregions on the African continent (Plumptre *et al.*, 2003a, 2007). It contains more threatened mammals' species than any other site within the Albertine rift and ranks as the second most important site in the Rift for conservation of endemic species, third for conservation of threatened species and second of total species richness (Plumptre *et al*., 2003a). Consequently this is one of the most important parks in the world for biodiversity conservation.

The Eastern lowland gorilla (*Gorilla beringei graueri*) only occurs in DRC in the Maiko-Tayna-Kahuzi-Biega landscape covering 67,121 km^2 (CBFP, 2006). In 1982, it was estimated that there were still 3,000 to 5,000 lowland gorillas in Eastern DRC (Mühlenberg *et al*., 1995). Recent survey in 2004 by the Wildlife Conservation Society (WCS) recorded 168 gorillas (Liengola, 2005). The chimpanzee (*Pan troglodytes schweinfurthii*) is the other species of great ape found mostly in the lowland sector of the park.

It has been estimated that there are around 10,000 species of plants of which 24 are endemic (Mühlenberg *et al.*, 1995). Owing to its phyto-geographical position between two different regions the KBNP has an exceedingly rich fauna. Research has shown that around 131 species of mammals, including 13 species of primates (gorillas, chimpanzees, baboons, colobus, mangabeys and guenons), 226 species of birds, 44 species of reptiles, 30 species of amphibians and numerous species of insects and butterflies inhabit the park. KBNP is a rich bird life; being recognized as a site of international significance for the conservation of birds, as such it is known as an Endemic Bird Area (EBA) as well as an African Important Bird Area (IBA) by Birdlife International (Stattersfield *et al*., 1998). There are many other poorly surveyed taxa; it is likely that several taxa could be discovered with more inventory effort.

The KBNP was designated World heritage Site in 1980 building upon only one UNESCO Exceptional Universal Value **Criteria x**, the latter highlights that the park contains highly and important natural habitats for the *in situ* conservation of biodiversity, including those where threatened species embedding exceptional universal value as far as science and conservation are concerned (World Heritage Convention-WHC, 1997; UNESCO; White & Vande weghe, 2008). It was the first park to start gorilla tourism world-wide in 1972.

3. 4 Park Management Sectors

The KBNP is made of four sectors, the Highland, Itebero, Lulingu and Nzovu sectors, as defined by park management requirements since February 2006 (Nishuli, 2007). Itebero and Lulingu sectors are not considered in the scope of the current research given the reason well stressed below. The highland sector covers an area of 600 km^2 and represents the first well known sector among the current four park management units. It contains a mountain forest in the most densely populated region of the country (**Figure 3. 12. 1 & 3. 22. 1. 2**) while Nzovu sector located in the lowland area covers 1,996 km^2 with some important land patches occupied by human settlements with agricultural areas (**Figure 3. 12. 1**).

3. 5 Sampling Design of the Study Area

Records are derived from 14,143 patrols forms collected in both highland (Tshivanga) and lowland (Nzovu) sectors (**Figures 3. 5. 1 & 3. 5. 2**) during 2004-2008. LEM data were only continuous in the two above mentioned sectors. They were scarce and less consolidated in the Itebero and Lulingu sectors. That's the reason why I've chosen to come up with a sampling design taking into account only the highland and Nzovu sectors consolidated data. Here, the goal was to monitor law enforcement effort and illegal offtake patterns in the park through patrol coverage (**Figures 3. 5. 1 & 3. 5. 2**) bearing in mind that estimates in line with counting wildlife and threats occurrence should be precise, but not necessarily accurate, and obtaining with a high level of consistency in methodology applied using large samples.

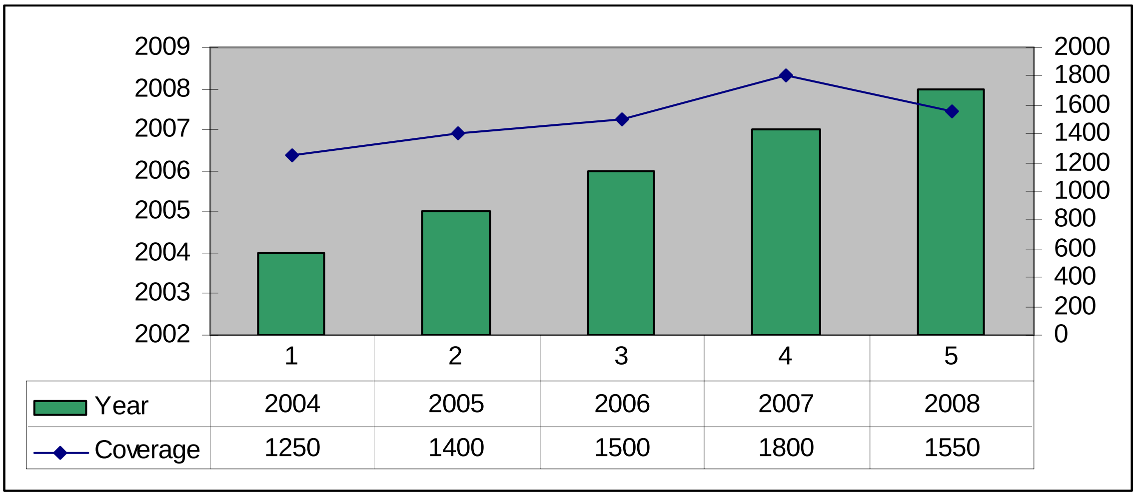


Figure 3. 5. 1 *Patrol coverage over the years in Kahuzi-Biega National Park.*

Estimates of wildlife abundance for this purpose was collected through cost-efficient index techniques, for example patrol index, where sighting of key species was related to patrol effort with full understanding of the consequences that spotting key human-induced threats will assist park and project managers to develop effective methods of regulation to save wildlife from unsustainable exploitation by identifying Wildlife Crime Hotspot (WCH), hence warranting closer inspection and specifying where to focus wildlife prevention or mitigation efforts.

Patrol coverage markedly increased at 10.7% from 2004 to 2005 then kept increasing at 6.7% from 2005 to 2006. From 2006 and 2007, patrol coverage substantially increased at 16.7% showing the highest level of patrol coverage (69.3% in 2007) ever reached during the study period, and unfortunately followed by 16.1% decrease between 2007 and 2008. The patrol coverage decrease documented between 2007 and 2008 may be explained the sharp decrease of 160% in the number of patrols launched in 2008. These trends and overall protection effort are better summarized in **Figures 3. 5. 1; 3. 5. 2 & Table 3.7. 1.** On average, patrol coverage during the five year period was set at 57.8% suggesting both the low level of coverage, and accordingly the low detection level of illegal activity. In this context, anti-poaching patrols were unlikely to represent significant deterrent to rule-breakers. Therefore despite their energetic efforts, patrol deployments couldn't stem the tide of poaching during wartime.

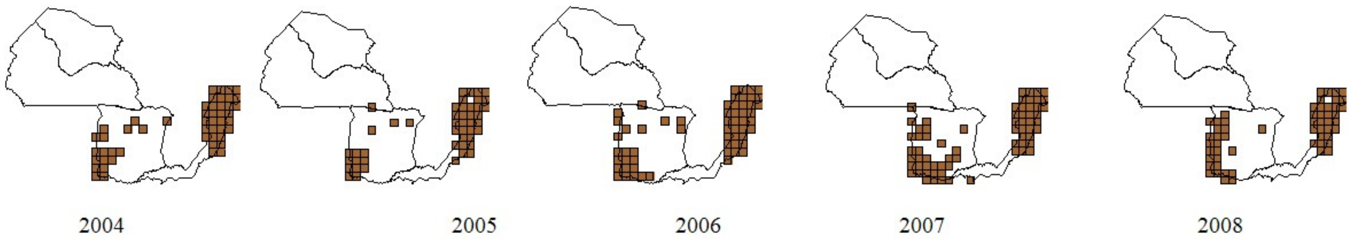


Figure 3. 5. 2. *5x5km grid patrol coverage of the study area.*

3. 6 Distribution of Target Wildlife Species across Different habitat types

Gorilla, elephant and chimpanzee were used as the flagship species for the conservation of the KBNP. Population estimate for gorilla in highland sector (**Table 3.15. 8**) was 168 individuals (Liengola, 2005) while elephant was set to a paltry figure of 20 individuals (Blanc *et al.*, 2007).

Table 3. 6. 1. *Seasonal changes in the use of different habitat types by chimpanzee*

Habitat	% use Rainy Season (N=15 grid*)	%use in Dry Season (N=11grid*)	Seasonal difference Mann-Whitney	Seasonal difference Probability
Primary Forest	54.01	47.61	-0.761	n.s
Secondary Forest	79.37	92.34	-2.176	$p < 0.05$
Bamboo Swamp	1.33	3.07	-0.603	n.s
Cyperus Swamp	9.33	12.8	-0.709	n.s
Cultivated areas	1.06	0.00	-0.779	n.s

*5x5grid

KBNP gorillas use their home range evenly over a large territory to avoid reusing the terrestrial herbaceous vegetation, as a folivores strategy while chimpanzee revisit a comparable small home range several times preferentially in primary forest to maximize the use of fruit-interpreted as a frugivory strategy (Basabose & Yamagiwa, 2009). The size of the home range of species influences the sensitivity of the species to over-harvesting and habitat fragmentation (Purvis *et al.*, 2000). Animals with small home range such as assessed above can survive in small relic population and therefore considered less vulnerable than wildlife with large home ranges (van der Hoeven, 2007). More individuals are likely to be killed when a group of primates is detected by hunter, whereas solitary animals provide only one prey. In this regard, th anti-predation strategy of animals does not work when hunted by poachers (Fitzgibbon *et al.*, 1995).

Table 3. 6. 2 *Seasonal changes in the use of different habitat types by Elephant*

Habitat	% use Rainy Season (N=4 grid*)	% use in Dry Season (N=4 grid*)	Seasonal difference Mann-Whitney	Probability
Primary Forest	25.31	27.61	-0.864	n.s
Secondary Forest	19.33	20.44	-0.686	n.s
Bamboo Forest	1.73	2.07	-0.604	n.s
Cyperus Swamp	20.32	27.12	-2.209	$p < 0.05$
Cultivated areas	0.02	0.00	-0.879	n.s

* 5 X 5 grid

Table 3. 6. 3 *Seasonal changes in the use of different habitat types by Grauer's Gorilla*

Habitat	% use Rainy Season (N=19 grid*)	%use in Dry Season (N=17grid*)	Seasonal difference Mann-Whitney	Probability
Primary Forest	35.33	37.51	-0.744	n.s
Secondary Forest	59.32	61.64	-0.693	n.s
Bamboo Swamp	29.73	38.06	-0.604	n.s
Cyperus Swamp	31.36	24.43	-0.711	n.s
Cultivated areas	0.07	0.04	-0.822	n.s

*5x5grid

Table 3. 6. 3 Shows that was no clear relationship between Grauer's gorilla occurrence and the major habitats. However, there was a significant relationship between elephant (*Loxodona africana cyclotis*) and *Cyperus* swamp (*Cyperus latifolius* Poiret.) habitat as well as the chimpanzee and the secondary forest. In the KBNP elephant concentrations are known to be associated with swampy clearings (Hart & Hall, 1996). The habitats varied from dense *Macaranga* and *Hagenia* sp. dominated secondary forest to dense mountainous primary *Polyscias-Hagenia* forest intermixed with bamboo stand and moderately moist woodland and *C. latifolius* swamp. Chimpanzees used secondary forest more frequently than the primary forest (Basabose, 2005), and both swamp and bamboo forests albeit there was no significant seasonal difference in the use of primary forest, bamboo forest, *Cyperus* swamp and cultivated areas by chimpanzee (**Table 3. 6. 1**). It is noteworthy to mention that among the six chimpanzee most preferred fruit species; two were identified among the most preferred species used in charcoal making, including *Maesa lanceolata, Syzygium div. sp.* Basabose (2005) found that chimpanzees were dispersed in clumped pattern and that Kahuzi chimpanzee may adjust their foraging to the distribution of their preferred fruits. The high level fuelwood encounter rates pattern between Lemera and Tshibati (**Figure 3. 7. 2**) might negatively impact the habitat used by chimpanzee in this area. In the montane forest of KBNP, seasonal change

in distribution of foods, such as fruits and bamboo shoots, may influence the range shifts of gorilla. This may result in the larger gorilla home range at KBNP than of mountain gorilla *Gorilla beringei beringei* at Virungas (Yamagiwa *et al*., 2005). However, due to the presence of of military and rebel forces operating in Mikeno massif area and subsequently the contraction of large mammals in limited war-zone refugia observed in the park, the grauer gorilla home range in KBNP set at 31.15 km^2 (**Table 3. 15. 9**) was less than of the mountain gorilla in the southern VNP set a 58.3 km^2 but larger than Grauer's gorilla in Tshiaberimu set at 2.2 km^2 (**Table 4. 5. 3**). By the same token, as noticed by Yamagiwa (2003) amazingly, the virunga population was little disrupted, although of the gorillas in KBNP were killed, mostly for bushmeat. On the whole, all the three charismatic species were concentrated between 2,000 - 2,250 m isohyets of altitude in the highland sector and between 1,000 and 1,250 m isohyets in Nzovu sector (**Figures 3. 15. 4; 3. 15. 5 & 3. 15. 6**).

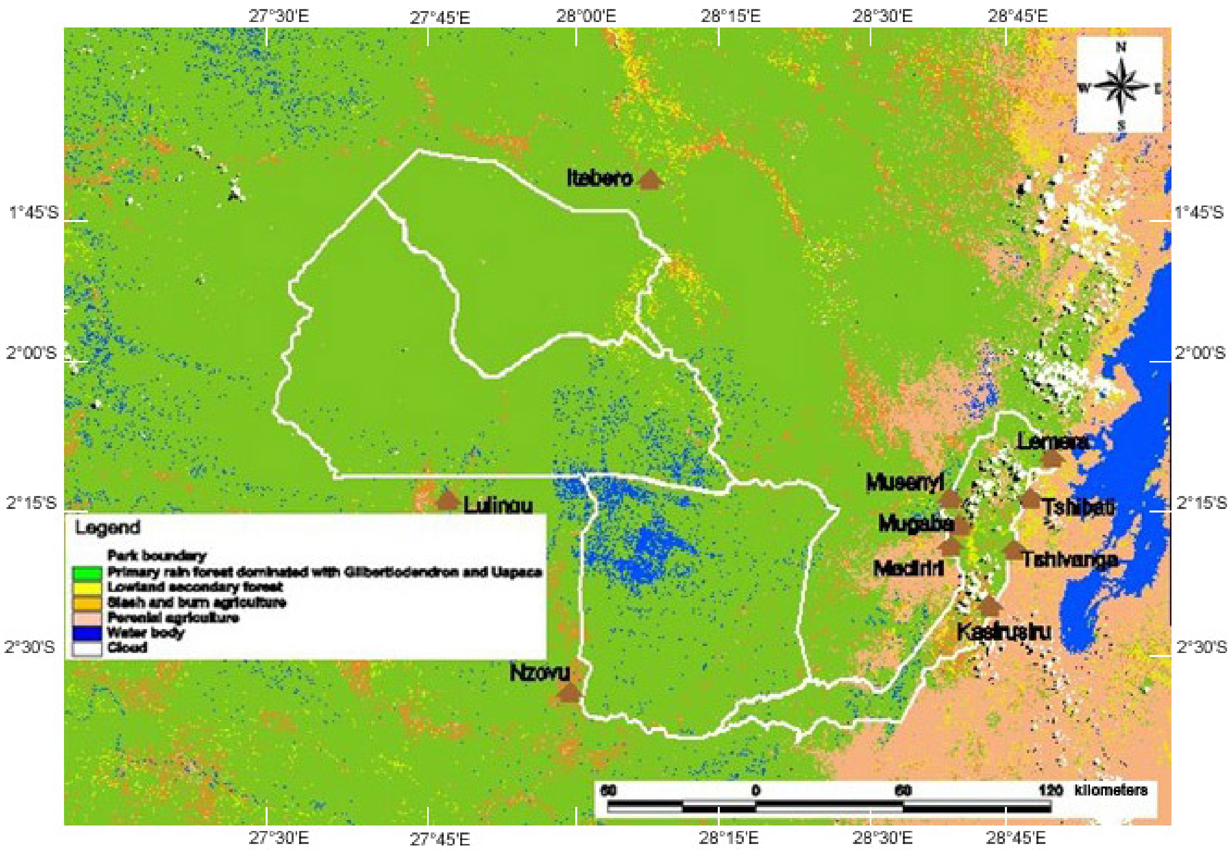


Figure 3. 6. 1 *Dominant Vegetation types and land use pattern as per the Landsat-Thematic-Mapper.*

It is noteworthy to mention that compared to Basabose & Yamagiwa (2009) home range of gorilla and chimpanzee in KBNP, the study results indicate a slight reduction in home range size going from 42.3 km^2 to 31.15 km^2 for gorilla and from 15.7 km^2 to 10.57 km^2. This reduction may be explained by the siege strategy showed by the small remaining elephant population in the highland sector, hence rendering them less vulnerable than animals with large home ranges (Purvis *et al*., 2000).

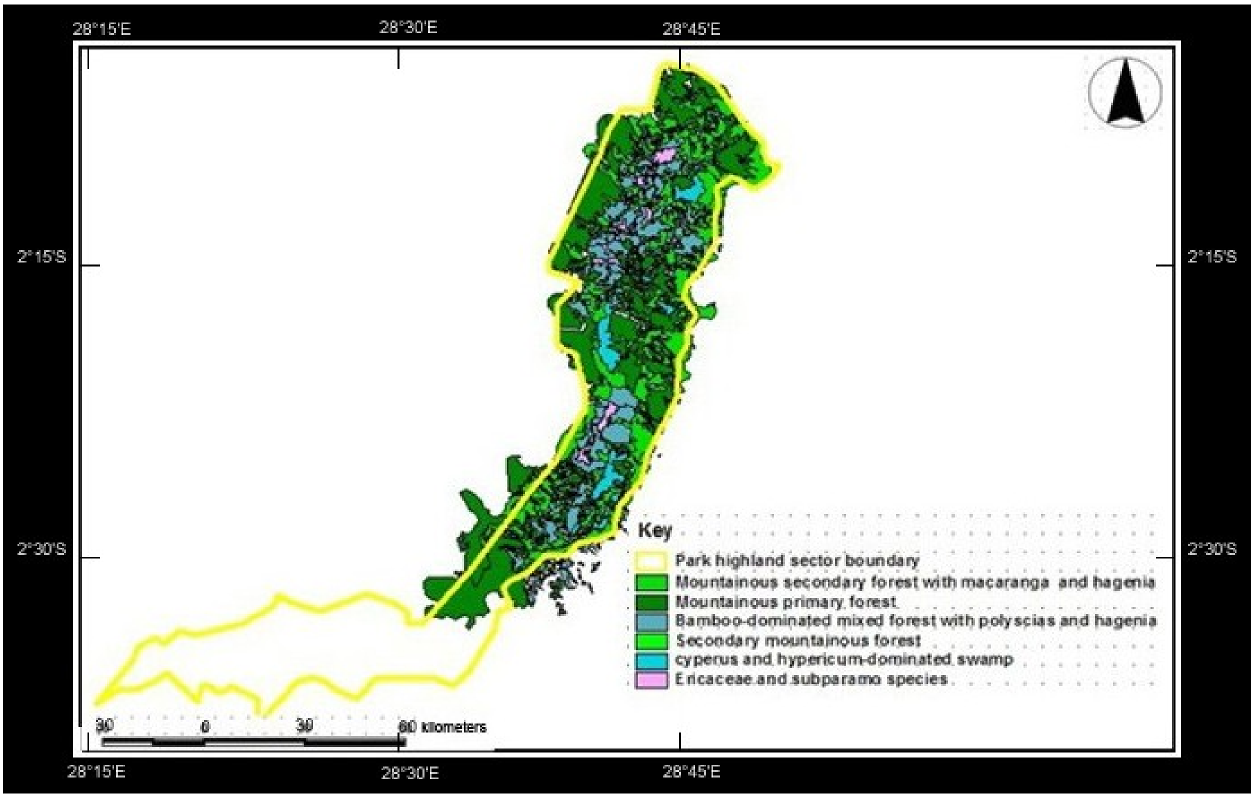


Figure 3. 6. 2 *Vegetation of the highland sector of the Kahuzi-Biega National Park.*

Although, the monitoring data show that there was a positive relationship between the distance from the main road and the abundance of elephants as found in the previous studies in Central Africa (Barnes *et al*., 1993), it is puzzling why there was no similar relation for gorilla signs encounter rates given the fact that their distribution were found within those of chimpanzees (Yamagiwa *et al*., 2003). Gorilla densities seem unaffected by human presence and hunting pressure in the highland sector. In the rainy season, Grauer's gorilla restricted their ranging to the natural bamboo forest of the park. Indeed, the young bamboo growth constitutes their main food during this period of time of the year. In the tropical primary forest around Nzovu, the pith of herbaceous plants of the Zingiberaceae, Maranthaceae and Commelinaceae made up an important percentage of their food. Because gorilla tourism has been the main source of revenue for the park, protecting and patrolling their home range has been a priority. Thus, it appears that KBNP strategy for protecting the habituated gorillas' area was relatively successful though habituated gorillas were 1.6 times more susceptible to poaching than their non-habituated counterparts (Kasereka *et al*., 2006). However, as suggested by Mubalama and Bashige (2006), local variability in patchy faunal distribution across surveyed area and abundance cannot be explained entirely by human activities now or in the recent past. Biogeographical barriers, variability in forest habitats, and vegetation history are all factors that may have a vital role.

3. 7 Distribution of Threats across Diverse Habitats

Because generally, the poached wildlife are removed and therefore all direct evidence of the threat is hidden, the number of carcasses, recovered and dismantled snares and arrested poachers were used as main threat indicators (Plumptre *et al*., 2009). Heterogeneity χ^2 was performed to confirm that data from all strata were homogeneous (χ^2 = 99.7, $P < 0.05$). There was a significant difference between snares and habitat types (χ^2 = 96.7., $P < 0.05$); and between wood cut and habitat types (χ^2 = 86.3, $P < 0.05$). Observed and expected fire, mining and human encroachment did not show significant difference ($P > 0.05$). Key human threats distribution and abundance were similar to those depicted for charismatic species and were encountered between 2,000 - 2,500 m of altitude (**Figures 3. 15. 4; 3. 15. 5 & 3. 15. 6**). Both rope and wire snares were mostly distributed in the mixed forest with bamboo, *Polyscias* sp. and *Hagenia*, in the *Macaranga-Hagenia* dominated secondary forest, and to a lesser extent in the primary mountainous forest (**Figure 3. 15**). Woodcut mostly occurred in *Macaranga-Hagenia* dominated secondary forest (**Figure 3. 16**). There was uneven distribution of snares across the park, however **Figure 3. 7. 1** shows a trend towards concentration of snaring activities along the park boundary and their decrease as offenders penetrated deeper in the core of the park (**Figure 3. 9. 1a**)

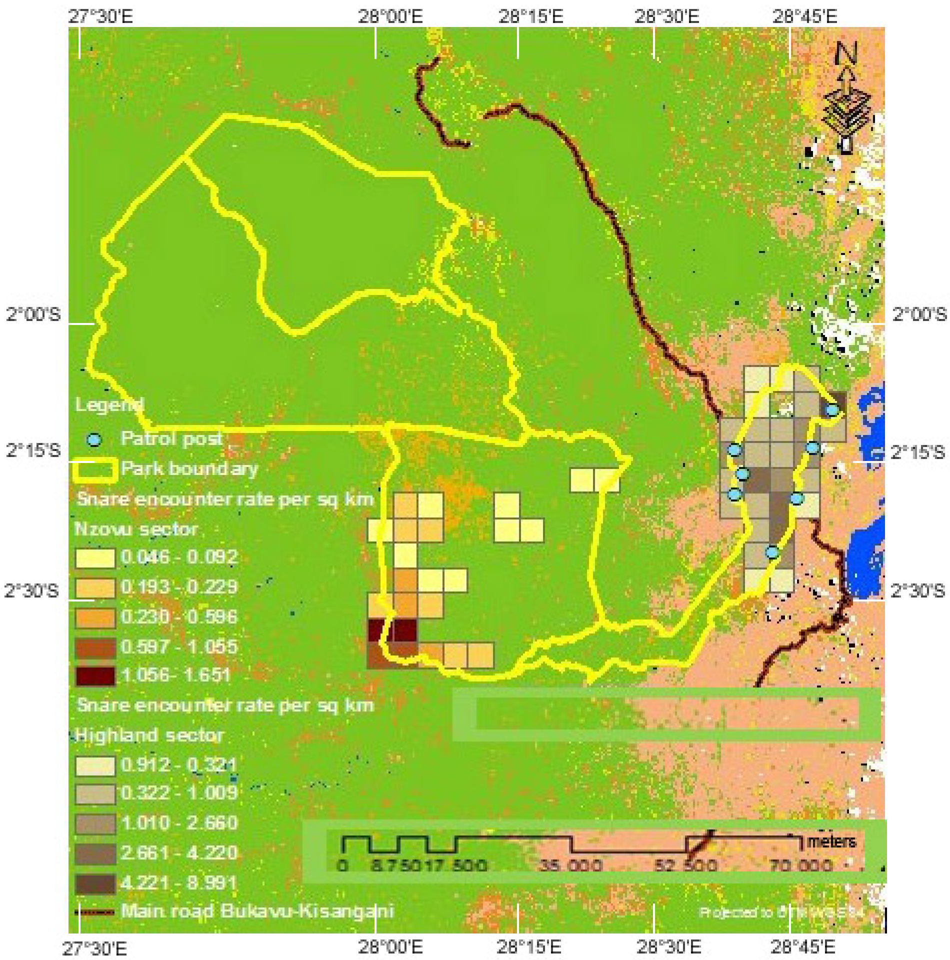


***Figure 3. 7. 1** Snaring encounter rates in Kahuzi-Biega National Park.*

The subsistence harvesting of fuelwood remains important in many rural communities (Scoones *et al*., 1992) surrounding the KBNP. Fuelwood is the main source of energy for cooking, heating and building material in the region, and the KBNP forest provides the only local supply. Though a small percentage (23.5%) of the households interested in gaining access to the park wood resources said they were only interested in fuelwood collection with woody biomass largely resulting from residues: twig, stems, branches and leaves; a majority (76.5%) said they would use the access to extract trees suitable for sale or pole and/or medicine plants. The expressed interest was driven by an expected profit-based gain rather than a subsistence-based need. This result is similar to Songorwa (1999) who found similar effects of relative wealth on resource-use interests in an examination of conservation project in southern Tanzania. Likewise, a greater 'familiarity' with the park did associate with an interest in gaining access to the park fuelwood resources.

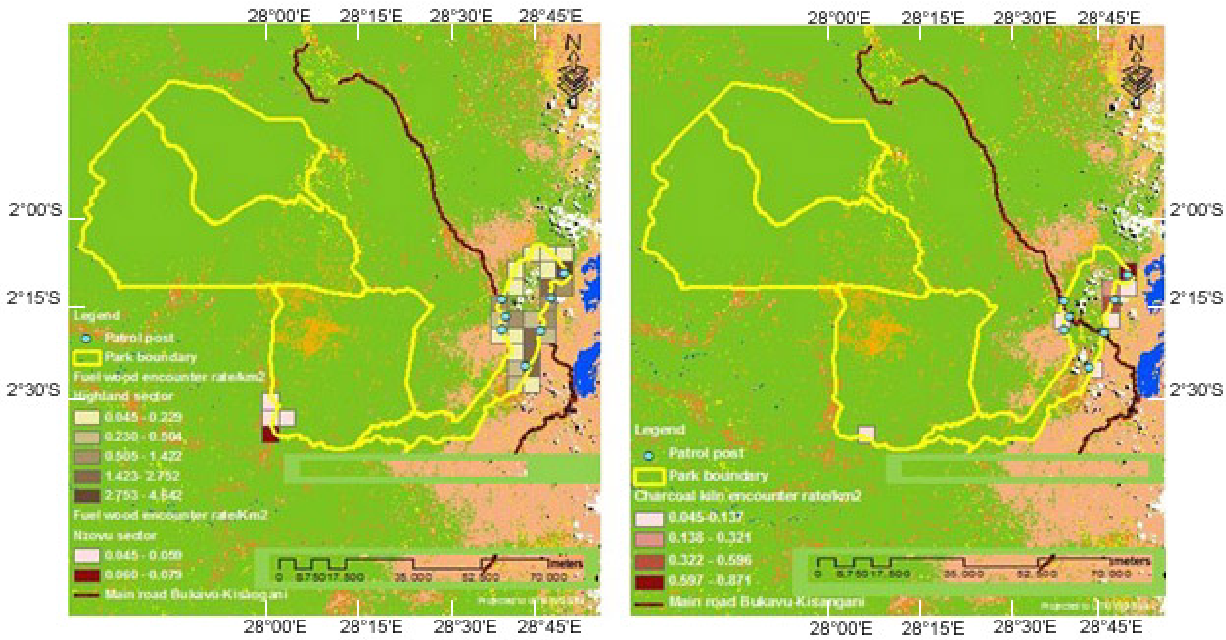


Figure 3. 7. 2 *Fuelwood and charcoal kiln encounter rates in Kahuzi-Biega National Park.*

Indeed, these results *per se* challenge a number of important assumptions that are the basis for cooperative resource management programs. The apparent for-profit interest in gaining access to the park wood resources coupled with the growing human population suggests that allowing the local communities access to the resources would not improve conservation of the park's biological diversity. Such expressed interest would likely lead to an increased and increasingly unsustainable demand for the resources (Barrett & Arcese, 1995). It is therefore recommended that the park be 'buffered' naturally in human settlements spread over in Nzovu lowland sector (**Figure 3. 22. 1. 1**); realizing the effects of these buffers may help conservationists further understand the nature of communities' perceived utility of the park natural resources. In the meantime, it is strongly recommended that the park management in partnership with collaborating NGOs develop a range of incentive mechanisms aiming at boosting the production of wood outside the park, and encourage and implement initiatives related to efficient fuel conversion techniques along with the use of appropriate alternative energies.

Table 3. 7. 1 *Synthesis of woodland-related law enforcement activities, 2004-2008*

Patrol data	*Mean*
Effective patrol-days per patrol group per km^2 per month	1.8
Wood collectors encountered per month	14.4
Wood collectors harvesting fuel wood illegally (%)	18.8
Wood collectors groups encountered per month	3.9
Wood collectors groups encountered per month per Effective Patrol day	0.3

Data analysis suggest that women were primarily responsible for domestic fuelwood collection, and accordingly sustained a high chance to being caught by guard patrols in the areas between Lemera and Tshibati patrol posts and around Kasirusiru patrol post (**Figure 3. 7. 2**). Women groups collected fuelwood in groups of around 4 individuals ($\bar{x}$ = 3.62, range 1-9). Eighteen point eight percent of women over the total of 23.5% were involved in illegal fuelwood collection. This may reflect the higher probability that illegal female wood collectors will be detected by guard patrols, though wood collectors were likely to try to avoid encounters. Compared with the potential number of guards working days (Bell, 1984b), the study results suggest that law enforcement was inefficient given the low number effective patrol days deployed to deter illegal fuelwood (**Table 3. 7. 1**). From that prospect, one option for park management is to increase patrolling effort in the park, regardless the fact that regulation is expensive (Milner-Gulland & Leader-Williams, 1992). Various penalties were imposed by the guards for illegal wood collection on rather an arbitrary basis. However, most fuelwood collectors frequently received a warning (67%) and just over 33% paid penalties ranging from $US 5 to 10 for gathering one head load of wood inside the park. Most severe penalties were not issued given the fact that people were not able to pay (only 12% paid a fine within the legally recognized detainment period of 48 hours) and their bunch of fuelwood collected were burnt by guards. This result is consistent with Abbot & Mace (1999) findings and may reflect a recent policy toward more lenient penalties for illegal wood collectors to improve the relationship between park management and local communities living around the park. The KBNP is still perceived by surrounding communities as inexhaustible source of tree resources. Effective management of tree resources requires, among other things, knowledge of which species are preferred locally and can therefore be successfully adopted into conservation plans, as well as an understanding of local attitudes towards tree conservation. Fairly basic questions still remain about (i) which woody species are considered most valuable to rural communities and how do priorities vary across different sectors of the local communities? (ii) What are local perceptions of the status of woody species and of the main threats to their conservation? (iii) What attitudes do local people hold towards conservation and what challenges do conservation initiatives face?

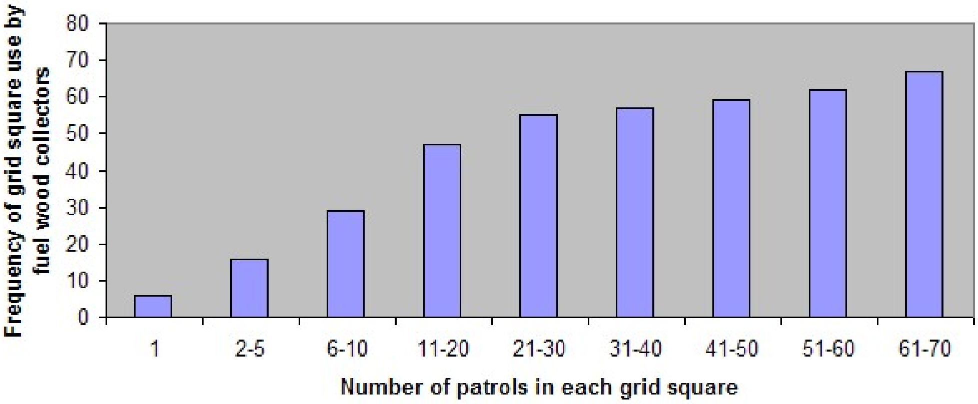


Figure 3. 7. 3. *Frequency of grid square use by fuelwood collectors in the park.*

The results are somewhat surprising since one might expect that some firewood collectors would disperse in the face of guard deployment, but this was not the case. In this regard, the finding from this study confirms Abbot & Mace (1999) results showing that law enforcement may influence patterns of wood collection. Similarly, a comparison of guard patrol routes with the sites where women gathered fuelwood shows that, rather than selecting low-risk areas, fuelwood collectors frequented the areas with the highest patrolling efforts (**Figure 3. 7. 3**). Such risk-prone behavior seems counterintuitive, given that most women had no alternative choice than collect illegally in the park and thus, remained subject to penalties once they got caught by patrol teams.

3. 8 Foot Patrols and Dynamic in Illegal Trends

Table 3. 23. 1 summarizing the protection effort shows that encounters with illegal activities were not evenly distributed over the study period. There was a clear evidence that much more numbers of patrols (one and multiple-day patrols) were noticed in 2006, not surprisingly the highest frequency of patrols coupled with its dissuasive psychological effect among rural people might explain the low level of illegal activity occurrence (CPUE for snaring was set at 0.32 per km^2) as compared to other years. Furthermore, 2006 was the year with the higher level of EPMD per km^2 reaching 34.13 (**Table 3. 23. 1**). Most wood cut producers have engaged haphazardly in fuelwood collection as a result of the laxity, over recent years, in the application of the law (Languy *et al*., 2009d).The persistent decrease in the numbers of fuelwood collection (**Figure 3.**

8. 2) and mining (**Figure 3. 8. 1**) is rather the indication the "familiarity" of the park staff with the offenders to the point that in some cases park guards and wardens depended on kickbacks from illegal mining to survive following their starvation wages (Hart & Hall, 1996). Reports from older guards, who served during the 1970s, state that internal poaching was widely practised by park staff during this period. The most common form of petty corruption involved bribing low-level civil servants and even high-ranking officials to get them disregard violation of certain rules and regulations that are profitable to violate, albeit this would normally result in punishment in the form of a fine. The apparent winners here were the parties at both ends of the corrupt transaction and the apparent loser was the park as an institution that was

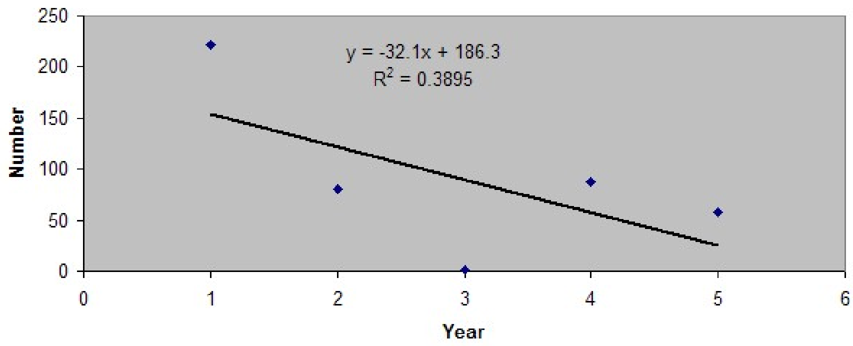


Figure 3. 8. 1. *Dynamic of mining in Kahuzi-Biega National Park.*

left in the dark about frequent uncollected fines. Seventy two and thirty nine percent of the variation of respectively depicted in **Figure 3. 8. 2** on fuelwood collection and in **Figure 3. 8. 1** on small-scale mining in the park are explained by the protection effort over the year.

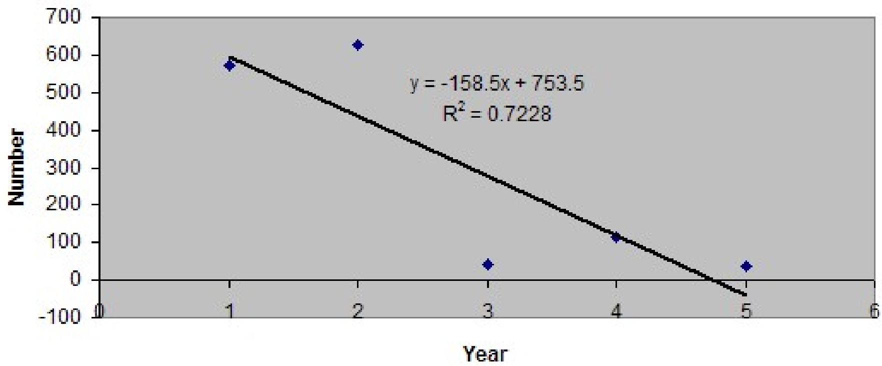


Figure 3. 8. 2 *Dynamic of fuelwood collection in the Virunga National Pa Kahuzi-Biega.*

Fuelwood collection and mining encounter rates were most noticed in 2004 with a mean CPUE varying respectively between 0.46 per km^2 and 0,18 km^2 (**Table 3. 23. 1**). Fuelwood collection should be considered as another major threat to the highland ecological integrity as local population has depleted fuelwood outside the park. The first line of intervention is to reduce the cutting of wood by promoting alternative sources of energy and by carrying out a large-scale dissemination of improved portable stoves. In addition, the potential of using the methane of Lake Kivu as a source of energy should be explored although the process may raise considerable political and technical challenges in the midst of current post conflict period.

3. 9 Quantifying Law Enforcement Effort in Kahuzi-Biega National Park

During the 3 documented unsuccessful encounters where the entire group of illegal hunters managed to get away, the average size of a patrol group was 3.5 (+/- 0.3), which is slightly lower, but not significantly different from the average patrol size during successful encounters (6.4 $^+$/- 0.5). The average size of a group of poachers during unsuccessful encounters was 5.3 (+/- 0.5), which is slightly lower, but not significantly different from the average group size during successful encounters 5.5 (+/- 0.3). Hence, the ratio of patrol members to poachers was slightly higher during successful encounters (1.19) than during unsuccessful encounters (0.65). It should be mentioned that during unsuccessful encounters, poachers' gangs carried relatively more firearms than park staff, and the latter often retreated following heavy gunshot exchange, as they were frequently outmanned and outgunned during clashes with militias. Surprisingly, the park staff firmly stood their ground in the face of armed offenders repeated attacks.

At first sight, there seems to be no straightforward explanation for the above encounters to have been unsuccessful. The sighting distance at which the group of offenders is first seen is important in determining the outcome of an encounter. The average group size of poachers was constant during unsuccessful encounters as compared to successful encounters, but was 65.5% higher than the average size of the park staff group. The drop in arrests per successful encounter in 2005 and 2006 (PNKB/ICCN 2006; 2007) cannot be attributed to declining fire-power only but also to a reduction in patrol group size. The relationship between patrol group size and the percentage of offenders arrested during a successful encounters (**Figure 3. 17. 1**) was significant following the estimated line of regression (y = 18x – 57.4; R^2 = 0.5611; P = 0.042).

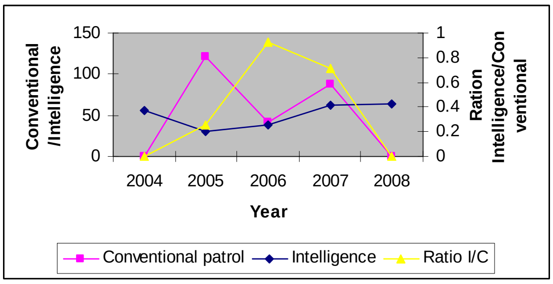


Figure 3 .9. 1a. *Encounter rates of arrests per 100 effective patrol days and arrests per 100 effective investigation days, and the ratio of arrests on investigations to arrests on patrol, from 2004 to 2008*

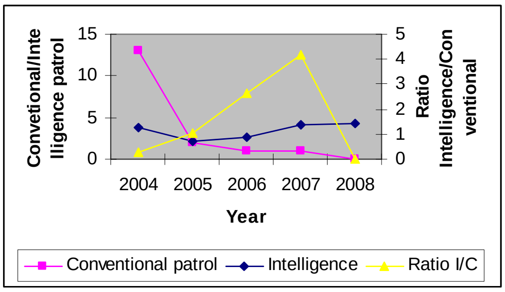


Figure 3. 19. 1b. *Encounter rates of firearms recovered per 100 effective patrol days and firearm recovered per 100 effective investigations days, and the ratio of firearms recovered investigations to those recovered on patrols, from 2004 to 2008.*

Although the optimum patrol group size was estimated at approximately 6 patrol members, an increasing size of the patrol group will result in an increasing probability of being detected by poachers, first. This finding compares well with the increased detection of illicit activities within Kerinci Seblat National Park in Sumatra as patrol units contained a greater number of staff (Linkie *et al*., 2003). Preferably, a patrol group in KBNP should consist of between 6 (for routine patrol) and 12 (during sweep operation) with one patrol post combining two sections (12 park guards) to counteract the effect of frequent attacks launched against patrol posts and park staff during political instability. However, in articulating a coherent anti-poaching strategy for the park during peaceful period, a pragmatic approach of defining strategically located patrol posts across the park with 6 guards could be considered in the near future.

Table 3. 9. 1 *Spatial distribution of the threats in the study area*

Threat type	Area (sq km)	% of the park	Notes
Fuel wood collection	725	27.9	24.1 in Highland sector
Human encroachment	1050	40.4	23.1 in Highland sector
Mining activity	600	23.1	13.5 in Highland sector
Snare	1250	48.1	27.9 in Highland sector
Garden	375	14.4	7.7 in Nzovu sector
Bushfire	750	28.9	23.1 in Highland sector
Pit sawing	75	2.8	All in highland sector
Honey and *Dioscorea* sp harvesting	300	11.5	All in highland sector
Poachers' camp	675	26	13.5 in Highland sector
Bamboo cut	250	9.6	All in highland sector
Charcoal	200	7.7	6.7 in highland sector

3. 9. 1 The optimal law enforcement effort in Kahuzi-Biega National Park

The mean visibility profile was 0.005 km (e.g., 5 m or 2.5 m on either side of the line of walk), taking into account the difference in visibility between relatively open forest and closed forest. Using this figure in combination with an estimated mean patrolling distance per day of 10 km at 2 km per hour (Bell, 1979) gives a mean area surveyed of 2 km^2 per day or 0.4 km^2 per hour, or 0.01 km per km of travel. This meaning that to survey completely a square of 25 km^2 would require 12.5 days, or 62.5 hours or 125 km of patrolling, assuming no repetition of routes.

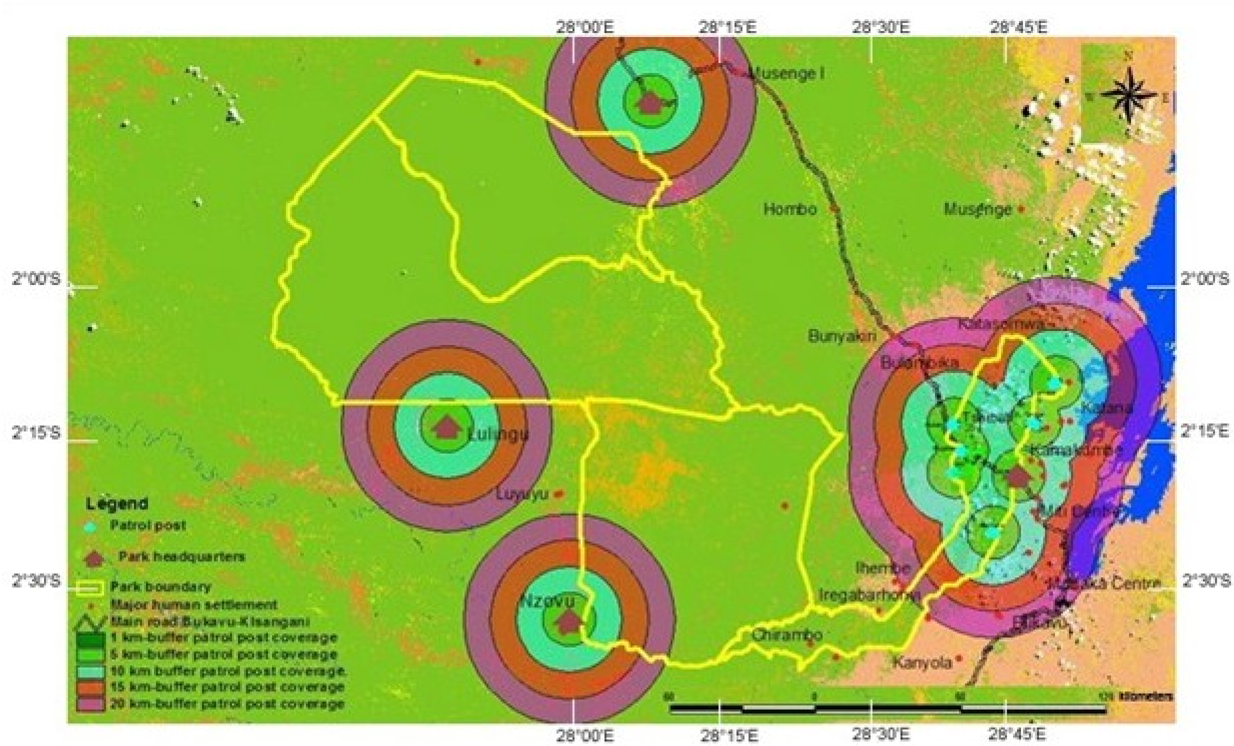


Figure. 3. 9. 1. *Map showing spatial pattern of protection effort from existing patrol posts setting in Kahuzi-Biega National Park.*

Assuming no route repetition, complete surveillance of the KBNP would require 3,000 effective patrol days or 15,000 patrol hours of 30,000 km per year^{-1} of patrolling (2,500 km per month^{-1}) instead of 21,692.6 km per year^{-1} or 1,807.7 km per month^{-1} documented over the five year study period (**Table 3. 21. 1**). Looking back over the patrols performance realized, the results show that ratio between multiple and single days per staff was 1/4, suggesting a mean multiple days patrol per staff set at 1.27 versus 5.03 for the mean single day patrol per staff. Therefore I strongly suggest that further protection efforts put much emphasis on multiple days' patrols to increase the current average multiple days' set at a mean of 1.27 days per month^{-1} per staff in order to sustain at least a ratio of 1/3. Average multiple days patrol deployment was set at 116.6 with an average of 1.27 days per month per staff and should be increased to reach 156. 24 multiple days patrol with an average of 1.70 days per year per month (taking into account the required increase of the optimum protection effort set at 34%). Not surprisingly, anti-poaching patrols were unlikely to represent a significant deterrent to hunters as only approximately 294 hunters and porters were arrested by anti-poaching patrols within the park annually. Many hunters operated multiple trips per year (Hofer *et al*., 2000), as hunters arrested inside the park admitted to 2.6 ± 0.2 (range 1-25, n = 137 hunters) hunting trip per year. This represents only 3.1% besides the fact that not all estimated 9,491 people were conducted hunting trip every year. Options for optimal allocations and management implications are considered in section below.

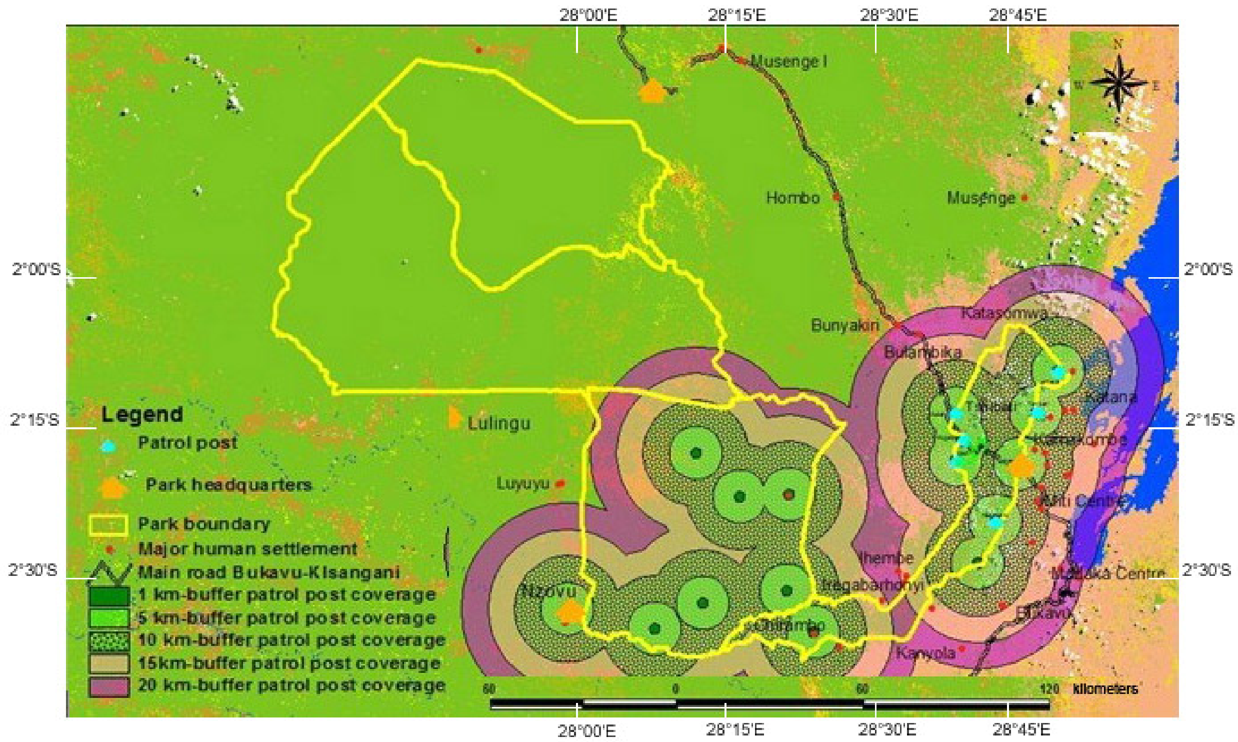


Figure 3. 9. 2 *Map showing spatial pattern of protection effort from existing and proposed patrol posts design in Kahuzi-Biega National Park.*

Figures 3. 9. 1 & 3. 9. 2 show the low patrol coverage as a result of limited number of familiar paths followed by park guards. Indeed, mean distance of patrols launched from different patrol posts was set at 4.6 km (+/-0.39). Five km-buffer patrol post coverage indicates that only a limited area around the anti-poaching units could be effectively covered. Mean distance by biological survey team was set at 5.4 km (+/- 0.2). Furthermore, **Figure 3. 9. 1** shows that even though they could extend the patrol deployments to reach 20 km-buffer patrol coverage the spatial coverage in terms of protection effort could still be insufficient in order to ensure full protection of the park. However, **Figure 3. 9. 2** indicates that most of the highland and Nzovu sectors should be covered with 15 km-buffer patrol post coverage when taking into account the full implementation of new proposed patrol posts design. This finding is consistent with Jachmann (1998) stressing that walking approximately 6 hours per day at an average speed of 3 km per hour in undulating terrain would give 18 km of patrol per day. While **Figure 3. 9. 2** provides the best scenario as far as spatial park coverage is concerned, yet with $US 95 per km^2, under-funding jeopardizes the ability of the park staff to safeguard biodiversity. In this regard, as the best option at this particular point in time, I do recommend much more patrols deployment in limited identified WCH (**Figure 3. 15. 3**) where there is a highly probability of offenders presence while taking advantage of the new Trailguard technology (**Box 4. 10. 1**) well tested in VNP in controlled conditions with rangers posing as poachers and holding AK-47 weapons. Well designed intelligence network is worth considering.

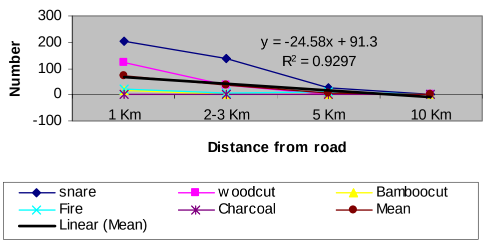
The question of route repetition by patrols is worthwhile, especially in a natural ecosystem which lies within a region of political instability and because of the existence of widespread hide-out for militia groups. The tendency of patrol to follow a limited number of familiar routes in areas where the forest was often crossed with narrow footpaths and where deployment was difficult because of thick vegetation or broken topography was clearly noticed. The extent of routes repetition was examined, and it was found that during the five years, 72.3% of all patrol movements were on routes used more than once, many being on footpaths used repeatedly. As a result, the 2,500 km per month^{-1}, which potentially could have been covered with no repetition route were reduced to 1,807.7 km per month^{-1}, thus representing a waste investment time evaluated to 72.3% of patrol hour spent on footpath repetition. On average, 1,500 km^2 of the park was covered annually, which represents 57.8% of the effectively controlled park area per year^{-1}. Patrol effort was set at 21.8 EPMD/km^2 per year^{-1} per park guard. This figure is well below the required protection effort of 33 km^2 per ranger (Bruner *et al*., 2001). The sharp decline in protection effort was probably due to low patrol coverage induced by insecurity coupled with the major influx of commercial poachers concentrating on key species.

3. 9. 2 Relating Illegal Activity to Patrol Effort

By and large, a closer look at the LEM data revealed that out of the overall mean of 105 park staff dedicated to anti-poaching operations, 85 park guards effectively spent 8,826.9 man-days, which translates into 8.9 man-days per guard per month; implying that the park striking force was working at 59.3 % (8.9 out of 15 patrol-days required per guard per month^{-1}) of its capacity on the ground. Measure of efficiency of the field staff as well as guard density as a measure of strength of the deterrence capacity excluded time spent on escort and protecting property duties, time-off and time spent at base, but not actively in any enforcement activity. Mean duration of effective patrol day was set at 4.2 ± 0.8 hours. The study suggests that the success of the anti-poaching effort could be increased by improving the mean duration of effective patrol-day from 4.02 ± 0.8 hours to recommended 6:00 hours of patrolling per day (Jachmann, 1998). In addition, while less than 20% of the field force should be involved in non-patrol duties (Jachmann, 1998), in KBNP, a total of 22% of the field force was involved in non-patrol duties, including escort (time spent escorting chief and assistant park wardens) and guardian (time spent guarding offenders, property or park entrance gates) duties. To optimize staff density efficiency, it is recommended that all enlisted park staff be fully dedicated to anti-poaching thus, complying with their formal professional job description set in writing or else, the field force will never get anywhere by going against the grain. Yet the mean single day patrol set at 5.03 should be increased to 6.7 in line with the calculated 34% optimum protection effort requirement.

Snaring pressure was identified as the most important threat in the KBNP. Wire snares density in highland sector decreased with increase in distance from the road network. It then declined to zero at a distance of 10 km (**Figure 3. 9. 2. 1a**). The regression equation (**Figure 3. 9. 2. 1a**) indicates that 93% of the variation of the threats detection in the highland sector decreased with the distance from the road while the regression equation (**Figure 3. 9. 2. 1b**) shows that 92% of the variation of the threats detection in Nzovu lowland sector rather increased with the distance from the road. However, the incidence of illegal activity remained more or less the same throughout the study period suggesting that hunters' snares may be placed in suboptimal areas depending on trade off between increasing snare success and reducing probability of being arrested by patrol rangers (Wato *et al*., 2006). Because both rope and cable snares were more affordable and accessible to local hunters than were firearms, extensive areas could be operated.

Figure 3. 9. 2. 2a shows that there was a significant relationship between the number of snares detected and the effective patrol man-days per km^2. The number of snares increased as effective patrol-man days increased ($y = 54.021 + 1{,}226.243\,x$, $R^2 = 0.101$, $P < 0.05$). Correlation analysis in **Figure 3. 9. 2. 2b** indicates that the detection of fuelwood density decreased as effective patrol-man-days/km^2 increased ($y = 61.841 - 273x$; $R^2 = 0.022$), but no significant relationship between fuelwood collection detection and EPMD/Km^2 was detected ($P = 0.371$). Also, probability of finding carcasses does not significantly change with an increase number of EPMD/Km^2 ($y = 4187 - 0.003$; $R^2 = 0.003$; $P = 0.0873$). The latter result related to carcass occurrence may be explained by the subsequent removal of carcasses on the ground (**Figure 3. 9. 2. 3**) following the evidence that small (2.0 – 4.9 kg) and medium-sized (5-14.9 kg) species provided more carcasses to total kills (32.4% and 30.0% respectively) than larger-bodies (15.0 – 99.9 kg) ones (21.9%), thus becoming important prey items in disturbed areas (Eves & Ruggiero, 2000). On the whole, **Figure 3. 9. 2. 3** examplifies Janzen (1988) finding ascertaining that we must not let a forest full of trees fools us into believing that all is well while many of the KBNP forests are "leaving dead".



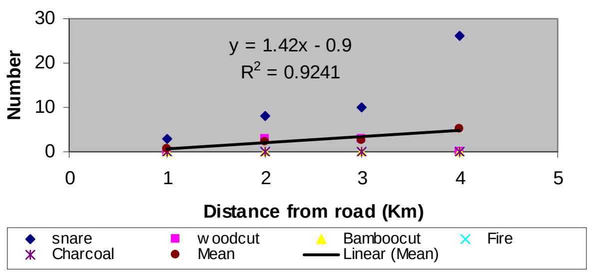


***Figure 3. 9. 2. 1a** Threats distribution versus distance to road in the highland sector* .

***Figure 3. 9. 2. 1b** Threats distribution versus distance to road in Nzovu lowland sector.*

The snare encounter rates mapping (**Figure 3.7. 1**) shows that areas that were extensively patrolled had more snares collected compared to those that received less patrol efforts. This result confirms that areas that have a high illegal human activity and attract more offenders using different methods including setting traps, would also logically be expected to have more field observations. Patrol data have documented on several occasions some medium-sized mammals and large mammals such as *Tragelaphus euryceros* and *Cephalophus* sp. that were caught by snares, but broke the cable and escaped due to the fact that cable snares were indiscriminate and wasteful (Noss 1995, 1998*a*, *b*). Such incidents (broken cable and animal escape) linked to the fact that most poached wildlife were removed from the snares could explain the low number of carcass encounter rates as evidenced by above mentioned carcass correlation equation and spatial distribution (**Figure 3. 9. 2. 3**).

A particular interesting finding of the study was that, for families living in extreme poverty, market sales of bushmeat were more important than household consumption. The sheer difficulty of survival would exert a permanent check. Because of this urge the human population, when unchecked, would always tend to increase in geometrical ratio, but food production would likely increase in arithmetical ratio. An important implication of this result, for both conservation and development policy, is that while commercial hunting is usually perceived as a greater conservation threat than subsistence hunting, it is the market sale and not consumption of bushmeat than can be most important to local people living in extreme poverty. This challenges the view put forward in certain conservation quarters, that the way to reconcile the interests of the poor with those of conservation, in a 'win-win' scenario, is to prohibit market sales, but turn a blind eye to subsistence use while regulating natural resource harvest through a well designed participatory community conservation scheme. From that prospect and in order for proposed biosphere reserve to fulfill its multiple roles, it must have suitable boundaries (**Figure 3. 22. 1 .1**) and develop objectives to enable each of these roles to be implemented.

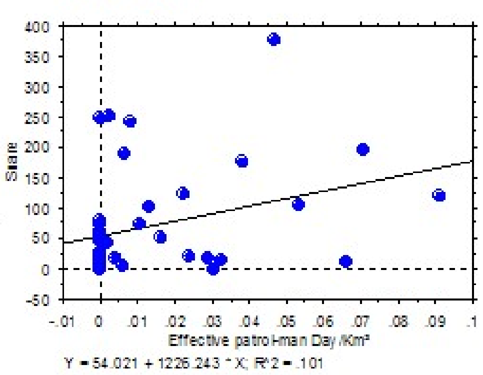


__Figure 3. 9. 2. 2a.__ Effective patrol man-day/km^2 versus snare detection

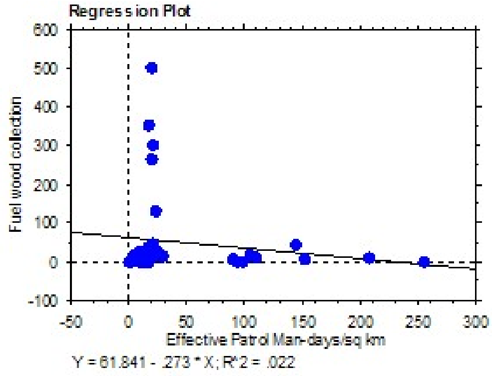


***Figure 3. 9. 2. 2b**. Effective patrol man-days/ km^2 versus fuelwood detection*

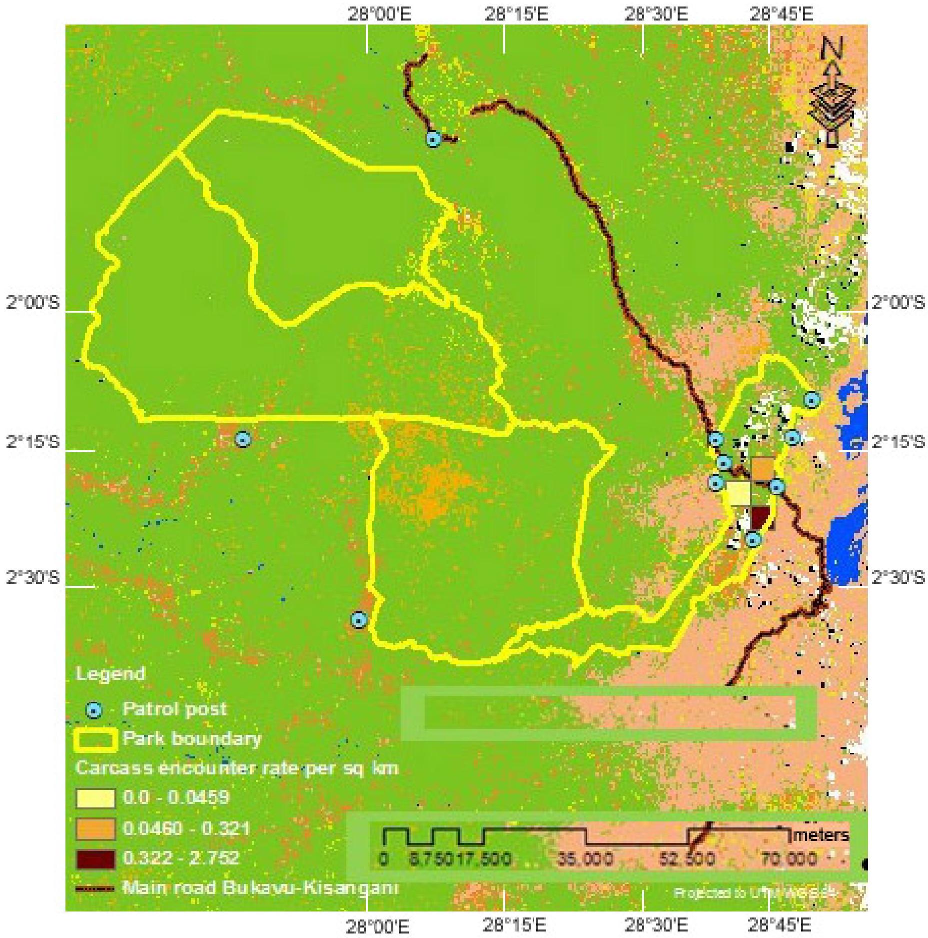


Figure 3. 9. 2. 3 *Carcasses encounter rates in Kahuzi-Biega National Park.*

3. 10 Patrol Effort and Seasonal Variation in Snares Distribution

Only, 0.3 percent of all patrols were successful in arresting armed poachers. However, correlation analysis shows that there was a significant relationship between both park staff numbers and arrested offenders ($Y = 31.2x - 6249$, $R^2 = 0.8919$, $P < 0.05$) on one hand, and a significant relationship was detected between the EPMD per km^2 and snares detection as shown by **Figure 3. 9. 2. 2a,** on the other hand. Most successful patrols leading to firearm seizure were performed with six guards in group size, with less seasonal variation (t-value = 34.5; $P < 0.05$). There was a suggestion that having more than six rangers on patrol team may have decreased the detection effectiveness of both armed and unarmed poachers. This might be expected given the fact that hunters were more often alerted to the proximity of noisy park staff, thus increasing the probability of seeing guards approaching the area and escape under cover of dense vegetation. Overall, the study results suggest that investigations appear to be far more effective in arresting offenders than conventional patrol. The relative efficiency of investigations (ratio) shows peak in 2005 (**Table 3. 23. 1**) when the cost operational budget per guard per year was set at the lowest level ($US/366.24 km^2) with a cost of effective investigation days being set at $US5.0 /km^2. This outcome is consistent with the relative efficiency of investigation operations over conventional patrols, in terms of arrest and recovery of firearms and ivory as demonstrated by Leader-Williams *et al*. (1990). This confirms that investigation patrols have an overwhelming effect on the ability of patrols to disarm poachers. Not surprisingly, the highest CPUE for snaring was 1.91 in 2005 (**Table 3. 23. 1**) while the highest CPUE for woodcutting was set at c.0.45 in both 2005 and 2004 (**Table 3. 23. 1**). Paired-sample t-tests comparing randomly months between years and using z-scores (rather than data count data) shows a strong significant (t-value = 46.8; $P < 0.0001$) changes in snares detection with a peak occurring in August-November-December during which mean encounter rates varied between 0.68 - 0.88 with local communities deriving substantial consumption value from wild resources in the lean season when agricultural products were scarce. However, forest resources were utilized by people for their cash income throughout the year to procure protein when crop are scarce (Knapp *et al*., 2010). It is also important to recognize that the value of commercialized bushmeat still remains insufficient to increase the income of any household above the threshold of extreme poverty following plundered resources.

3. 11 Patrol Effort, Operating Costs and Staff Morale

A cost analysis was performed for the park building upon reliable figures or estimates from ICCN, German Technical Cooperation (GTZ) and WWF accounting data. Annual budgets included both recurrent cost and capital development and improvement for the park. Cost from the national agency responsible for country-wide PAs (ICCN) was taken separately in staff salary item. Total law enforcement expenditure was \$US95/km^2/year^{-1}, but the ranger emoluments per month were very low (\$US 41 /month^{-1} for a first rank guard including c. 17.7 US\$ official pay). Thus, the standard living of the ranger force was very bad through low salaries, resulting in low morale among the striking force while *in situ* large mammals' conservation and habitat protection requires a funding commitment of close to US\$240/ km^2 (James *et al*,. 2001). Surprisingly, there was a highly positive correlation between the effective patrol man-day/km^2/Year^{-1} and both conventional ($P < 0.001$) and intelligence ($P < 0.001$) patrol (**Figure 3. 11. 1)**. For both types of patrol, the EPMD/km^2/month^{-1} increased with the cost per km^2 (**Figure 3. 11. 1**) Of this amount, the great majority is derived from foreign and nongovernmental assistance basically provided by the German technical cooperation (GTZ) and WWF that provide recurrent management expenses and capital outlays, the minority from allocations by national government covering the staff salary. I feel that this is undesirable balance since the management of natural resources must be the responsibility of national government rather than external bodies. Normal management procedures recommends that no more than 30% of the recurrent expenditure should consist of staff salaries, while 70% should consist of backup (particularly transport) equipment and other facilities (Bell & Clarke, 1984).

A range of operational procedures is required to guide staff in their duties, including those involving physical risks; these need to be developed, along with the training system needed to ensure their use through the various field forces. Carrying out these operational procedures efficiently and in safety to attract sufficient manpower of adequate quality necessitate that living conditions for park staff be improved, in terms of location of camps, the type of housing, the protection of camps, the availability of schooling and medical facilities, and the supply of food and other related accessories. Physical injuries when they occur must be compensated, the terms of compensation legislation should be reviewed as there are generally continually exposed to physical risks, from disease, wild animals, and miscreants evading arrest. Indeed, they are regularly killed or injured by wild animals and in encounters with heavy armed poachers (Bell, 1984d). This applied as well for the VNP and other parks. Although the government gives higher priority to funding economic development and social programs than to conserving parks in the aftermath of the civil wars, government may be persuaded to increase the budget allocation for PAs if it can be demonstrated that parks generate substantial economic benefits albeit generating revenue is not the park primary objective.

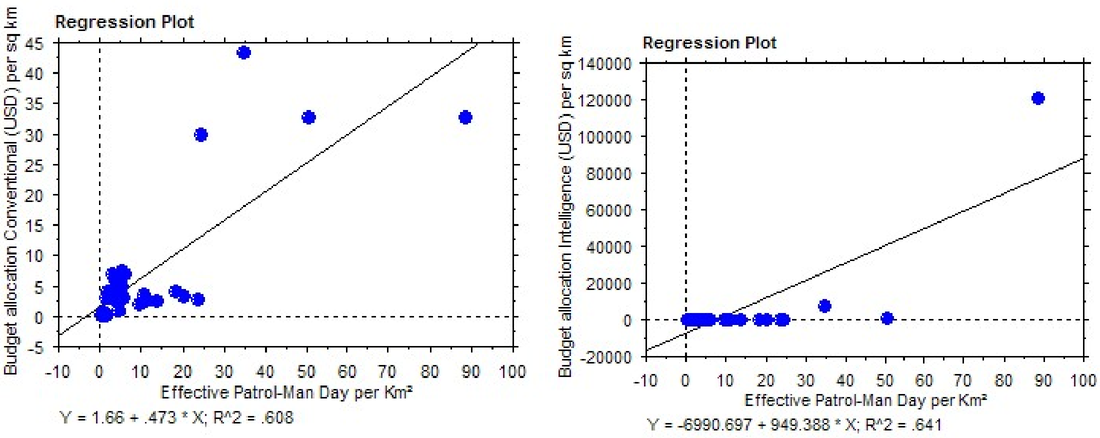


Figure 3. 11. 1 *Recurrent, capital protection cost in $US per square km versus effective patrol man-day/km^2/month.*

Current conditions for park staff are not good. Abuse of office, corruption and in some cases, the involvement of park staff in illegal activities was frequently reported. Frequently PA staff found themselves turning to other ways of supporting themselves including illegal killing of wildlife (Kujirakwinja, 2010). Senior staff may have to supplement their salaries, for example through the per diems for attending national or international meetings (WCPA-IUCN, 1999) or local workshops. While on patrol, guards eat provisions such as beans (*Phaseolus vulagris*), (*Zea mays* L), salted small fish. ICCN policy allowed patrols to eat dead animal remains for rations, a policy much abused by guard and officer alike, and one of the few benefits of being away from home. Guards still illegally killed animals for food when patrolling, although more discreetly. Such abuse was most pronounced amongst junior enforcement staff operating from remotely located patrol posts. They were usually poorly paid, based far from supervisory staff, and were quickly co-opted by the very people they are meant to police. Aside from the game meat that going on patrol might produce, however, few guards enjoyed the patrolling activity; it forces them to endure conditions more uncomfortable than those of camp life (especially in the rainy season). In many cases, there were confirmed reports of guards operating illegal licensing systems where, for a payment to a guard of $SU41per month (often not delivered in due time), community members were able to access resources such as fuelwood, and building poles. When the same community members were caught by unexpected mobile controls from the headquarters, they were harassed, beaten and often fined. Growing body of evidence suggests that people will only abide by park regulations if they perceive that they are evenly and fairly enforced. In addition, park staff should have a down-to-earth manner which is reassuring when it comes to to public relations to reduce social antagonism towards them.

3. 12 Relationship between Human Signs and Mammal Signs

Rates of encounters with human signs ranged from 1.3-5.2 signs/km (Mean = 2.8 signs/km, SD = 1.2, n = 8) at the 8 sites (patrol posts). Human signs were encountered at the highest rate within 2.5 km buffer from the villages within and around the park as shown in **Figure 3. 22. 1. 1**. Snares and traps were found at all sites and were the most frequently encountered type of human sign at most sites. A total of 14 animals were found trapped and rotting amongst the snares and traps discovered during patrols deployment. Most of the snares observed in the forest were set for muroid rodents. Animals found in traps included duikers (*Cephalophus* sp), bushpigs (*Potamochoerus porcus*), one-striped forest mouse (*Hybomys univittatus*), porcupine (*Hystrix cristata*), fire-footed rope squirrel (*Funisciurus pyrropus*), Gambian rat (*Cricetomys gambianus)* long tailed pangolin (*Manis tetradactyla*) and Giant-pouched rat (*Cricetomys emini*). Little field evidence of target ungulates all over the study sites was documented, supporting our observations that populations of larger game were very low and less spatially ubiquitous (**Figures 3. 15. 4; 3. 15. 5 & 3. 15. 6**).

There were no significant correlations between signs of snares/ traps, camps, tree cutting or honey and/or *Dioscorea munitiflora* Engl. collection with any sign of the large mammals ($P > 0.05$). There were significant negative correlations ($P < 0.05$) between poacher signs and signs of chimpanzees, gorillas, and all large mammals combined. There were also significant negative correlations ($P < 0.01$) between signs of mineral mining and bush pigs (*Potamochoerus porcus*), and between signs of mineral mining and signs of all ungulates combined (**Table 3. 12. 1**).

It should be noted that it would be careless to disregard the possibility that some of all of the small number of significant correlations produced by the above analysis might be spurious. Whenever a large number of correlations are run on a dataset, a small percentage can expected to have resulted by chance alone and therefore have no biological meaning. In the case of the below analysis, 85 correlations were run with only 6 significant results at the $P < 0.05$ level and only 2 significant results at the $P < 0.01$ level.

Table 3. 12. 1 *Spearman rank correlation coefficients (rs) for the relationships between signs of human disturbance and large mammals . Correlation coefficients in* **bold** *have P<.05*

Species	Total human disturbance	Snare / trap	Camp	Poacher signs	Tree cutting	Honey/Discorea sp collection	Encroachment	Mining	Bush fire
Chimpanzee	-0.023	-0.017	0.256	**-0.326**	0.613	0.065	0.079	0.223	0.267
Gorilla	0.366	0.624	-0.288	**-0.212**	0.130	0.075	-0.566	-0.357	0.021
Cercopithecus sp	0.203	0.344	-0.123	-0.132	0.260	0.002	0.310	0.028	0.322
Colobus	-0.347	-0.131	-0.144	0.268	0.127	0.224	0.006	0.145	0.333
Total primates	-0.167	0.124	-0.221	**-0.561**	0.112	-0.113	0.311	0.037	0.128
Bushpig	0.034	0.076	0.323	0.126	-0.221	0.133	0.212	**-0.556**	0.213
Duiker	-0.089	0.167	-0.351	-0.044	0.014	-0.112	-0.0132	-0.061	-0.044
Bongo	0.014	0.056	0.313	0.146	-0.252	0.113	0.201	**-0.513**	0.212
Elephant	-0.221	-0.019	0.255	-0.127	0.412	0.055	0.099	0.276	0.367
Buffalo	-0.377	0.031	0.144	0.286	0.124	0.234	0.046	0.155	0.323
Total ungulates	-0.247	-0.231	-0.144	0.168	0.137	0.244	0.206	**-0.105**	0.311
Carnivores	0.112	0.142	0.123	-0.122	0.201	0.102	0.210	0.013	0.422
Giant pouched rat	-0.043	-0.331	-0.143	0.128	0.132	0.134	0.101	0.045	0.033
Gambia rat	-0.077	0.321	0.044	0.086	0.424	0.133	0.022	0.235	0.023
Porcupine	-0.312	0.131	0.231	0.215	0.241	0.321	0.341	0.032	0.121
Grand total	-0.165	-0.122	-0.221	0.511	0.011	-0.113	0.302	0.130	0.023

Other forms of human disturbance found at more than half of the 8 sites included felled trees, burned areas, signs of poachers, signs of honey and/or *Dioscorea munitiflora* Engl harvesting, and camps setting. Agricultural field were encountered at Kyaselela, Kyabuye, Kanosso, Mulolo 1, Idunga, Tchibinda, Mumbili 1 and Mumbili 2 in Nzovu sector; most often in the area comprised in the triangle Idunga-Tshibinda and Mumbili 2 (**Figure 3. 12. 1 & 3. 24. 1**) as well as in Nindja corridor. These gardens included at least one of the following crops: beans (*Phaseolus vulagris*), cabbages (*Brassica* sp.), Irish potato (*Solanum tuberosum*), sweet potatoes (*Hypomea batata*) or tobacco (*Nicotiana tabacum* L).

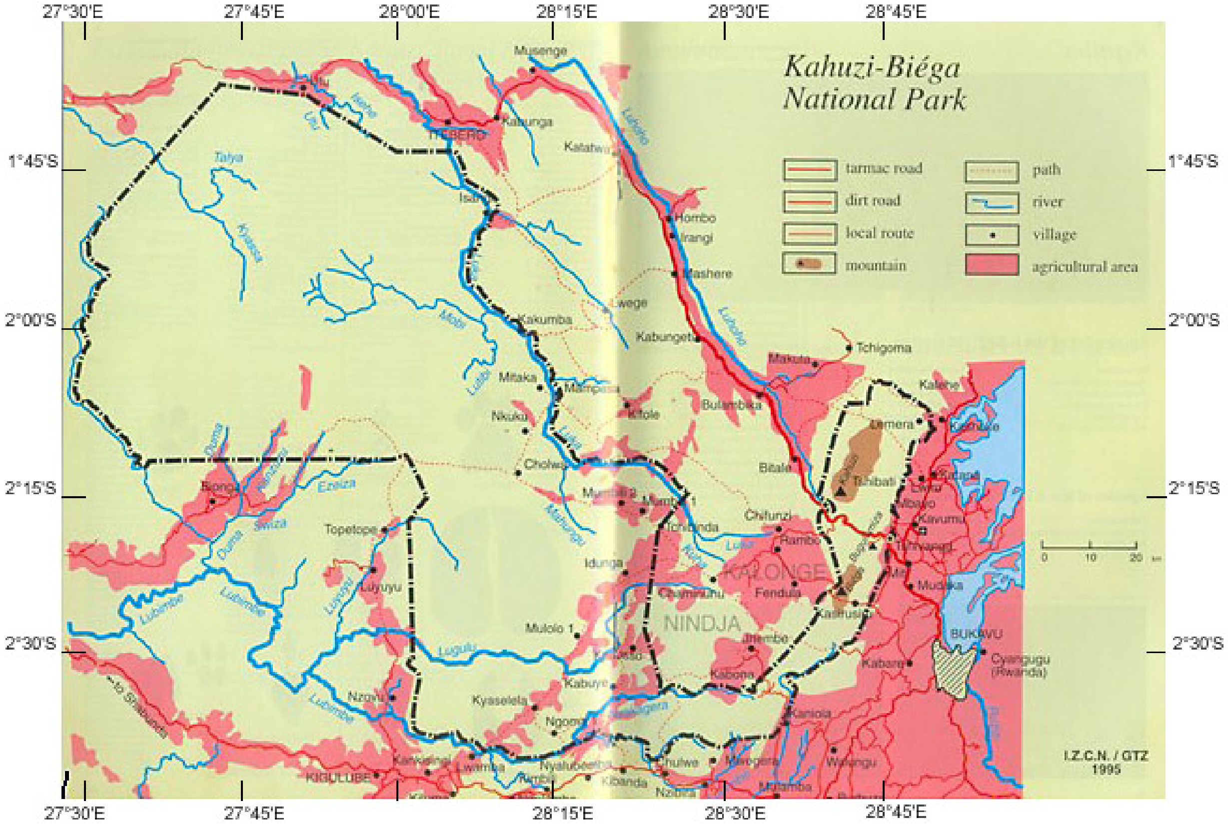


Figure 3. 12. 1 *Kahuzi-Biega National Park agricultural areas (Source:* Mühlenberg *et al., 1995).*

Corse-scale evidence of cattle entering the reserve was reported in the Nindja corridor, most often at Mulume-Munene, Kalubwe and Lushanja blocks (2,550 ha) with gardens size varying between (< 0.5 - 2.0 ha). Creation of new pastures for cattle by burning and forest clearing posed a major threat to the park forests, in particular at the highest altitudes. Much pastures showed signs of overgrazing, indicating significant pastoralist expansion into new area, particularly around Lushanja and Kalubwe blocks in the northernmost region of Nindja corridor where wealthy businessmen extensively violated park space (**Figures 3. 12. 2 & 3. 22. 1**), thus leading to habitat fragmentation. Wildlife populations stranded in forest fragmented therefore are expected to face the double threat of habitat fragmentation and over hunting. Forest fragmentation could aggravate the effects of hunting with manifold and far-reaching consequences of human activities by (i) initially reducing and isolating vertebrate populations averse to the surrounding habitat matrix (Gascon *et al.*, 1999); (ii) reducing or precluding recolonization of over harvested areas (Robinson, 1996); (iii) increasing the perimeter to area ratio and the amount of core forest habitat accessible to hunters on foot and (iv) further reducing the area of suitable habitat for species averse to forest edge (Laurance *et al.*, 2000). However, it remains unclear whether any level of game harvest could be defined as sustainable in highly fragmented landscapes, because few studies have quantified large vertebrates' abundance within forest fragments differentially affected by a history of hunting (Cullen *et al.*, 2000).

The most feared threat in line with habitat fragmentation was related to current small endangered forest elephant (*Loxodonta africana cyclotis*) population which may be divided into two or more subpopulations, each in a restricted area (Rochelle *et al*., 1999). These smaller populations may be more vulnerable to inbreeding depression, genetic, and drift, and other problems associated with small population size. While a large area of habitat may have supported a single large population, it is possible that none of its fragments can support a subpopulation large enough to persist for a long period (Primack, 2000). Previous research has illustrated strong long-term impacts on breeding in heavily poached populations (Gobush *et al*., 2008). The KBNP endangered elephant population therefore represents an opportunity to use detailed demographic data (including data generated through camera trap) to assess the recovery of an elephant population after intense poaching. So far, law enforcement still remains a casualty of the war.

To that end, recalling Decision **29 COM 7A.4,** adopted at its 29th session (Durban, 2005), the WHC has adopted the Decision **30 COM 7A.6** at its 30th session (Vilnius, 2006), reclaiming as soon as the security situation allows the farms inside the Park on the basis of the results of the 2001 provincial committee ("*Commission des Institutions Etatiques Provinciales concernées par le Conflict foncier du PNKB*"), and noted that the delimitation of the Park limits in the ecologically important corridor between the lowland and highland sectors remains a priority for the conservation of the KBNP. In the light of this decision, the WHC also urged the Congolese army- Forces Armées de la République Démocratique du Congo (FARDC), in consultation with the Park authority to develop a strategy to evacuate all armed groups from the property, in particular rebels belonging to FDLR (Forces Démocratiques pour la Libération du Rwanda-*Interahamwe*) and implement this evacuation in cooperation with the MONUC. The strategy also needs to take into account the closing of all illegal mining operations inside the property. The strategy has to avoid driving FDLR rebels inside the property, as is currently the case, where they still engage in mineral extraction and armed poaching, thus doing a land-office business while obtaining a significant proportion of its income from gold mining and trading. It is therefore important, where possible, to build on systems that have emerged in these spaces to design and implement more rule-bound governance systems.

The negative effects of war on wildlife were much more commonly observed in mining where wildlife products were often sold or bartered for food, arms, ammunition, other goods, or services. Overall, the presence of militia forces aggravated the illegal harvesting of animals in KBNP (Plumptre *et al*., 1997; Dudley *et al*., 2002). Substantially strengthening the presence of ICCN Park guards in the lowland sector of the park, with the assistance of the government with inputs from MONUSCO is urgently recommended.

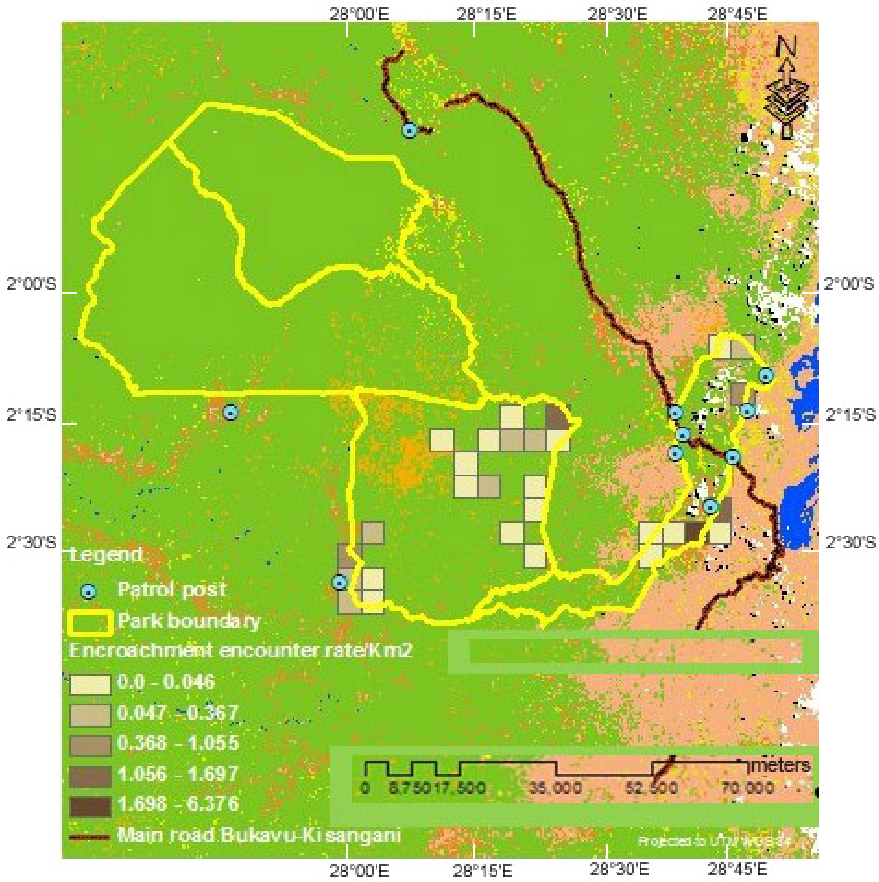


Figure 3. 12. 2 *Map showing the human encroachment encounter rates in Kahuzi-Biega National Park*

3. 13 Indicators of Success in Wildlife Protection in the Kahuzi-Biega National Park

Worthy of particular mention where the KBNP has made a breakthrough since the launching of the Community Conservation Committee (CCC) program has been in identifying collaborative framework with some dedicated traditional chiefs. Contrary to the VNP, important number of firearms was recovered by traditional chiefs, especially Mr Muombi Lubula from Mulonge groupement in Buloho chiefdom who has adopted as his own the principals of community conservation, as a result he turned in two military grade weapons seized from poachers since 2006. The other field of collaboration was the role played by Mwami Nakalonge Mpangaza II, the traditional chief of Kalonge chiefdom who over the past five years has worked tirelessly to mobilize its collaboration in patrols to confirm and map the park limits in several contested areas. Over the last nearly 10 years, he secured and recovered arms, vehicles and radios belonging to the park and either taken or at risk of confiscation by rebels during the war. Mwami Mopipi Mukulumanya of the Bakisi chieftancy has also served in the national government as a minister and was one of the rare politicians that put law and conservation in front of popularity for election. These people were among others Congolese, the first Abraham Awardees in DRC and Africa recognized for their outstanding bravery to defend the KBNP. Oscar Biringanine from the Bugobe groupement, Marie Sangara chieftainess of the Lemera localité, Mwami Kaseketi from Bamuguba south as well committed to the conservation of the KBNP in eastern DRC's most turbulent history.

In the face of unprecedented habitat destruction with support from the local government at provincial and local level, including traditional chiefs (PNKB, 1998), particularly in Kasirusiru and Mulume-Munene, the park management made the move of integrating about 30 local poachers within the KBNP park forces in the attempt to curb poaching scourge under the UNF funding (PNKB, 1998). The UNESCO later on has recognized the merit of such initiative during the war. Most of the patrol equipment was hauled by the brave converted poachers who at the beginning acted as both informants and carriers. Though the use of these informants may seem trivial, they did contribute with notable sobriety and high *esprit de corps* to the deterrence effect of trespassers in the park. Because they knew the park like the back of their hands, these hidebound veterans of the guard force provided tip-offs leading to the arrest of dealers in illegal activities as they knew the seasons and areas susceptible to illegal activities, as well as having a good idea of the likely perpetrators. However, it is unfortunate that frequent central government delays in delivering guard salaries made it difficult for the new converted staff to survive. To make life harsher, the latter even were delayed before the government recognized them under the ICCN category of "classified employed" or first rank guard. Though, they rendered excellent service and displayed cheerfulness and a willingness to work, they even experienced even more conditions of services than their supposed servant counterparts. Unfortunately, five of them died while they still put up with a reduced life-style they were recognized as civil servants.

As a consequence, ten of them were sold on the idea of resigning and as good as they words, they decided to step down after they realized that they were no better off in this new job position as they had to scrape the bottom of the barrel to pay their food and rent. Twenty five are recognized civil servants and only one of them was promoted to the rank of *garde principal*. The inclusion of these former poachers within the park anti-poaching unit not only offered job opportunity for local people but launched a climate aiming at establishing trust between the park management and local community as a basic prerequisite to successful conflict resolution.

Well managed join operations with park guards supported by FARDC soldiers, including nine join ICCN-MONUC patrols totaling 25 days (PNKB-Tshivanga, 2010) have proven successful. Indeed, in the latter part of 2009, a marked increase in poaching had been seen within the northern and southern parts of the highland sector. A coordinated effort to remove these poachers was put into action through a one-month sweep nicknamed *Interconnexion* launched in

November 2009 and covering 550 km^2 representing the third of the studied area per year. Several large and well established charcoaling and poaching camps were identified and raided simultaneously during the operation. The sweep was launched in three separate join patrols in 19 days and has covered Tshibati, Lemera, Musenyi and Kasirusiru management units (**Figures 3. 6. 1 & 3. 6. 2**), and dismantled 34 active wire snares and removed 965 cows from the park. One hundred and twenty eight camp signs were observed and destroyed. Hunting torch lights and hemp (*Canabis sativa*) were also confiscated. Moreover, they put down illegally armed farmers incursion in the Nindja corridor and elsewhere (e.g., Ntulo) and acted in intelligence with both *Interahamwe* and unchecked elements of the FARDC in controlling mining sites (PNKB, 2008). Toward this end, the patrol teams were armed and supplied with heavy weapons and adequate ammunitions to ensure that they were on equal footing with the heavy armed poachers or were even more powerful. To sum up, this sweep went off in apple-pie order and shows that well managed sweep with park staff supported by disciplined FARDC elements may prove successful in any attempt to stemming the tide of poaching, as poachers frequently move, impairing their ability to plot attacks on species.

This single large-scale sweep translated into 30.5 EPMD/Km^2 per guard with an average operational cost of $US 193.6 per km^2 in the light of the current global economic downturn. Such a protection effort close to the required 33 EPMD/km^2 (Burner *et al*., 2001) coupled with a well-designed intelligence approach could efficiently mitigate poaching in the future, especially the human encroachment if the law enforcement exercise is applied over the park. Actively seeking out evidence of the benefit of such operation will assist law enforcement in justifying operational expense, and planning future crime reduction strategies. However, strong evidence today indicates that benefits will eventually decay over the longer term (Ratcliffe, 2004; Ratcliffe & Makkai, 2004) so targeted guard operations should be part of a wider wildlife crime prevention policy agenda.

3. 14 Empowerment of Indigenous Peoples and Local Communities

The CBD, adopted at the 1992 Earth Summit in Rio de Janeiro, acknowledged the need to protect and encourage customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements (Article 10). There are many links between spiritual traditions and PAs. Long before the existence of officially PAs, Pygmies better known locally as Mbuti were protecting their sacred lands. Sacred sites are probably the oldest method of habitat protection and they still form a large and mainly unrecognized network of sacred sites within the park. They are important as a tool for in situ conservation of flora and fauna. They occur in different forms, including remnants of old forests, caves, burial grounds and sites of ancestral worship (Mgumia & Oba, 2003).

In the eyes of local people, more than the biological uniqueness, it is the spiritual heritage of place that renders it so special and so important to preserve. People throughout time have been much more inclined to safeguard their natural environment when it is linked with their deep-rooted belief systems. There are countless cases where endogenous knowledge of natural places and resources has proved to be a welcome addition, if not superior to, scientific conservation measures (Byers *et al*., 2001). This is true, as well for both the KBNP and VNP. Indigenous peoples have knowledge, skills and institution of great value for biodiversity and landscape conservation. They are often directly dependent on PAs for their cultural survival and livelihoods and in many areas around the park they have been involved in several activities related to ecosystem management. **Figure 3. 14. 1** indicates that honey and wild *yams-Dioscorea munitiflora* Engl harvesting which is basically carried out by Mbuti was localised along the park boundary at a low encounter rates levels, thus suggesting no major disturbance in the core area.

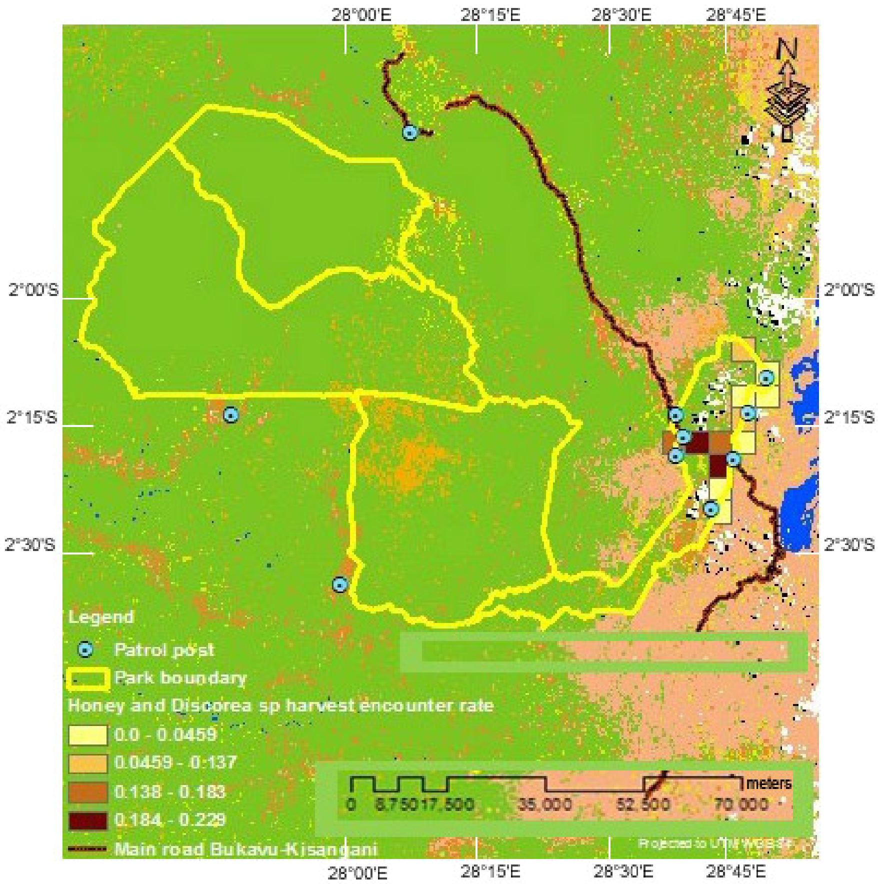


Figure 3. 14. 1 *Honey and Dioscorea munitiflora* Engl *harvesting encounter rate in KBNP*.

Byarugaba (2004; 2010) highlighted how the Abayanda people near Bwindi forest in Uganda helped for cheaper and quicker study by their taxonomical knowledge of the seven species of *Dioscorea* and six species of stingless bees. Abayanda people's knowledge on the plant pollination ecology and nest site selection was invaluable in working towards developing a sustainable use system of the stingless bee resource. This has been achieved and conservation of

Dioscorea should follow suit. Such examples describe how indigenous knowledge has been used in scientific studies, the management of resources, conservation efforts and in moving towards a more sustainable lifestyle. In doing so, sustainable resource practices hinged on cultural and oral history practices safeguard nature and uphold biodiversity conservation systems. With all these in practice, indigenous knowledge could direct conservation issues for sustainable management. This in turn would allow the amalgamation of indigenous knowledge and modern way of understanding systems in conservation and farming. This is something far from reality in KBNP where Mbuti people around the park are estimated to be 594 houselhods consisting of 1,068 individuals (pers. comm.).

The plight for the indigenous people, the source of this knowledge, is about to crash in KBNP. In the perspective of encouraging effective use of zoning in PAs to allow different objectives to be achieved in the framework of the Biosphere reserve scheme, implementation of zoning system building upon long-term indigenous knowledge should be compiled and explored. The MAB Program and the World heritage convention share a number of convergences of vision as these two instruments can be seen to belong to a wider international movement epitomized by the 1972 Stockholm Conference on the Human Environment. In this regard, they are two sides of the same coin (Bridgewater, 1999) and offer opportunity for involvement of local people such as that suggested in the action plan for UNESCO-MAB biosphere reserves (Bridgewater & Cresswell, 1998). The Serengeti NP holding both the world heritage site and MAB status is a scheme worth trying. Mbuti population in VNP is estimated at 12,400 (Plumptre *et al*., 2003a).

3. 15 Snare and Fuelwood Distribution versus Habitat Preferences

Table 3. 13 shows that increasing spatial distribution of snaring (48.1%) and human encroachment (40.4%) as the most important threats in the KBNP. These threats are followed by bushfire (28.9%), fuelwood collection (27.9%) and mining exploitation (23.1%). Wire and rope snares were basically observed in six vegetation or habitat types of the highland sector (**Figure 3. 15. 1**). Snares were sighted particularly in two main habitat types of mixed forest with *Bamboo, Polyscias* and *Hagenia,* and the secondary forest with *Macaranga* and *Hagenia*. Snares were most sighted (30% of the total observations) in the mountainous primary forest. Cultivated areas attracted 24% of snare occurrences (**Table 3. 15. 1**), thus explaining high level of hunting with rope and wire snares in secondary forest and fallows and human encroachment areas near park boundary (**Figure 3. 7. 1**). Indeed, growth in the global extent of secondary forest (Wright & Muller-Landau, 2006), has led some researchers to herald their potential as hunting grounds (Lovejoy, 1985; Wilkie & Lee, 2004). The view is quite widely held that the wild-meat supply is

higher in disturbed habitats than in primary forest due to canopy openness and greater abundance of understory vegetation (Robinson & Bennett, 2004). Consequently, hunting in secondary forest could be rewarding for forest dwellers who often live near successional mosaic. Although the results of empirical hunting studies suggest that secondary forest can support substantial wild meat offtake (Wilkie, 1989; Gavin, 2007), harvest sustainability remains unclear in the KBNP because offtakes have not been compared with reliable biomass and productivity estimates for hunted species. However, there are some reasons to question the potential importance of secondary forests as havens for biodiversity conservation and a protein source for the rural poor. Even though secondary forests can provide a supplementary source of meat to local people, Parry *et al*. (2009) results cast serious doubt on the long-term sustainability of hunting in the secondary forest type suggesting that it falls significantly short of providing the necessary reprieve to the widespread negative consequences of overhunting on tropical forest wildlife

Sustainable hunting in secondary forests is also unlikely in Africa because rural populations are increasing (United Nations, 2005), which reduces the chance of forest recovery (Wright & Muller-Landau, 2006). Indeed, when the forest is cleared nearly all the woody vegetation greater than 3-4 years cm dbh (diameter at breath height) is cut, charcoaled locally and removed, subsistence slash-and-burn agriculture, typically of different types of crops, is then practiced on the deforested lands for 1-3 years before abandonment. During these farming periods, the remaining deforested areas are often colonized by tall grasses, which subsequently burn in the fallow and secondary forest. The increasing human populated, however, coupled with rapid loss of wildlife habitat, make it less and less likely, that uncontrolled harvesting of wildlife will be sustainable.

Poachers' habitat preferences throughout the year, preference indices (PI), are presented in **Tables 3. 15. 1 & 3. 15. 2** as well as **Figures 3. 15. 1 & 3. 15. 2**. Their PIs differed significantly within and between seasons. For example, poacher's highest preferences were in mixed forest with *Bamboo, Polyscias* and *Hagenia,* and the secondary forest with *Macaranga* and *Hagenia* vegetation types where they showed high PI values. In fact, wire snares were placed at an optimal height to catch any ungulate; while by-catch often occurred, the species that were most caught frequently were the most abundant (Holmern *et al*., 2006). On the other hand, cultivated areas, *Cyperus-Hypericum* dominated marsh as well as the *Ericaceae* and *Subparamo* sp association were negatively preferred habitat types. The avoidance of *Cyperus-hypericum* dominated marsh habitat may be explained by the fact that swamp forest type develops in places where the plants' reproductive cycles take place on soaking wet soils or where the soil has at least a layer of water on its surface during the dry season. Dominant species in this type of forest are *Syzygium rowlandii*, *Podocarpus usambarensis*, *Agauria salicifolia*, *Anthocleista grandiflora* and some Meteoricaceae. Periodic and occasional floods were documented in this type of vegetation which is very difficult to penetrate. However, the easy detection of hunters' footprint by the guards might lead to their arrest once they strategically deploy in such habitat.

A detailed investigation of the attempts to examine the indices of sustainability in current use, the maximum sustainable-harvest potential and to model sustainability in KBNP biodiversity hotspots is beyond the scope and purpose of this thesis, but it remains a high priority for future research. Our understanding of sustainability would be improved through temporal monitoring of either hunting catchments size (Clayton *et al*., 1997) or hunted populations (Noss, 1998a). Understanding hunting sustainability remains therefore a key challenge.

Table 3.15.1 *Poacher's habitat preferences through snares distribution in different vegetation types both in wet and dry seasons*

Vegetation type	*Area (km²)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/ r+p*
Cultivated area	28.21	24	0.05	0.24	-0.19	0.29	-0.65517
Cyperus-Hypericum dominated swamp	33.64	22	0.06	0.22	-0.16	0.28	-0.57143
Mixed forest with bamboo, *Polyscias* and *Hagenia*	109.84	6	0.18	0.06	0.12	0.24	0.5
Ericaceae and *subparamo* sp association	13.7	3	0.02	0.03	-0.01	0.05	-0.2
Mountainous primary forest	240.81	30	0.4	0.3	0.1	0.7	0.142857
Secondary forest with *Macaranga* and *Hagenia*	173.8	15	0.29	0.15	0.14	0.44	0.318182

Key *r = the ratio of habitat type where snares occurred*
p = the proportion of snares occurrence

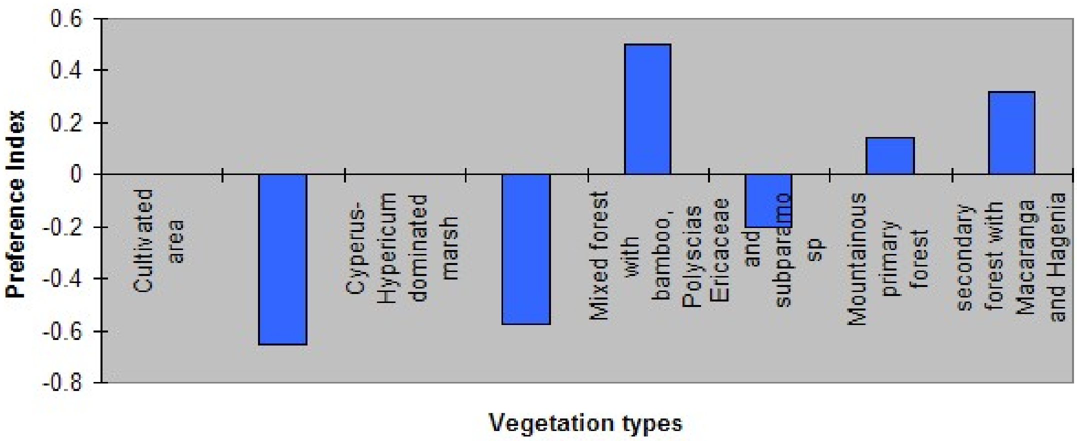


Figure 3. 15. 1 *Hunters' habitat selection for snares distribution in both dry and wet seasons.*

***Table 3. 15. 2** Poacher's habitat preferences through fuelwood cut distribution in different vegetation types both in wet and dry seasons*

Vegetation type	*Area (km²)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/r+p*
Cultivated area	28.21	1	0.05	0.01	0.04	0.06	0.66667
Cyperus-Hypericum dominated swamp	33.64	1	0.06	0.01	0.05	0.07	0.71429
Mixed forest with bamboo, *Polyscias* and *Hagenia*	109.84	15	0.18	0.15	0.03	0.33	0.09091
Ericaceae and *subparamo* sp association	13.7	10	0.02	0.1	-0.08	0.12	-0.6667
Mountainous primary forest	240.81	71	0.4	0.71	-0.31	1.11	-0.2793
Secondary forest with *Macaranga* and *Hagenia*	173.8	2	0.29	0.02	0.27	0.31	0.87097

Key *r = the ratio of habitat type where fuel wood collection occurred*

p = the proportion of occurrence of fuel wood collection

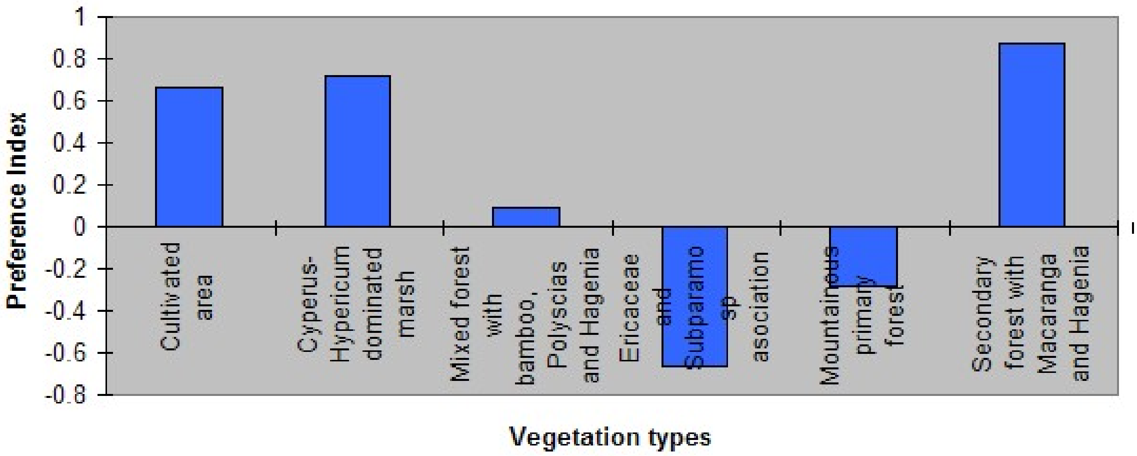


***Figure 3. 15. 2** Offenders' habitat selection for fuelwood collection in both dry and wet seasons.*

Sightings of snares in different vegetation types did not differ seasonally (df = 11, F = 1.38, *P* = 0.267). Similarly, the encounter rates of the fuelwood collection and human encroachment in various vegetation types showed no seasonal variation with respectively (df = 11, F = 0.319, *P* = 0.319) and (df = 11, F = 1.072, *P* = 0.307). High human pressures both outside and within the park might explain the continous dependence on park natural resources. In addition, as Perch, (1995) and Dudley *et al*. (2002) put it, human populations undergoing food and fuelwood shortages in lawless landscapes exact heavy tools on wildlife and habitats

However, there was a different pattern of charcoal species utilization from one park management unit to another as shown in the **Table 3. 15. 3** below. Fifty nine percent of most preferred species charcoaled in the park were collected in the secondary forest (**Table 3. 15. 3**). The six most preferred species used by local people for charcoal making were: *Nuxia floribunda (16.1%), Macaranga neomildbreadiana (12.9%), Sapium ellipticum (12.9%),* and *Syzygium div. sp (9.7%).* They were followed by *Ficalhoa laurifolia*, *Hagenia abyssinica*, and *Millettia dura* (6.4%). The other species, including *Rapanea melanophloeos, Parinari excelsa, Agauri salicifolia, Maesa lanceolata, Alangium chinense, Neoboutonia macrocalyx, Dombeya torrida* and *Strombosia scheffleri* were as well among the most used species but with only 3.2% of rank preference.

Table 3. 15. 3 *List of plant species most used in fuelwood collection by local community*

No.	Species	Park Management Unit	Frequency	Habitat	%
1	*Nuxia floribunda*	Mt Kahuzi-Mugaba, Kasirusiru, Tshivanga, Lemera, Tshibati	5	Primary forest	16.13
2	*Macaranga neomildbreadiana*	Mt Kahuzi-Mugaba, Kasirusiru,Tshivanga, Tshibati	4	Secondary forest	12.90
3	*Sapium ellipticum*	Kasirusiru, Tshivanga, Lemera, Tshibati	4	Secondary forest	12.90
4	*Syzygium div. sp.*	Mt Kahuzi-Mugaba, Lemera, Tshibati	3	Primary forest	9.68
5	*Ficalhoa laurifolia*	Mt Kahuzi-Mugaba, Lemera	2	Primary forest	6.45
6	*Hagenia abyssinica*	Kasirusiru, Tshivanga,	2	Secondary forest	6.45
7	*Millettia dura*	Tshivanga, Lemera	2	Secondary forest	6.45
8	*Rapanea melanophloeos*	Mt Kahuzi-Mugaba	1	Primary forest	3.23
9	*Parinari excels*	Mt Kahuzi-Mugaba	1	Primary forest	3.23
10	*Agauria salicifolia*	Kasirusiru	1	Secondary forest	3.23
11	*Maesa lanceolata*	Tshivanga	1	Secondary forest	3.23
12	*Alangium chinense*	Tshivanga	1	Secondary forest	3.23
13	*Neoboutonia macrocalyx*	Tshivanga	1	Secondary forest	3.23
14	*Dombeya torrida*	Tshivanga	1	Secondary forest	3.23
15	*Strombosia scheffleri*	Lemera	1	Primary forest	3.23
16	*Chrysophyllum gorungosanum*	Lemera	1	Primary forest	3.23
	TOTAL		**31**		**100**

3. 15. 1 ***Widlife Habitat Use and Inter-Specific Relations***

Accordingly to Basabose & Yamagiwa (2009), KBNP gorillas used their home range evenly over a large territory to avoid reusing the terrestrial herbaceous vegetation, as a folivorous strategy while chimpanzees revisit a comparatively small home range several times, preferentially in primary forest, to maximize the use of fruit interpreted as a frugivory strategy.

Table 3. 15. 4 *Density gradient analysis results of key species density correlated to human settlements*

Species	Coefficient	Std Error	Std Coefficient	t-Value	P-Value
Gorilla	0.029	0.043	0.457	0.687	0.16 +884X
Chimp	-0.017	-0.005	-0.925	-3.453	1158 – 0.017X
Elephant	0.045	0.004	0.991	10.408	-0.399+0.45X

The multiple regressions show that there was no significant variation in gorilla densities in different sampling zone due to human densities location ($P > 0.05$). In contrast, it does indicate that there was significant correlation ($P < 0.05$) between chimpanzee densities and human settlement with a negative coefficient (**Table 3. 15. 4**), and an R-square value of 0.856, implying that 86% of the variation is explained by the distance from the main centre of human activities. This indicates that densities decreased further from human settlements. Elephant density was also significantly ($P < 0.05$) correlated to human settlements but with a positive regression coefficient, with an R-square value of 0.982 indicating that 98% of the variation in elephant density could be explained by the distance from the most important localities in the area; thus explaining the obvious densities increase further from human settlements (**Table 3. 15. 4**).

Chimpanzees in secondary forest, where gorillas are frequent rarely nest in those trees bearing ripe fruit whose fruit is also eaten by Grauer's gorillas. This was interpreted by Basabose & Yamagiwa (20090 as a strategy to avoid competition and conflict encounters over food with the Grauer's gorillas. Small viable elephant population, 20 individuals (Blanc *et al*., 2007), was found to be compacted within 2.36 km^2 around Musisi *C.latifolia* swamp area in highland sector (**Figure 3. 15. 6**), suggesting that elephant distribution was governed by the distribution of both past and present human activities (Barnes, 1993). The contraction of elephant population in KBNP has been attributed to severe and well organised armed poaching, particularly for ivory, and habitat encroachment, which greatly reduced the elephant's rangeland (Kangwana, 1995).

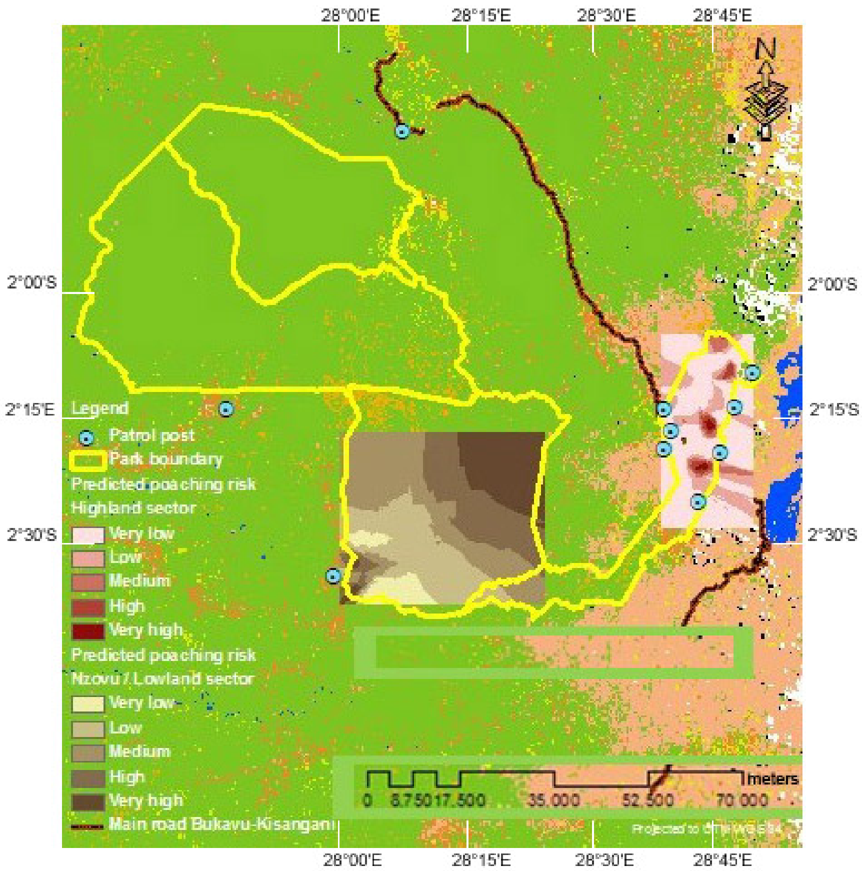


__Figure.3. 15. 3__ Predicted poaching hotspots over the study area in Kahuzi-Biega National Park.

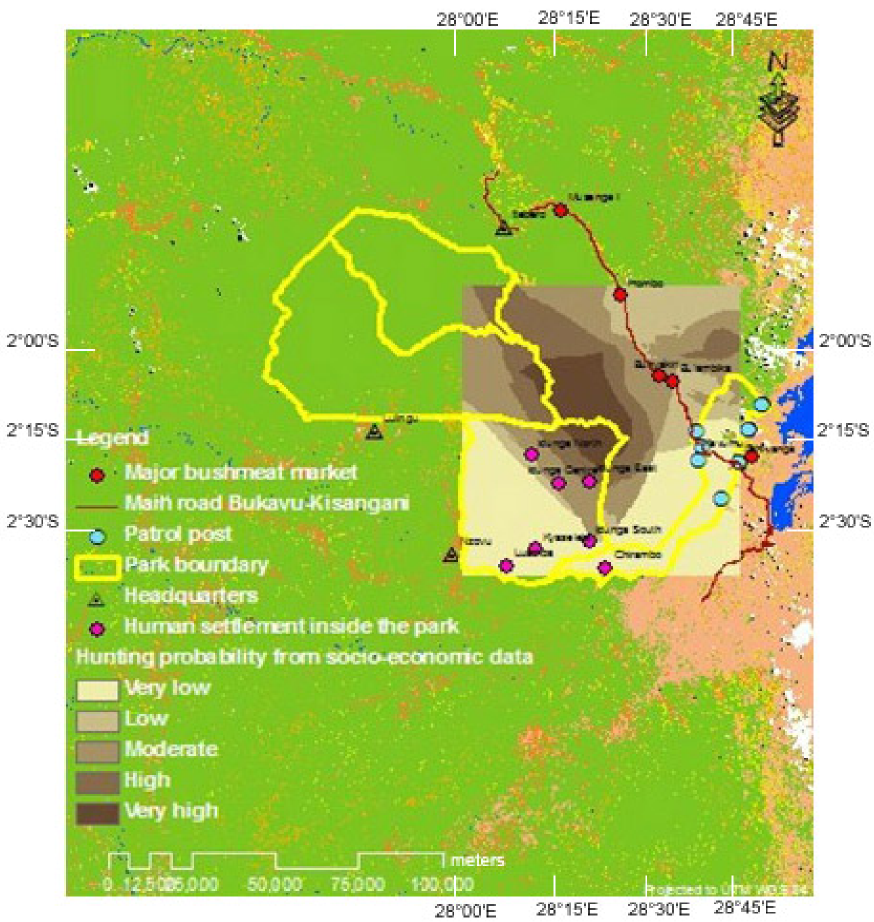


__Figure 3. 15. 3. 1__ Hunting probability pattern from socio- economic data in KBNP.

Table 3. 15. 5 *Threat analysis from law enforcement monitoring data*

Park sector	Moran's Index	Z-score (SD)	Significant level	Critical value
Highland sector/Tshivanga	0.73	4.54	0.01	2.58
Lowland sector/Nzovu	0.89	28.84	0.01	2.58

Table 3. 15. 5. 1 *Threat analysis from socioeconomic survey data*

Park sector	Moran's Index	Z-score (STDEV)	Significance level	Critical value
Highland/Thivanga	0.62	71.2	0.01	2.58
Lowland/Nzovu	0.93	105.57	0.01	2.58

Overall, from **Figure 3. 15. 3** and **Table 3. 15. 5** generated by GIS hotspot analysis and ordinary kriging-based interpolation method with spherical semivariogram model, there was less than 1% likelihood that the major threats (encroachment, snaring, and fuelwood cutting) clustering of high values could be the result of random chance particularly in the human settlement areas both in the highland and Nzovu sectors (**Table 3. 15. 5**). However, the spatial autocorrelation analysis performed on year basis indicated changes in clustering pattern, especially in lowland sector where the pattern was neither clustered nor dispersed in 2005 (Moran's Index = - 0.05 and Z-score = - 0.59 SD), and where there was less than 5% likelihood that the dispersed pattern was the result of random chance (Moran's Index = - 0.06 and Z-score = - 2.56 SD) in 2007. Finally, in 2004 and 2006, there was less than 5% likelihood that the clustered pattern could be the result of random chance (Moran's Index = 0.15 and Z score = 2.16 SD in 2004, and Moran's Index = 0.02 and Z-score = 6.94 SD); while somewhat clustered the pattern may be due to random chance (Moran's Index = 0.01; Z score = 1.4 SD) in 2008.

Hotspot analysis from both law enforcement data and socio economic data show that there is less than 1% likelihood that the cluster pattern of major threats could be the result of random chance. The critical Z-score values when using a 95% confidence level was larger in Nzovu sector than in Tshivanga sector (**Tables 3. 15. 5 & 3. 15. 5. 1**) indicating the more intense clustering of high values (Wildlife crime hotspot) in Nzovu area. Therefore the null hypothesis was rejected implying a statistically significant spatial pattern with different threat clustering levels. One striking finding from this analysis is the relationship between the spatial distribution of human settlement within the park and the high probability of the threats occurrence, especially in the lowland sector where permanent human settlements (**Figures 3. 22. 1. 1 & 3. 22. 1. 2**) were documented, thus suggesting the necessity of implementing a set of patrol posts in the lowland sector as soon as possible.

Table 3. 15. 6 *Threats specific hotspots in the highland sector*

Park Management Unit	Illegal activity	Year	Poaching hotspot (sq km)
Highland sector	Poacher camp	2004	88.37
		2005	113
		2006	31.12
		2007	114.5
		2008	97.61
	Snare	2004	23.58
		2005	89.02
		2006	19.87
		2007	75.53
		2008	81.13
	Human encroachment	2004	46.52
		2005	56.86
		2006	80.33
		2007	61.24
		2008	2.38
	Mining	2004	16.33
		2005	21.17
		2006	25.29
		2007	115.55
		2008	285.05
	Fuelwood collection	2004	27.83
		2005	14.89
		2006	67.95
		2007	44.22
		2008	36.89
Mean			65.45
STDEV			57.28

Tables 3. 15. 6 & 3. 15. 7 indicate that mean threats specific hotspot covered respectively 65.45 km^2 and 91.08 Km^2 in the highland and Nzovu sectors with poachers' camps being more frequent in 2007 in highland sector and in 2008 in Nzovu sector, and mining activity being most common in the highland sector in 2007 and 2008. Although snaring appeared to be most common in the highland sector than in Nzovu sector, it is likely that this activity might occur on a widely distributed range in Nzovu sector where patrols were very limited due to the insecurity and scarce patrol force, especially in Nzovu sector manned by only 14 guards (PNKB-Nzovu, 2006) for a patrol area estimated at 1,996 km^2. To crown it all, Nzovu was attacked and looted by the FDLR in February 2006 before they further launched furious attack against Madirhiri patrol post in August 2006 (SYGIAP, 2006a).

Table 3. 15. 7 *Threats specific hotspots in the Nzovu sector*

Park Management Unit	Illegal activity	Year	Poaching hots pot (sq km)
Nzovu	Poacher camp	2004	19.17
		2005	201.5
		2006	65.91
		2007	35.17
		2008	80.44
	Snare	2004	74.35
		2005	15.38
		2006	72.27
		2007	59.39
		2008	24.28
	Human encroachment	2004	276.23
		2005	123.37
		2006	199.81
		2007	238.02
		2008	218.91
	Mining	2004	40.12
		2005	103.34
		2006	97.56
		2007	143.46
		2008	126.6
	Fuel wood collection	2004	16.48
		2005	19.52
		2006	13.23
		2007	10.2
		2008	2.38
Mean			91.08
STDEV			80.65

One of the study key results is that the areas of most intense poaching risk (wildlife crime hotspot) were the areas between Katasomwa (the northernmost area was avoided by park's anti-poaching forces, accordingly such area suffered great loss of wildlife species to poachers), Lemera-Tshibati areas where fuelwood removal was rampant, Tshivanga and Kasirusiru areas in the highland sector, and the triangle Idunga-Mumbili2-Tchibinda in the lowland sector (**Figures 3. 22. 1 & 3. 24. 1**). Furthermore, **Table 3. 23. 1** shows that apart from one fresh elephant carcass found in 2004, there was no reported elephant, gorilla and chimpanzee killed implying on one hand, that the protection effort investment in safeguarding the limited remaining numbers of these large mammals within the park, and on the other hand, that the forest is becoming increasingly devoid of wildlife, with the concomitant breakdown of ecological processes, a phenomen known as the'empty forest' syndrome well described by Redford (1992) and to less extent by Janzen (1988). As long as wildlife is seen as an open-access commodity to be harvested and traded, species populations will continue to be plundered, wondrous diversity will continue to erode, and the forest will become increasingly more silent (Burgess *et al*., 2006). The potential of anthropogenic habitats as hunting grounds will likely be further confounded by hunter preferences. Wildlife depletion in primary forest does not necessarily lead to more hunting in other habitats. Hunters may continue to hunt smaller and fast-breeding species, which may still expose vulnerable, increasingly scarce species to extinction (Perry *et al*., 2009).

Table 3.15. 8. *Estimated population of selected large mammals in KBNP*

PA	Elephant	Gorilla	Chimpanzee	Year	Notes
KBNP	1,350-3,600	4,150-10,800	1,300-4,000	1,990-1,995	Count (Hart & Hall, 1996)
	771	-	-	1996	Count (Inogwabini 2000)
	-	1.36	1.86	2000	Density per km
	10	130	-	1997	Count (Ilambu, 1998)
	No sign	1.38	1.74	2004	Density per km
	-	168	-	2004	Count (Liengola, 2005)
	20	-	-	2007	Count (Blanc *et al*., 2007)
	-	1.35	0.14	2007	Density per km

The KBNP is one of the five World Heritage sites in the DRC, designated in 1980 primarily because of its population of Grauer's gorilla. Research shows that this park contained about 85% of the world population of Grauer's gorillas in the mid 1990s (Hall *et al*., 1998). Grauer's gorilla population was estimated at around 7,760 (4,180-10,830) gorillas for the park, while 3,700 elephants and 2,600 chimpanzees (**Table 3. 15. 8**) were estimated for the park at that time (Hall *et al*., 1997; 1998). Only 130 gorilla nests were observed in Nzovu (Nishuli, 2007).

Table 3. 15. 9 *Keystone species' home ranges in Kahuzi-Biega National Park*

Species	Probability	Area (sq km)
Gorilla (*Gorilla beringei graueri*)	95	182.25
	50	31.15
Elephant (*Loxodonta africana cyclotis*)	95	20.12
	50	2.36
Chimpanzee (*Pan troglodytes*)	95	185.10
	50	10.57

As can be seen from **Table 3. 15. 9** & **Figure 3. 15. 4** on key species home ranges, chimpanzees were sympatric with gorillas throughout the study areas. Chimpanzees (*Pan troglodytes schweinfurthii*) tended to enlarge their range area with preference to small patches of primary forest but not farther from their core area. This finding correlates with Basabose (2005) results confirming Kahuzi chimpanzees' use of their home range in a clumped pattern, frequently visiting the core area and only rarely entering the peripheral areas. In addition, no consistent seasonal difference in the size of the home range was observed. While no seasonal effect was observed in the use of primary forest, the chimpanzees in the study area displayed a statistically consistent seasonal difference in their use of secondary forest, visiting it basically during the dry season obviously when fig *Ficus* spp. trees were in fruits. This finding sides well with Basabose results (2005), and emphasizing that chimpanzees used secondary forest for 67.8% of the time, primary forest for 10.5%, swamp forest for 6.6% and bamboo forest for 5.9%; furthermore, the size and distribution of small fragmented primary forests may be an important factor influencing the ranging pattern of chimpanzee at Kahuzi. According to our results, the secondary forests were ideal place where poachers could easily spot and consequently kill chimpanzees. Fortunately, they were less targeted because killing them is traditionally believed to cause misfortune once eaten by people and carries a perceived rise of prosecution. Their fast mobility in escape and the lower demand for their babies for export purpose could as well explain the likely that it could be hunted opportunistically.

According to Amsini *et al*. (2008), chimpanzees' numbers seem to be more stable and may have increased in the high altitude sector but have probably declined to about 40% of the pre-war number from encounter rate data of nests. Other primates seem to have declined but the species observed prior to the war all seem to be present following recent WCS surveys in the KBNP lowland sector.

Growing number of seized chimpanzee pets still shrick for park managers' attention. Indeed, research at other sites has confirmed that this pattern of male philopatry and female dispersal as typical of the species, and more intergroup killings has been observed (Pusey *et al*., 2007). The combination of inter-group hostility and male philopatry has two implications for conservation. First, if neighboring communities become unequal in size, the smaller community is at risk of being exterminated by its larger neighbor(s). Second, this intense hostility towards foreign chimpanzees complicates current efforts to reintroduce captive chimpanzees from to the wild. There are currently 28 chimpanzees and 29 monkeys in captivity at Lwiro sanctuary (Nishuli, 2007) which is a stone's throw away from the KBNP highland sector headquarters. Currently the confiscated eastern gorilla interim quarantine facility in Goma houses 6 Grauer's gorillas and two mountain gorillas (Spelman, 2007). Males of any age, and infants of either sex, still face a serious risk of being attacked if released into areas with wild chimpanzees (Goossens *et al*., 2005; Pusey *et al*., 2007). It is therefore recommended that further ecological research look into the male hostility pattern and female dispersal as typical of the species given suggestions in the offing to reintroduce in the wild current chimpanzees held in captivity both in Goma and in Musanze in Rwanda. Because their food resources are patchy and widely dispersed, chimpanzees require large home range on the order of 30-40 km^2 (Pusey *et al*., 2007). Specifically, other research topics to consider may include testing the impacts of environmental factors on the organization of great apes societies (survival, reproduction rates as well as the demographic impacts of the population's poaching history.

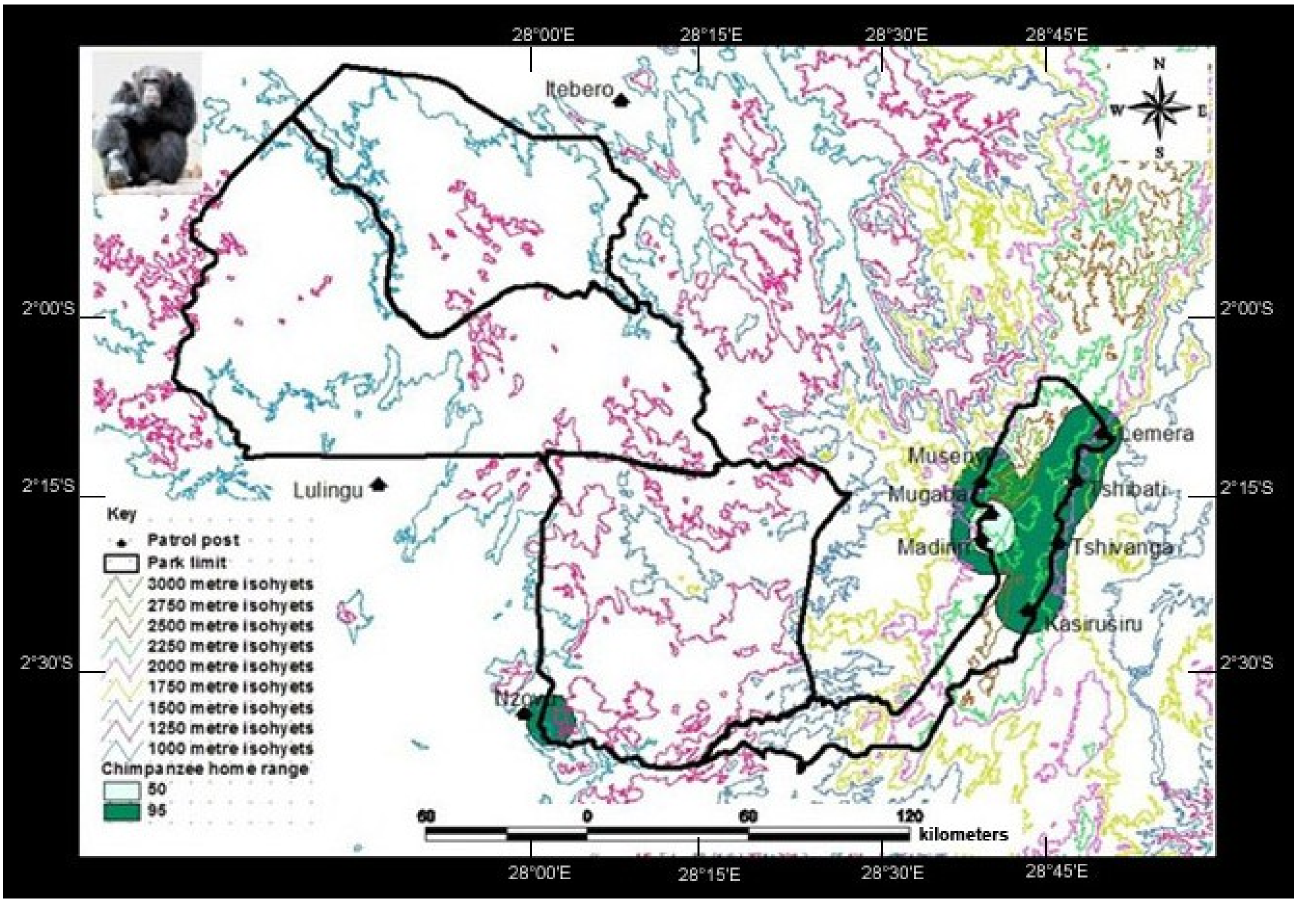
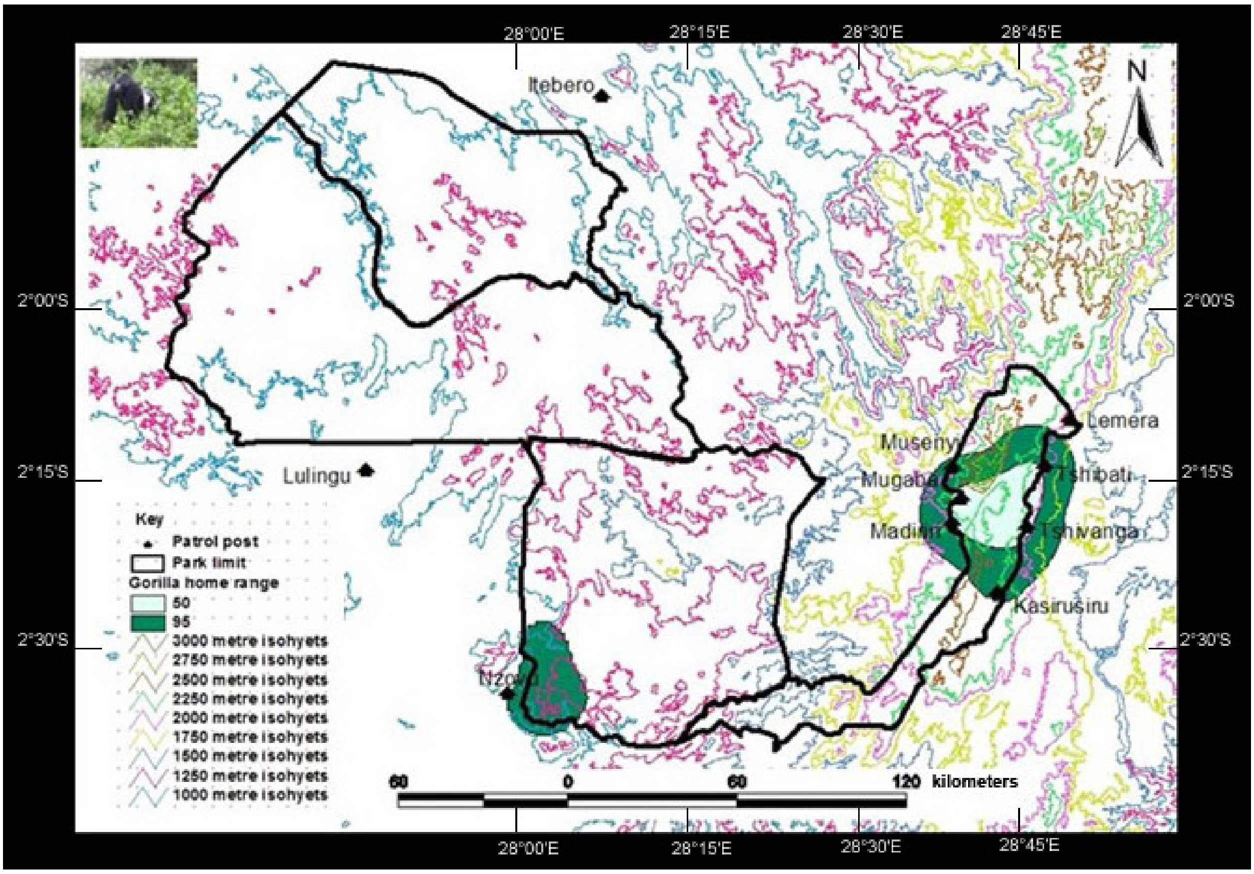


Figure 3. 15. 4. *Chimpanzee home range in Kahuzi-Biega National Park.*

The continuing strife in DRC has prevented thorough biological surveys, but initial reports from KBNP suggest a similar pattern over the last decade. A small population of the rare Grauer's gorilla (*Gorilla beringei graueri*) still persists in the highland sector (**Table 3. 15. 9** & **Figure 3. 15. 5**), where park staff has received support and remained active (Hart & Liengola, 2005). Outside this narrow zone, however, rebel-controlled mining operations, logging, settlements, encroachment, and widespread poaching have progressed unopposed for years, hence, explaining why only 57.8% of the park was controlled. Hunters reported steep declines in the availability of large game, including elephants and gorillas, and conservationists believe these species remain at high risk of extinction (Redmond, 2001). The results of the surveys carried out by WCS (**Table 3. 15. 8**) show that gorilla numbers are down from the previous censuses. In the highland sector a complete nest count method shows that numbers have dropped from 245 in 1996 to 130 in 2000 or 168 in 2004. Surveys in the lowland sector show a drop in encounter rates of gorillas along reconnaissance walks but not greatly when similar areas are compared between 1994 census and the ones between 2004 and 2008 (Hart *et al*., 2007).

However, the limited evidence of poaching within the ranges of more intensively studied gorilla highland sector of the KBNP supports the view that monitoring by researchers' field teams provides important conservation benefits (Pusey *et al*., 2007). Neither of recent biological censuses in the KBNP was able to survey the whole of the highland sector unlike the censuses in 1996 and earlier but they did cover the core areas where gorillas had been found previously (Amsini *et al*., 2008). Therefore there is a need to survey the areas under study with more transects and reconnaissance walks (Recce) once security is fully guaranteed in the park. Camera traps might open new efficient ways to carry out mammal surveys (elephant) over larger areas



***gure 3. 15. 5** Grauer's gorilla home range in Kahuzi-Biega National Park.*

The presence of many of the *Interahamwe* (ex hutu military from Rwanda) and various militia armed groups (usually lumped together as *Mai Mai*) in and around the park (PNKB/ICCN, 2005; 2006; 2007; 2008) has created over 10 years of insecurity. Elephant (*Loxodonta africana cyclotis*) numbers have plummeted and their home range has been reduced (**Table 3. 15. 9** & **Figure 3. 15. 6**). The war has wiped out around 3,700 elephants in the lowland sector and about 700 in the high altitude sector (Amsini *et al*., 2008). Following persistent concern over the extinction of this species, five camera traps were provided and used by WCS to monitor the pachyderm presence in Musisi marshland area and in Madirhiri park management unit. Evidence from 2009 LEM and camera trap data shows that 50% probability elephant home range core area using ArcView 3.3 (ESRI, 2003) was set at 7.4 $km^{2,}$, thus representing an increase of 68.1 % compared to 2.36 km^2 covered between 2004 and 2008. This increase is an indication of the patrol investment in Musisi swamp where these animals were concentrated; since the use by WCS of camera traps in October 2008, the elephant documented home range (**Figure 3. 15. 6**) has spatially extended to include Changulube area near the Madirhiri hot water spring, known locally as *May-ya-moto* reaching temperature as high as 95°C, Musisi bridge, Mugaba sector and Karhashomwa in Kasirusiru sector at he foothill of Mount Biega (PNKB-Tshivanga, 2010). The famous hot water spring which is an indication reminding the region's underlying geological activity supports a highly specialized micro-habitat. The frequent presence of the small elephant population in this area may suggest its habitat preference for alkaline soil where a microflora and microfauna have evolved in this marginal environment alongside algae and sulfobacteria. To sum up, both the small population paradigm and the declining population paradigm should still form the basis for approaches to assessing extinction elephant risk in the park. Populations have been reduced by poachers to paltry about ten individuals (PNKB, 2006) and may not be viable at all.

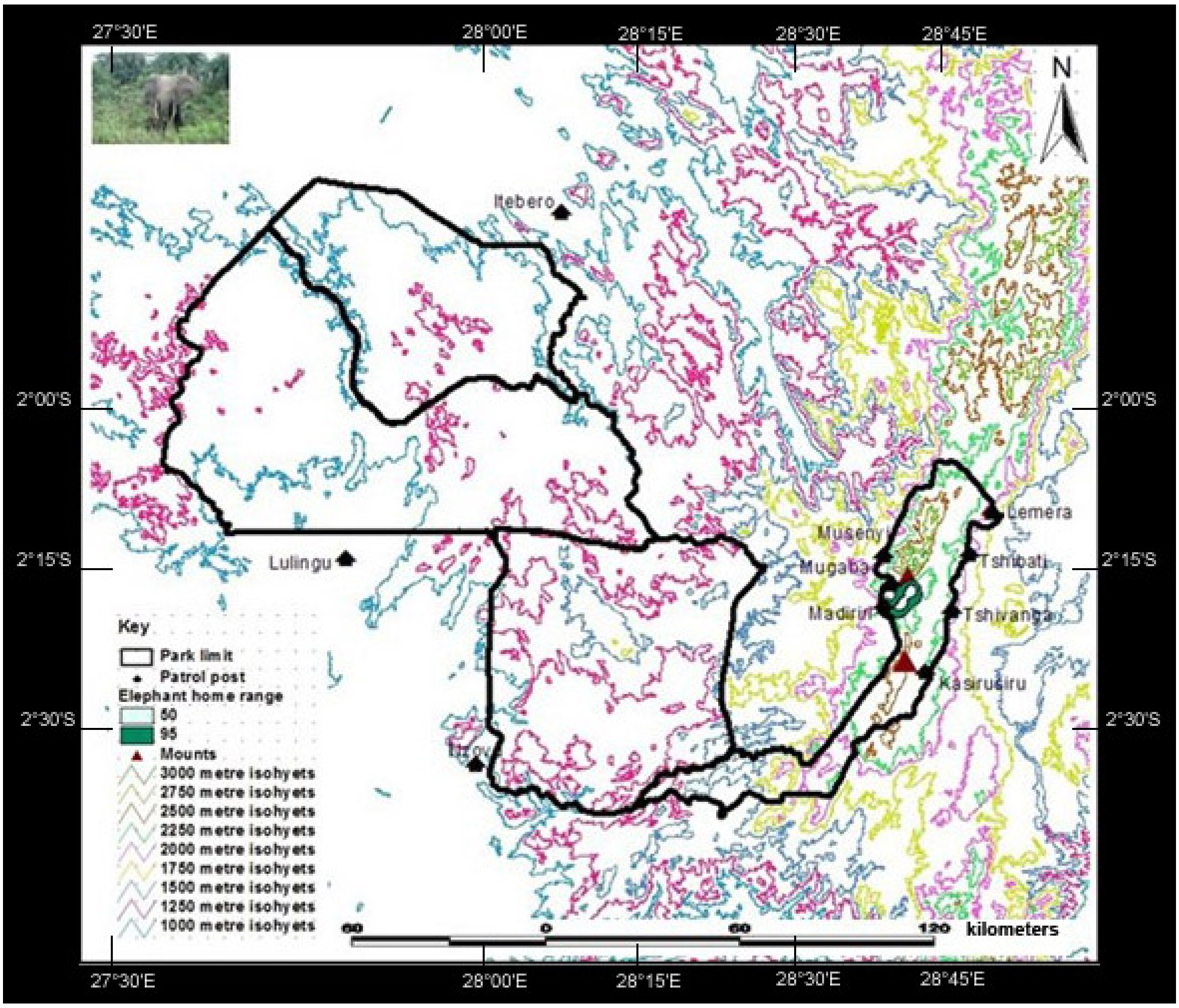


***Figure 3. 15. 6** Elephant home range in Kahuzi-Biega National Park.*

3. 16 The Art of Snaring and Trapping among Local Hunters

Hunting is part of the culture of the people in the forest zone of West and central Africa because wild meat or 'bushmeat' is most important source of protein (Asibey, 1974; Lam, 1993; Wilkie & Carpentier, 1999; Bakarr *et al*., 2001). The fact of the matter is that the community objective is to continue to live, hunt and garden on the traditional lands of their ancestors. With the bushmeat becoming an open access resource available to anyone willing to go hunting, local people exert a high pressure on the exploitation of resources. All poaching events in KBNP and elsewhere are caused by the desire for profit of some kind with the difference being in terms of the scale of profit. There were three distinct types of poaching, including subsistence poaching for bottom line profit of food and basic survival, commercial poaching for mid-level profit and food and trophy poaching for vast profit. There were various different methods of killing the animals, these include: shooting sometimes by heavily armed poachers, pitfalls, net traps, snare, and dog. The use of leg-hold and leg and neck snares, especially cable snares, was widespread in KBNP, and accounted for the extraction of more game species. Why these snare types were preferred amongst others?

Leg-hold snares are simple, cheap and yet highly effective. This method of hunting allows teams of hunters to set many snares per day providing maximum coverage of an area in an effort to catch many animals with very little financial cost, physical exertion or risk of being caught. Professional poachers prefer heavy-duty cable since this minimizes lacerations that would reduce the value of the skin. However, this type of cable requires a substantial investment by poachers and financial constraints thus limit the number of snares that can be set. Brake cable or heavy-duty nylon rope were also used; the advantage being that cheap materials allow for a large number of snares to be set.

In the case of the body and neck snares, two sticks are erected (as large as is deemed necessary from a consideration of any identified spoor) on either side of a path/track. A snare is then made using steel wire or cable. The snare is placed between the two sticks and the end is connected to a solid flexible young tree trunk, which serves as a spring. The tree is selected because of its strength and flexibility. It must be small and flexible enough that it can be bent over to act as a spring for the snare, yet big enough that it can hold the partial weight of the 'victim' suspended in the air once the snare is sprung. Setting the spring usually requires the help of at least two other people to bend the tree over and set the trigger mechanism. An animal walking along this trail would push the wire releasing the trigger. This allows the tree to snap back to its upright position and draws the snare tight around the neck or body of the animal. The tree in its upright position keeps tension on the wire so that the snare does not loosen allowing the animal to escape. The animals have little chance once caught in a snare. The snares were set in many locations and the poachers were killing much more than they can possibly eat. Anti-poaching patrols often come across large animals like duikers that have simply been left to rot in a snare. Poacher's snares killed indiscriminately often trapping valuable and endangered animals.

Cable snares are more durable and easier to maintain as opposed to rope snare because the material is stronger and animals are less likely to escape or break the line. They are also non-selective and capture animals ranging in size from large rats to gorillas. In the past, traps were highly specialized and intricately constructed. Older men in some villages still set a few types of traditional traps using natural materials, such as the "downfall trap" which employs a partially suspended log within a baited or barrier passageway into which an animal walks. Along with square traps of twigs over the exit holes of species burrow, it is now mainly used as a plantation barrier trap to protect crops from porcupines and cane rats, but is also formerly set for animals as large as duikers and bush pigs (Lahm, 1993). "Downfall trap" and other related fierce traps of taut sharpened saplings, ready to spear the flanks of animals which employ a partially suspended log within a baited or barrier passageway into which an duikers and bush pigs walks.

Other examples of indigenous technology include a noose trap (often baited with banana) made of branches and lianas placed on fallen trees to capture rodents, birds, snakes, pangolins (*Manis tetradactyla*) and monkeys and heavy-weighted harpoon traps which were suspended over African buffalo (*Syncerus caffer*) and elephant trails. A variety of camouflaged pit traps were utilized for medium-sized and large mammals. Snaring usually entails hanging a noose of wire over a well-trodden animal path. An unsuspecting animal will run into the noose headfirst; the noose, normally a slip knot, constricts, around the animal's head as it struggles. Snares are usually reserved for smaller animals, but larger species sometimes get wounded or killed by them. The porcupines and bay duikers are nocturnal and are more often trapped than shot. Wildlife managers should, therefore bestow attention to the conservation of all species for a balanced ecosystem and species survival.

The encounter rates for investigations related to firearms recovered varied between 0 and 4 times with the relative efficiency of investigations (ratio) showing peak in 2007 (**Figure 3. 9. 1b**). This efficiency of investigation operations over patrols, in terms of arrests (**Figure 3. 9. 1a**) and recovery of firearms/ammunitions is consistent with Leader-Williams *et al.*(1990) findings in Luangwa Valley in Zambia. Not surprisingly the highest number of snares recovered was observed in 2007 (**Table 3. 23. 1**).

3. 17 *Snaring Practices and"Have-to-eat-today principle*"

Cable snares are probably the most widespread hunting method used in central African forests today to the extent that bushmeat consumption and trade is the greatest threat to biodiversity conservation in African forest regions (Noss, 1998b). Although trapping occurred primarily toward the edge of the park (**Figure 3. 7. 1**), hunting took place through the forest. For species that were only trapped, the center of the forest acts as a refuge from harvesting. By and large, instead of encouraging guards to set up road-blocks or raid market places on random occasions to enforce bushmeat market regulations as pinpointed by Wilkie *et al*., (1998), I rather support Leader-Williams & Milner-Gulland (1993) who suggested that increasing detection intelligence-based patrols is an effective way to reduce illegal bushmeat hunting originating from the park as shown by **Figures 3. 9. 1a; 3. 9. 1b & 3. 17. 1**.

If demand for bushmeat is strong and substitutes do not exist, scarcity of bushmeat will likely drive up prices, which will provide incentives for people to enter the market and seek ways around the supply constraints. They will continue, not surprisingly, to demand wildlife as an affordable and tasty source of meat. Consequently, solutions to the bushmeat crisis must include measures to increase access to alternative sources of protein that are perceived as palatable substitutes and viable alternatives. Small animal rising has been shown to be viable in rural and peri-urban areas that are close to sources of demand, and where proximal species populations have already been wiped out of vast areas (Lamarque, 1995). Yet, if domestic production of meat only becomes economically viable after wild game become too scarce to hunt profitably, the strategy is clearly ineffective as a conservation measure. Reducing demand for bushmeat will require therefore that (i) the price of bushmeat raises relative to alternative sources of meat (assuming that bushmeat demand is elastic), and (ii) alternative sources of meat are produced in sufficient quantity to meet demand at prices comparable to or below of bushmeat.

Bushmeat for the majority of consumers is eaten probably because it has few less expensive substitutes, and is an open access resource available to anyone willing to go hunting. Urban elites may however view bushmeat and particularly the meat of apes, as cultural-heritage luxury item and thus, may be willing to pay a price premium to obtain it. If population growth rates continue at their present levels set at 4% per year (Institut National de la Statistique, 1984), per capita demand remains constant, effective substitutes remain unavailable and bushmeat continues to be an open access resource, it is highly likely that there will be an increasing need for additional farmland to produce stapple foods and for land for building. Even when bushmeat scarcity causes prices to rise and substitutes to be more competitive, hunting will continue in areas where bushmeat capture and transport costs remain comparable to the cost of livestock rearing, or to satisfy whatever demand persists for bushmeat as a high priced luxury item. The bottom line is that poverty and associated "have to-eat-today" principle are often assumed to be the root cause of unsustainable exploitation that precludes a long-term perspective on resource management (Freese, 1998).

Controlling hunting for domestic consumption is likely to be untenable given the size of the area and the importance of bushmeat of local populations. Moreover, hunters have traditionally maintained their popular belief that wild meat is healthier than domestic meat thereby, creating demand for the former. This is a well established fact because ungulates have superior meat with less fat and greater amount of edible protein per unit of live weight than domestic animal (Ledger, 1967). As suggested by Wilkie *et al*. (1998) any attempt at *de jure* control of household bushmeat consumption will likely fail for two reasons: (i) households depend on bushmeat as nutritional staple and are unlikely to relinquish this without considerable pressure or access to substitutes, and (ii) sufficient repression would require large number of trustworthy guards which the park administration cannot afford right now. It should be noted that banning or substantially curbing bushmeat for domestic consumption without providing an acceptable substitute is unrealistic from a cultural and financial viewpoint. This in turn may fuel huge resentment and alienation among the local people, much of which is still felt almost eighty five years later since the gazettement as a national park led to the eviction of several people who had been living in the area since 1925 (Wilkie *et al*., 1998; Baker, 2004), especially when park staff don't have a down-to-earth manner vis-à-vis local people. Open access resources that are exploited for sale at local level markets almost always results in the over-exploitation of the resources (Trefethen, 1975). To ground conservation efforts, it's crucial to explore the "zone of win-win partnerships" (Meffe *et al*., 2002) reflecting the importance of compromise in achieving ecosystem management goals.

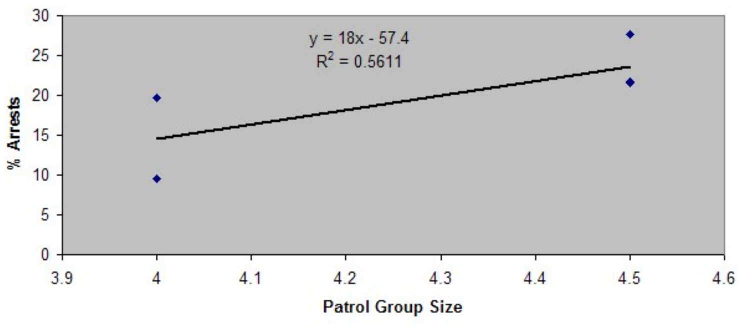


Figure 3. 17. 1 *Relationship between patrol group size and the percentage of offenders arrested during successful encounters in the KBNP.*

3. 18 Snaring Pressure and 'Empty Forest' Syndrome

Wildlife utilization through cable snare hunting is perhaps the greatest conservation threat of economic and development activities in African forests (Brashares *et al.*, 2001). Although snares were indiscriminate on broad scale, there were more small wire snares (in highland sector) and rope snares (in lowland sector) collected (PNKB, 2006; 2007) compared to larger ones suggesting that hunters targeted more small bodied mammals; as the species preferred in trade were extirpated from local areas, hunters shifted to less preferred species thus, supporting the 'empty forest' syndrome ominously described by Redford (1992). Furthermore, the eclectic nature of the hunt means that populations of a wide range of large mammal were affected and will likely continue to wink out.

Duiker, rodent, primate and pig were the most commonly hunted groups of animals in the forest, with rodent and primate both numerically and in terms of biomass being the most important bushmeat markets. Rodents gain an importance in mature (e.g., long established) markets, presumably because slow reproducing primates and large duikers are being wiped out in accessible forests. The Fa *et al*. (2005) study also shows that, as expected, hunters are most likely to be active in areas with most game. Heavily hunted areas had, on average, smaller prey, with mounting evidence of depletion of larger-sized animals. As a corollary, there is a higher proportion of ungulates extracted in lightly hunted areas, but more rodents in the more heavily hunted sites (Fa *et al.*, 1995; Fa *et al*., 2000; Fa *et al*., 2001).

Bushmeat is a cultural preference especially in park lowland sector region and there was evidence of town-dweller consumers' willingness to pay a price premium over domestic meat for the privilege of eating bushmeat. More evidences suggest simply that wild meat is often the only source of animal protein available and cash across in the tropics (Bennett & Robinson, 2000) and tends to be cheaper than domestic substitutes. As large species vanished, people more and more turned to hunting smaller ones, such as squirrels or cane rats (Bennett *et al*., 2002), including the giant pouched rat (*Cricetomys emini*), Gambian rat (*Cricetomys gambianus*), African brush-tailed porcupine (*Atherurus africanus*), mountain sun squirrel (*Hebomys univitatus*) and Zenker's flying squirrel (*Idurus zenkeri*). The traveling time required by trappers means that it was rarely worth to set traps more than 1 or 2 km from the park limit (**Figures 3. 9. 2. 1a & 3. 9. 2. 1b**), thus explaining snaring pattern near patrol posts (**Figure 3.7. 1**).

Furthermore, in areas where larger species have been severely declined, poachers would extract fewer of the targeted larger blue duiker (*Cephalophus monticola*) and more of the smaller species, including the cane rate (*Tryonomys swinderianius*). As suggested by Eves & Ruggiero

(2000), rodents only become important prey items in disturbed areas. The fecundity of prey communities might also affect hunting sustainability, and vary across different park management areas. To side with Fa *et al*. (1995), the view is quite widely held in Africa that disturbance-tolerant rodents and duikers are highly fecund and can provide a substantial offtake from secondary forest (Wilkie, 1989). These results are consistent with Milner-Gulland *et al.* (2003b) which found that large ungulate species most threatened by hunting are rarely seen in markets, because they are already at very low population densities in the park. The declining wildlife population (**Table 3. 15. 8**) supports the evidence that poaching is an ever growing epidemic that plagues the KBNP. As the demand for bush meat increases to meet the needs of the ever increasing population, one might expect to see a sharp decline in the remaining large mammal densities adjacent to human settlements (**Figure 3. 22. 1. 2**). Therefore conservation efforts are imperative to counter such trends in the near future. Increased patrol effort with 12 staff per patrol post following the military Strategic Deployment Models (Tucker, 2003) and current security context might increase current average of 4.2 ± 0.8 guards on patrol deployment by boosting patrol post effectiveness and filling seasonal troughs, thereby providing better-all-round surveillance in large areas, especially when offenders involved in illegal exploitation and land grabs find that the park provide easy takings. Such figure has been documented in Garamba National Park in northeastern DRC where patrols were carried out by teams typically ranging from 10 to 20 armed guards and more recently, patrols of over 30 guards have been used in response to the increased size and fire power of organized poaching groups (Hillman-smith, 1997; de Merode, 1998).

Given the urgency of the crisis, and the geographic distribution of crimes, immediate action is needed. But one also needs research and monitoring, to ensure that actions taken are having their desired effects. Understanding which factors influence the sustainability of hunting and determining the effects of current harvesting levels, including the index of catchability of hunted fauna remains a priority for future research. In this regard, combining long-term surveys of markets, households and wildlife populations is necessary to capture the whole picture, enabling researchers to predict how offtake can be made sustainable. In the same line of thought, bio-economics modelling can also predict the effects of policy interventions in a way that might be impossible from field studies alone. Successful solutions to the wild meat crisis involve multi-disciplinary approaches, and the full integration of the conservation of natural resources into development agendas at the local, national and international levels. As Sustainable Northwest (1997) points out “If we function by conflict and competition, there will be winners and losers; but if we work together, we can create a new way of doing business. The cases reviewed hold this is not naïve idealism.

3. 19 Elephant Poaching Crisis as a Bioindicator of General Health and Rainforest Ecosystem

Historically, the KBNP had one of the largest and most diverse wildlife populations in DRC. Hall *et al*., 1998 estimated at 3,700 elephants for the lowland sector of the park and about 700 in the highland sector (**Table 3.15.8**). The elephant population has shrunk dramatically since the mid-1990s and during the last decade this decline has gathered speed to the point that the species has virtually vanished from many regions in the lowland sector of the park. Only small isolated population still survives in the highland sector. The documented demise of elephant during DRC's recent civil unrest represents the largest episode in a cycle of killing since the end of the 19^{th} century.

For 50% kernel home range (**Table 3. 15. 9; Figures 3. 15. 4, 3. 15. 5 & 3. 15. 6**), elephant had the less core home range (2.36 km^2) as opposed to gorilla (31.15 km^2) and chimpanzee (10.57 km^2), thus implying the necessity to direct law enforcement to WCH where elephant adopted a siege strategy incurred by human pressure. With respect to chimpanzee distribution, these results compare quite well with Basabose (2005) finding on KBNP chimpanzees which indicate that Kahuzi chimpanzees used their home range (12.81 km^2) in a clumped pattern, frequently visiting the core area and only rarely entering the peripheral areas. However, because their food resources are patchy, widely dispersed chimpanzees should require much larger home range, on the order of 30-40 km^2 (Pusey *et al*., 2007). In addition, although slightly different as far as gorilla spatial distribution is concerned, the study results fit well into Mühlenberg *et al*. (1995) figure of approximately 35 km^2 occupied yearly by gorilla group.

While the siege strategy might reduce the risk of poaching, it will likely result in loss of access to widespread food resources, reduced quality and increased feeding competition promoting aggressive social interactions with negative consequences for social cohesion and reproductive success which ultimately reduces population size (Wittemyer *et al*., 2007). In addition, the siege strategy may increase the isolation of small sub-population and reduce the genetic fitness and health status of small populations potentially increasing in the probability of extinction (Wilcox & Murphy, 1987). Finally, the restricted movement of besieged elephants may increase the destructive impacts of over browsing on local vegetation (Van Aarde & Jackson, 2007), and reduce the effectiveness of forest elephant mediated seed-dispersal (Chapman & Onderdonk, 1998). A poorer reproduction rate coupled with lower density of elephants renders these more vulnerable to over-exploitation. The catastrophic plight of the elephant population mirrors particularly well what might happen to other keystone species in the park, including the Grauer's gorilla as the pillar of wildlife viewing tourism. Building upon the single elephant crisis case in the KBNP, the study results stand in contrast to those of Inogwabini (2000) findings, and rather highligh the potential of basing conservation strategies for an entire area on a keystone-dependent bioindicator species, such as elephant and Grauer's gorilla charismatic species who remain key to the long-term existence of the park, and essential source of revenue for the local and national economies.

Under current harsh conditions, a combined strategy of collaboration with traditional chiefs and ongoing park protection through a very substantial investment of conservation funds might make the park both less expensive to manage and more effective in achieving conservation goals. Yet grave though the situation is, it is by no means hopeless and recovery still seems possible provided that anti-poaching measures are stepped up and people are educated and provided with alternative sources of protein.

3. 20 Human Pressure and Insecurity: A Tremendous Challenge to Protection Effort

In areas where armed fighting frequently occurred, large mammals were often hunted on a major scale to feed troops, and this had a devastating impact on wildlife populations. Larger species with low reproductive rates were particularly vulnerable. Commercial extraction of resources such as timber, ivory, coltan and gold often occurred to raise funds for military supplies and activities, and PAs was prime targets. The exploitation of valuable resources and availability of weapons were parts of a vicious circle which enabled armed groups to maintain control over source areas, resources and illegal trade networks. Proliferation of arms from conflicts often results in escalation of bushmeat trade; the influx of automatic weapons into the region following the periods of intense conflict around park headquarters was said to have broadened local involvement in the bushmeat trade because a wide range of men were able to access these weapons and substantially increase their harvests (de Merode, 1998). Local communities have suffered extremely as a result of the war and were heavily dependent on the natural resources of the PAs for shelter and subsistence. In KBNP, many people from the surrounding villages were forced to hide in the reserve for protection.

Figure 3. 20. 2 shows that most higher density of emptied poachers' camps were found near the park boundary in the highland sector implying that offenders were well aware of park guards' deployment strategy. Poachers' camp density pattern was different in Nzovu lowland sector where offenders rather carried on hunting activities far from the headquarters. The very limited number of fourteen staff based at Nzovu headquarters coupled with poor equipment (10 weapons holding only 149 ammunitions), 4 tents (one in bad shape) and 3 GPS (PNKB-Nzovu, 2006, 2007) and the ongoing insecurity situation are the major factors explaining the poor performance of the staff in dismantling widespread hunters' camps in Nzovu park management unit.

KBNP was and is still being used as a safe haven and refuges for armed bandits involved in conflicts and therefore tend to be in the centre of military action. Even when field staff can be trained to adapt higher levels of threat, it will be impossible to secure the PA without active cooperation from military authorities. However, the military themselves often constitute a major threat to the natural resources of the area, since many armed groups tended to exploit natural resources for subsistence and profit all the more so since the mining was exploited in the park, with the wildlife as the chief food source. It is therefore crucial to try to develop a positive cooperation with the military authorities, without however scarifying the neutrality of the PA administration in relation to the conflict. Such cooperation should be developed at both the local level (local military commanders) and at the very high level of military decision-making. Where specific mixed or trained operations are to be carried out with local people, clear-cut agreements will need to be signed to define the limits of their interventions and avoid it getting out of hand. Parallel to these activities, it is important to continue organizing an international information campaign such as the blog developed in Virunga by Wildlife direct on the impact of the conflict on the conservation status of the site. International attention can increase significantly the willingness of the authorities to support the willingness of the authorities to support PA conservation activities (Debonnet & Hillman-smith, 2004).

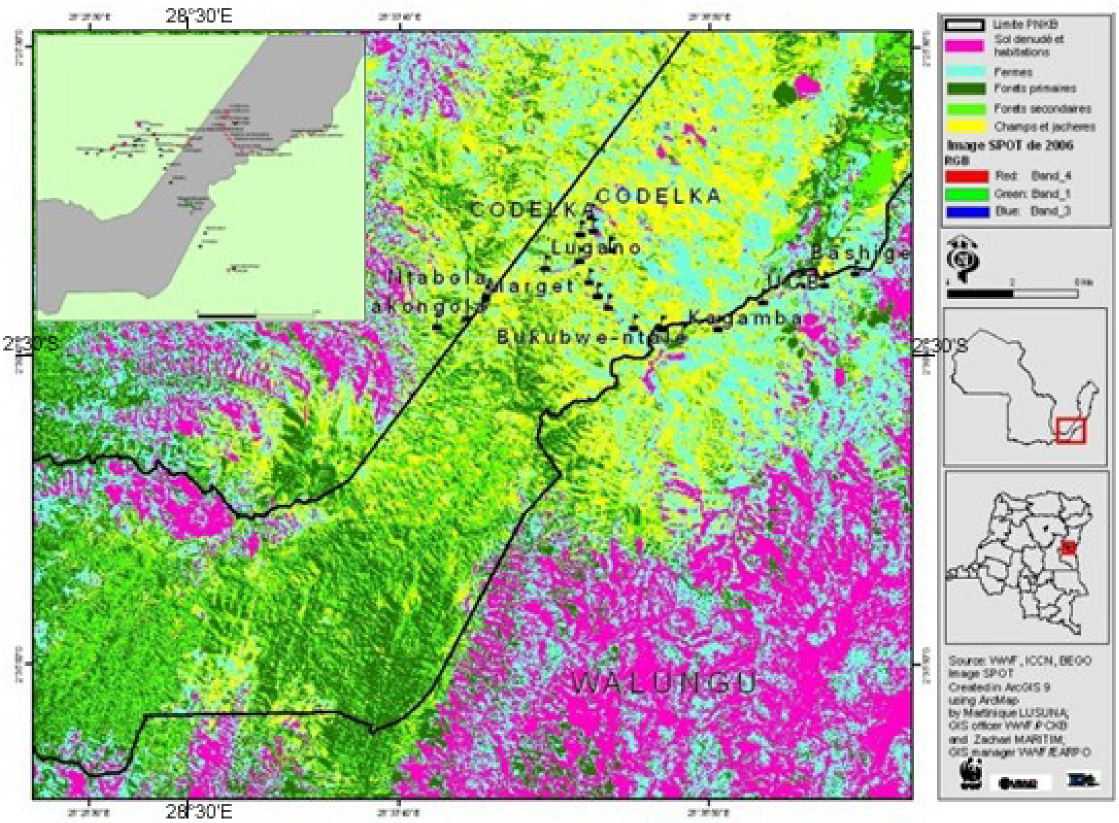


Figure 3. 20. 1 *Spatial analysis of the Nindja ecological corridor (Source: WWF, ICCN, BEGO).*

Large areas of the park between Nzovu and the highland sector have small settlements and villages with associated farming taking place. The increase in human impacts on the park is particularly important in the southern-central region around Nzovu and Idunga regions. Human settlements have grown here with three villages of at least 100 people now within the park. This part of the park is most at risk of being lost together with the Nindja corridor (**Figure 3. 20. 1**) that links it to the rest of the park. While it is probably not possible to remove all the people here from the park (given that some of the villages pre-date the creation of the park) there is a need to work with the people to zone the region (following **Figure 3. 22. 1. 1**), and reduce the number of satellite camps and settlements and then develop land use plans for the region around the villages within the park (Amsini *et al*., 2008). Not surprisingly, areas in lowland sector with high faunal indices also had higher frequencies of hunting signs, suggesting that hunters continue to seek areas where highest returns ca be expected. Frequencies of snares set for small mammals such as porcupines indicate nevertheless that populations of larger species preferred by hunters may be wiped out in some areas of the park (Hart *et al*., 2003; Hart *et al*., 2007).

The expansion of crop and livestock represents a direct threat to the forests in the corridor. Already the forest corridor linking the highest and lower parts of Kahuzi-Biega National Park has been completely opened up and the continuous immigration of people from the high-altitude to low-altitude is increasing the level of current threat (CBFP, 2006). Although patrol teams could not reach this area due to insecurity, analyses of the 2006 and 2008 SPOT image by WWF-PCKB (2009) indicate that the forest degradation varied between 10 and 24% between 2006 and 2008 with major adverse effects in the area southern of Kabona included within the Nindja corridor as well as Chirambo with 3,000 inhabitants (PNKB, 1998; PNKB, 2008) and Kabukiki settlements (**Figures 3. 12. 1**). Pastoralists also graze their cattle in this area and maintain temporary settlements, some hardwood extraction and very limited non-mechanized gold mining also occurs in the areas, especially in Kakundu and areas surrounding Chulwe and Mwegerera settlements (**Figure 3. 12. 1**).

Habitat fragmentation documented following **Figure 3.20.1** as a frequent habitat loss (Wilcove *et al*., 1998), is a primary threat to population and species in Nindja corridor because isolated subpopulations are expected to experience reduced population viability and ultimately greater risk extinction (Hilty *et al*., 2006).

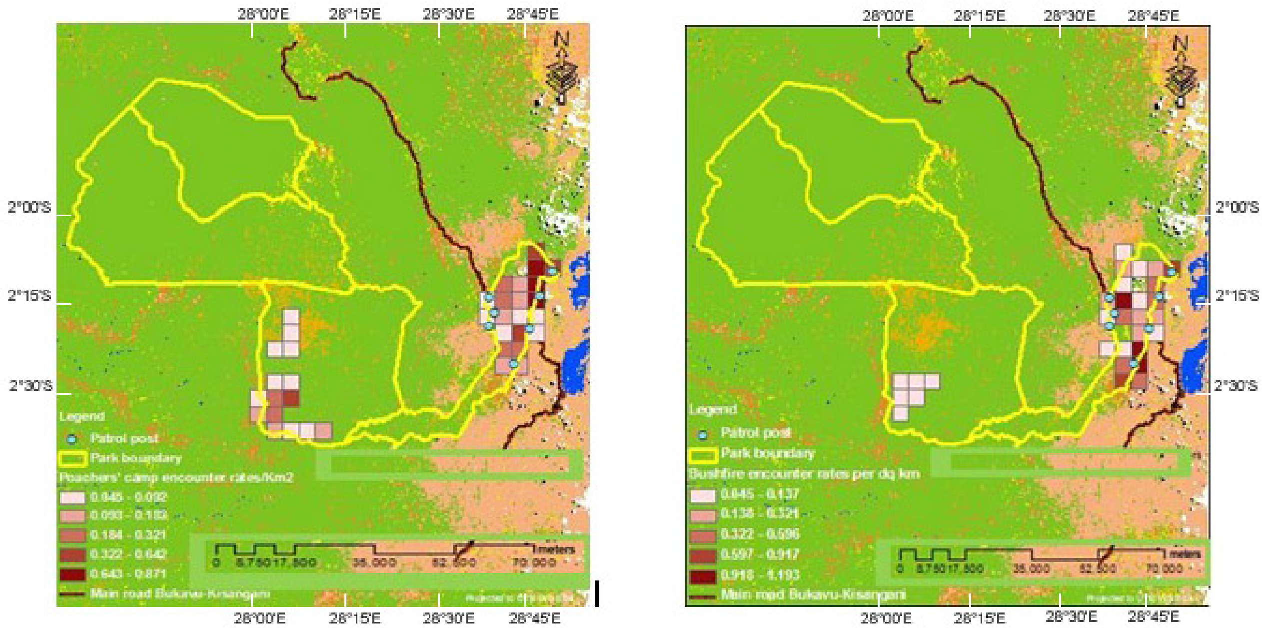


Figure 3. 20. 2 *Poachers'camp and bushfire encounter rates in Kahuzi-Biega National Park.*

The narrow corridor linking the highland to the lowland is occupied by numerous farms and plantations, especially in Kalubwe (3,300 ha), Mulume-Munene (2,550 ha) and Lushanja (832 ha) blocks. These areas were deemed appropriate for agro-pastoral activities by the local communities and past attempts to remove or limit their occupation has always resulted in fierce opposition. The migration of wildlife which used to take place in the dry season between Mulume-Munene block and the Mount Biega (2,709 m) does not longer happen due to human incursions. In addition, the demand for firewood and charcoal in this area has resulted in severe deforestation. It has been estimated that around 10,000 sacks of charcoal are sold in the northern part of Kabare territory each year. This represents about nearly 1,700 trees and corresponds to over 90 ha of deforested land in the corridor (DFGF, 2003). Charcoal kilns were basically found in the eastern park boundary in highland sector (**Figure 3. 7. 2**) where literally thousands of trees had been cut, hence depicting how far the park boundary has been increasingly squeezed.

In sum, as a consequence of the political instability in the region, the KBNP has faced general lawlessness and banditry, including that by the *Interahamwe* (calling themselves the FDLR – Forces Démocratiques pour la Liberation du Rwanda), various militia armed groups resulting in the KBNP being currently ascribed as a "World Heritage Site in Danger" since 1997.

3. 21 Coltan Boom and Park Invasion: Gun, Gold and Greed

The coltan boom that hit the KBNP between 2000 and 2002 has made the exploitation of the coltan deposits prosperous for the local communities around the park. The coltan is a contraction of Colombite-tantalite, two oxide minerals of the metals niobium and tantalum that often occur in association. Tantalum metal is ductile, easily fabricated and good conductor of heat and electricity and has a high melting point. Tantalum passive capacitors are found in many everyday devices such as mobile phones, video cameras, sonny play stations, personal computers, and automotive electronics.Such multiple scheme applications prompted its exploitation at the height of the war.

From 2000, a price rise, rebel militias and lack of central government control created gold rush conditions, the profits funding the rebellion. Airstrips and dozens of mines were started, attracting more than 10,000 miners to the park which led to massive hunting for bushmeat and ivory, drastic deforestation and social destruction, and ruthless control by well armed gangs. On average, a miner could produce a kilogram a day. Back in 2000, the price was raised to the tune of $US 80, a remarkable bounty in a region where most people lived on 20 cents a day. Since than plundering, looting, racketeering, and criminal cartels with worldwide connections have become commonplace in the park and represent the next serious security problem in the region although today these miners make very little and fectching between $US2.5 and $US12/kg providing it is not simply confiscated from them by the soldiers and/or guards before they get a chance to sell it (DFGF, 2003). Drawing on a dearth of empirical evidence, this study suggests that trade militarization is a symptom of conflict rather than its cause, and therefore asks policy makers to address the real causes of insecurity in Eastern DRC, including the park's mineral wealth which was implicated as contributing in the violence. This portrayal matches accounts that have explained the conflict in the DRC as a consequence of various actors trying to accumulate wealth, often through the exploitation of natural resources and control over informal trading activities (Keen, 1998). The three 'T' metals: tantalum (coltan), tungsten (wolframite), and tin (cassiterite), as well as gold, have all been portrayed as being at the root of conflict dynamics (Global Witness, 2008).

Within the KBNP coltan is found in existing streambeds and in fairly soft rock of alluvial and alluvial deposits. The miners have no geological knowledge and only dig where the deposit outcrops on surface. Therefore many deposits are inefficiently exploited. The artisanal miners simply cleared the areas of vegetation and excavated the mineral bearing gravels. The miners dug with shovels, sometimes with picks and crowbars to loosen the substrate. The loose gravel mix was then concentrated by passing in through a sieve washing the product in a bowl or more commonly passing it through a crudely constructed sluice box or piece of curved *Eko* bark until only the heavy coltan particles remain. As shown in **Figure 3. 21. 1**, these artisanal mining occurrences were common in Katasomwa-Nyawarongo (extreme northern part of the highland sector in Lemera park management unit), Tshibati, Kakundu in the corridor and in the extreme western Nzovu lowland sector (Hewa bora, Kosovo, Kakili, Migelo and Masingu).

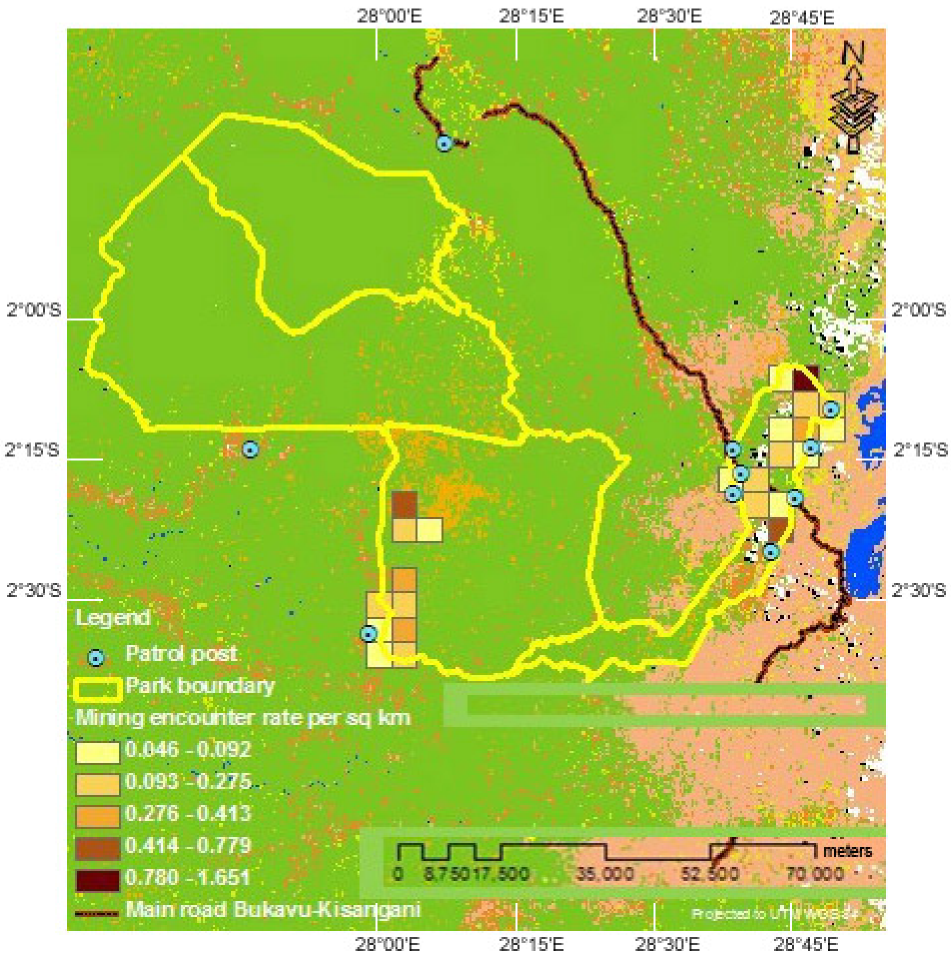


Figure 3. 21. 1 *Map showing the mining encounter rates in the KBNP.*

Small-scale gold panning continued at scattered locations throughout the park. Most sites visited were worked by fewer than 10 miners, and forest clearing and stream degradation were minor in most cases as compared to 2001 when coltan mining was widespread phenomenon across some selected sites in the park. A number of these mining camps served and still continue to act as a base for heavy armed hunters. As can be seen from the map (**Figure 3. 21. 1**), there was a clear overlap between the patrol posts location and mining occurrence suggesting that there was no evidence for the wildlife Act effectiveness aimed at preventing the exploitation of natural resources.

One of the biggest challenges facing the government will be how to control and monitor the smaller scale, but very widespread mining activities for gold, coltan, cassiterite, etc., much of which is taking place in the KBNP (**Figure 3. 21. 1**). Two key issues will need to be addressed. First, many of the ongoing mining operations are illegal but are controlled by military and/or rebels and bandits. This is essentially a security and law and order issue that must be addressed within the framework of the current DRC's demilitarization and disarmament strategy. Second, the mining map shows clearly the extent to which mining concessions overlap within the park, including e.g., Twangiza Mining (241 square units - S3/28 Bukavu delivered on 17/12/1998 and to be exploited up to 18/09/2016) and Sakima sprl (51 square units - S2/27 Obaya delivered on 04/04/1969 and expired date fixed on 03/04/1999 but still active) as per SYGIAP (2006c) report. Attribution of exploration and exploitation permits in PAs should be suspended until Environment Code has been adopted to clarify the current legal ambiguities with respect to mining exploration in PAs. Natural resources have historically brought little to Congolese people; the product of poor mineral governance is suggested as part of broader governance weakness (Garrett & Mitchell, 2009).

Recalling Decision **30 COM 7A.6**, adopted at its 30th session in Vilnius, 2006, the WHC has already taken the Decision **31 COM 7A.5**, adopted at its 31st session in Christchurch, 2007, and expressing its concern about the map produced by the Ministry of Mines, showing that mining concessions were granted inside the property; it further calls on the holders of any concessions to respect international standards with respect to mining in World Heritage properties, as outlined in the International Council on Mining and Metals Position Statement on Mining and PAs in 2003, and also urges the State Party to immediately revoke any concessions that might have been granted, as mining operations are incompatible with the World Heritage status of the property. informed estimates suggest that the Congrès National pour la Défense du Peuple (hereafter CNDP) earns up to 15% of its revenue from the mineral trade; the FDLR up to 75% (most of it from unquantifiable and uncontrollable gold mining and trade); and the FARDC's 85th brigade up to 95%. Such militarization of the mineral trade makes it a special case in the complex security construct in Eastern DR Congo (Garrett & Mitchell, 2009).

"One of the tools for improving the conservation of WHS is the In Danger List. It is regrettable that In Danger List is not being used as it was intended. The Convention envisaged it as a list of threatened sites that required major operations and for which assistance had been requested. It was meant to be a published priority list of projects with cost estimates that could be used to mobilize international cooperation and major donors. To my knowledge, the In Danger List has never been used in this way. Instead, it is perceived as a black mark, a criticism to be avoided at all costs. It has become a poltical tool to get the attention of States Parties. In the final analysis, the negative aura around the In Danger listing process means that the In Danger List is far from capturing the full extent of seriously endangered sites. As a result, it is not being used as an effective conservation tool to identify needs and set priorities for investment in conservation. World Heritage Sites are therefore subject to further degradation". This introductory statement from Professor Chrsitina Cameron to the IUCN compendium (Badman *et al*., 2008) fully epitomizes the conservation status of the two WHS under consideration in this thesis.

Table 3. 21. 1 *Summary of Law enforcement effort statistics (2004-2008)*

	2004	2005	2006	2007	2008
Amount of patrolling					
Number of Patrols	2631	3228	4068	3859	1484
Number of Patrol days	2694	3330	4115	4037	1539
Effective patrol man-days per km²	17.72	22.43	34.32	24.73	9.9
Effective investigation days	132	151	0	13	0
Staff	66	101	108	122	126
Number of Effective patrolling guard	46	81	88	102	106
Coverage (km²)	1250	1400	1500	1800	1550
Frequency of offences					
Elephant killed	1	0	0	0	0
Gorilla killed	0	0	0	0	0
Chimpanzee	0	0	0	0	0
African buffalo	0	0	0	0	0
Porcupine	1	2	1	2	3
Rodent	4	7	1	2	4
Duiker	3	2	2	3	2
Firearms confiscated	2	1	1	6	0
Snaring	1248	2675	475	2434	1877
Wood collection	572	625	44	114	35
Poacher's camp	28	78	48	15	132
Mining	222	81	1	88	58
Bamboo cut	62	6	1	0	10
Wild fire	351	280	15	61	58
Encroachment	83	78	48	19	125
Results					
Arrests	122	42	87	95	96
weapon seized	2	1	1	6	0
Ammunition seized	0	0	25	165	0
Ivory recovered	0	0	0	0	0
Encounter	1	0	0	0	3
Encounter rates of serious offences per 100 effective patrol man-days/km 2- CPUE					
Elephant killed	0.08	0	0	0	0
Gorilla killed	0	0	0	0	0
African buffalo killed	0	0	0	0	0
Porcupine	0.08	0.142857	0.066667	0.111111	0.193548
Rodent	0.32	0.5	0.066667	0.111111	0.258065
Duiker	0.24	0.142857	0.133333	0.166667	0.129032
Snaring	99.84	191.0714	31.66667	135.2222	121.0968
Wood collection	45.76	44.64286	2.933333	6.333333	2.258065
Encounter	0.08	0	0	0	0.193548
Poacher's camp	2.24	5.571429	3.2	0.833333	8.516129
Firearm confiscated	0.16	0.071429	0.066667	0.333333	0
Encroachment	6.64	5.571429	3.2	1.055556	8.064516
Expenditure					
Total patrol cost (US$)	549426.7	36990	267452	489268.5	365858
Cost of patrol per guard per year	8324.647	366.2376	2476.407	4010.398	2903.635
Patrol day expenditure per km²	236.211	30.19592	104.8831	301.0883	271.0059
Cost of effective investigation days per km²	0.558822	5.000676	0	0.043177	0

3. 22 Park as a Sensitive and Threatened Island Ecosystem in a Human Sea of Subsistence Cultivation

For the past three decades, the KBNP has formed a major focus of conservation efforts across the South Kivu province, with a tenfold increase in the size of the PA since its creation in 1970. The KBNP is one of the most densely populated areas of the country, surrounded by over between 297.0 - 412.1 people per sq. km (Mubalama, pers.comm.), some 90% of whom depending mainly on agriculture (Basabose & Yamagiwa, 1997) It is surrounded by plantations and cultivation on 70% of its boundary where the human population has sustained a 4% growth rate (Inogwabini *et al*., 2000).

As stressed throughout the foregoing discussion, the most significant threat is the burgeoning human population's overriding need for land with the agriculture being already or rapidly becoming the man land-use (Mc Neely & Scherr, 2001) and thus, one of the greatest threats to the park. As a result, there exist a substantial empirical overlap between park and human land use around the region, leading to the fact that park landscapes are largely characterized by biological and socio-political dilemmas not found elsewhere. Seven separate tribal groups, originally some 9,000 people, lived in and around the park including the Bashi, Barega, and Batembo people (Musiti *et al*., 1997). Slash and burn farming and tea (*Camelina sinensis*) growing occur on the forest margins. Banana (*Musa sp*) beer is locally important, and the demand for land for banana plantations was very high, as it is also now for cattle rising. Fifteen existing villages of shifting cultivators, and mining settlements for gold, cassiterite and coltan were located in the western part of the park (**Figure 3.21.1**).Local people were not consulted when the park was created (Mugangu, 1997). The indigenous populations were simply pulled out of the KBNP in 1970s and received no compensation. Not surprisingly, they continue to hunt in the park; and most are camped wretchedly on the shore of Lake Kivu.

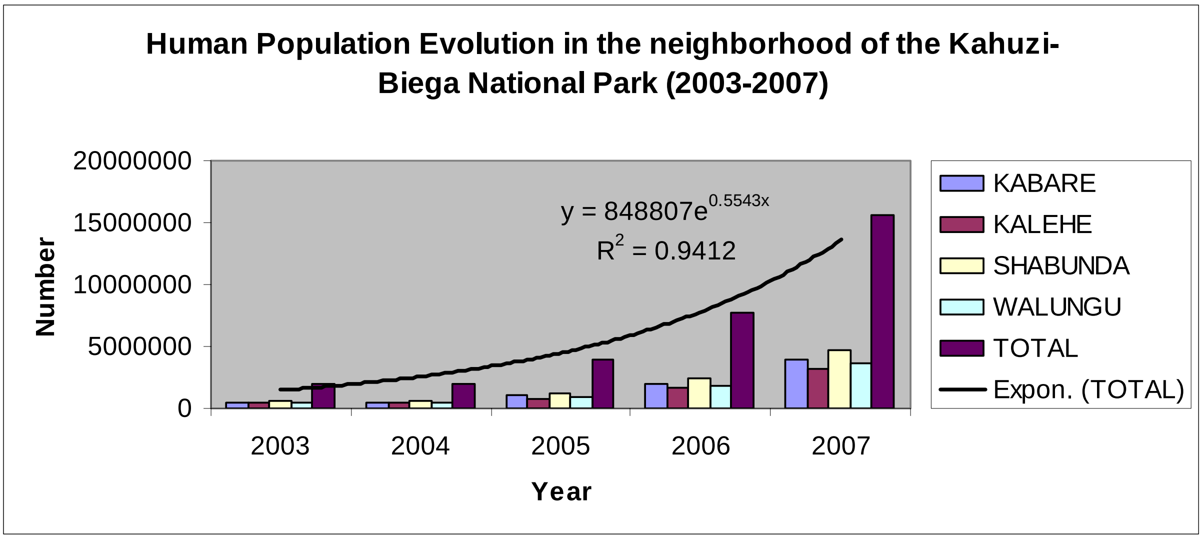


Figure 3. 22. 1 *Human population evolution in the neighborhood of the Kahuzi-Biega National Park (2003-2007).*

The KBNP and surrounding areas experienced changes to its natural environments that were unprecedented in historic times. The past decade has seen steady increase in human population growth on the borders of the park (**Figure 3. 22. 1**), suggesting that the park attract, rather than repel human settlement. Higher trend in human population growth on the park edges is evident across the studied park management units. This finding links population growth around KBNP to habitat loss and suggests settlement around PA may create a ring of disturbance that isolates the park from surrounding habitats (Wittemyer *et al*., 2008).

Forest reconnaissance in 2004 shows human sign density of 1.35 per km (Liengola, 2005) made of machete cuts and human trails, evidence of small-scale mining, poachers' camps (**Figures 3. 20. 2 & 3. 21. 1**) with large drying racks for meat in KBNP. Building upon demographic data in **Annex 10** provided by the local government administration in charge of home affairs (2003; 2004; 2005; 2006 & 2007), I estimated the human density in the park neighbor area to be set at 363.8 inhabitants per km^2. Bukavu population estimated to 225.431 inhabitants (Mediaspaul, 2007) with a human density estimated to 3.757,18 inhabitants/km^2 along with other cities surrounding the park (**Figure 3. 22. 3).** Increasing poaching pressure resulting from dense human settlements (**Figure 3. 22. 1**) may explain why more than 60% of the highland sector was threatened (Inogwabini *et al*, 2000). This scale of human settlement around the park is a strong predictor of illegal fuelwood and mineral exploitation, bushmeat hunting (Brashares *et al*., 2001), fire frequency, and more generally species extinction within PAs (Wittemyer *et al*., 2008).

There is a need to start building patrol posts in the lowland sector of the park taking into account the human population distribution (**Figures 3. 22. 1 & 3. 22. 2**) so as to increase patrol coverage with appropriate equipment. From that prospect, it's recommended that four proposed patrol posts be set up, these include: Lwamba on the Lubimbe River; Tope tope in the northern part of Luyuyu village; Lubimbe in Luhago groupement on the limit between the highland and the Nzovu lowland sectors and Idunga in Iregabarhonyi groupement straddling Kalonge, Nindja and Shabunda and Tchibinda (**Figures 3. 12. 1 & 3. 22. 3**). Once linked with the conflict resolution process, one could hope to reduce the friction between the local communities and ICCN staff and this could allow patrols to start to take place in areas that have never been patrolled. Such link has happened in the western coast of Lake Edward in VNP where previously guards were attacked if they tried to visit the place. Moreover, the rapidly increasing human population coupled with the insecurity could foreshadow the doom of otherwise viable populations of gorillas. Against this background, efforts must be made to ensure that large mammals are not adversely affected by the increased human use.

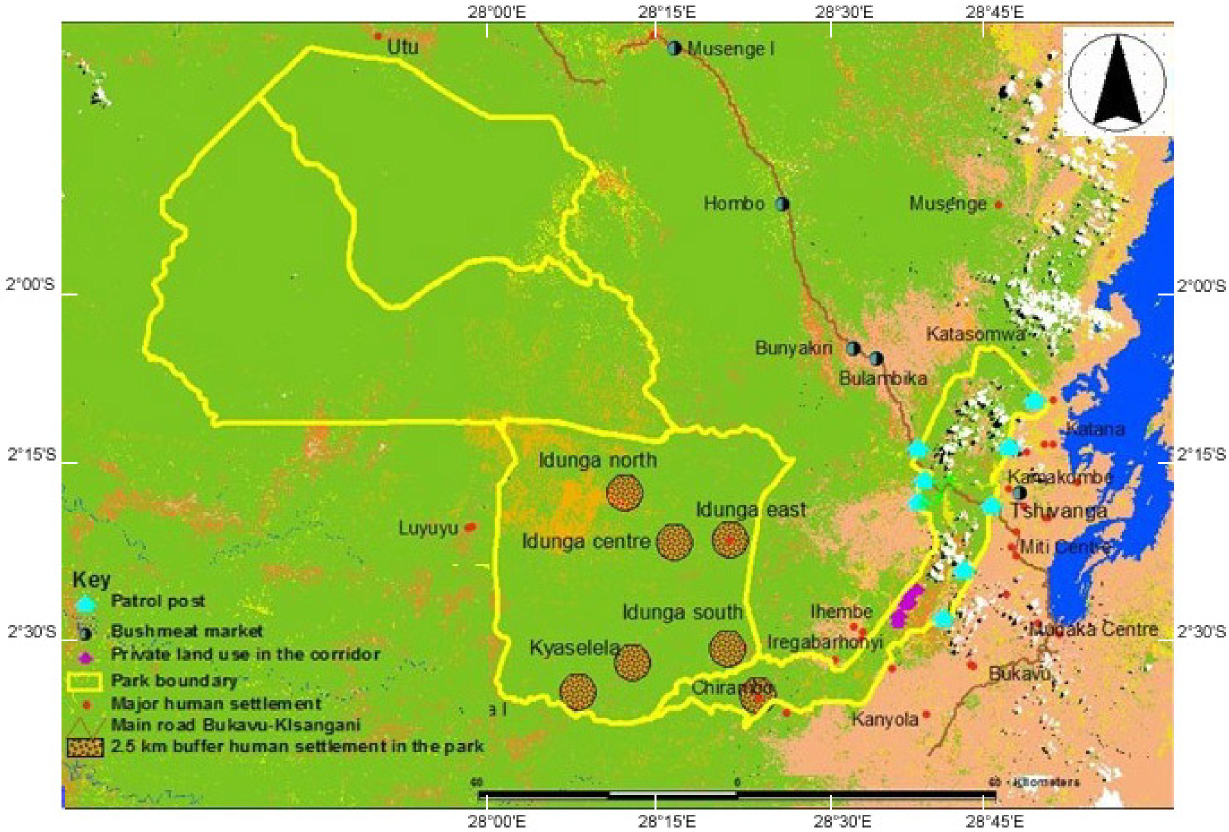


Figure 3. 22. 2 *Map showing 2.5 km-buffer human settlements buffer inside the park.*

If human are drawn to the park for the economic opportunities they provide, international funding for conservation may, ironically exacerbate the same anthropogenic threats to biodiversity it aims to alleviate. Creation of large multi-use buffer areas (**Figure 3. 22. 3**) surrounding core habitats and corridor between the KBNP and surrounding areas in the framework of the Maiko-Kahuzi-Biega-Lutungulu and Itombwe Massif landscape (possibly with mixed-use buffers) may facilitate effective protection of biodiversity while supporting potentially heavy human settlement on the park borders (Wittemyer *et al*., 2008). However, Gilbert-Norton *et al*. (2010) results suggest that although existing corridors increase species movement in fragmented landscapes and efforts spent on maintaining and creating corridors are worthwhile, it may be better to protect natural landscape features that function as corridors rather than attempting to create corridors. Community-based efforts to conserve forest resources through education and sustainable uses are possible and therefore can complement conservation efforts within the park. Such advanced landscape planning in concert with effective park management building upon the Biosphere concept, may maintain and increase the benefits of PA for local people while also ensuring those benefits do not result in unsustainable heavy use of the flora, fauna, and processes the park endeavors to sustain.

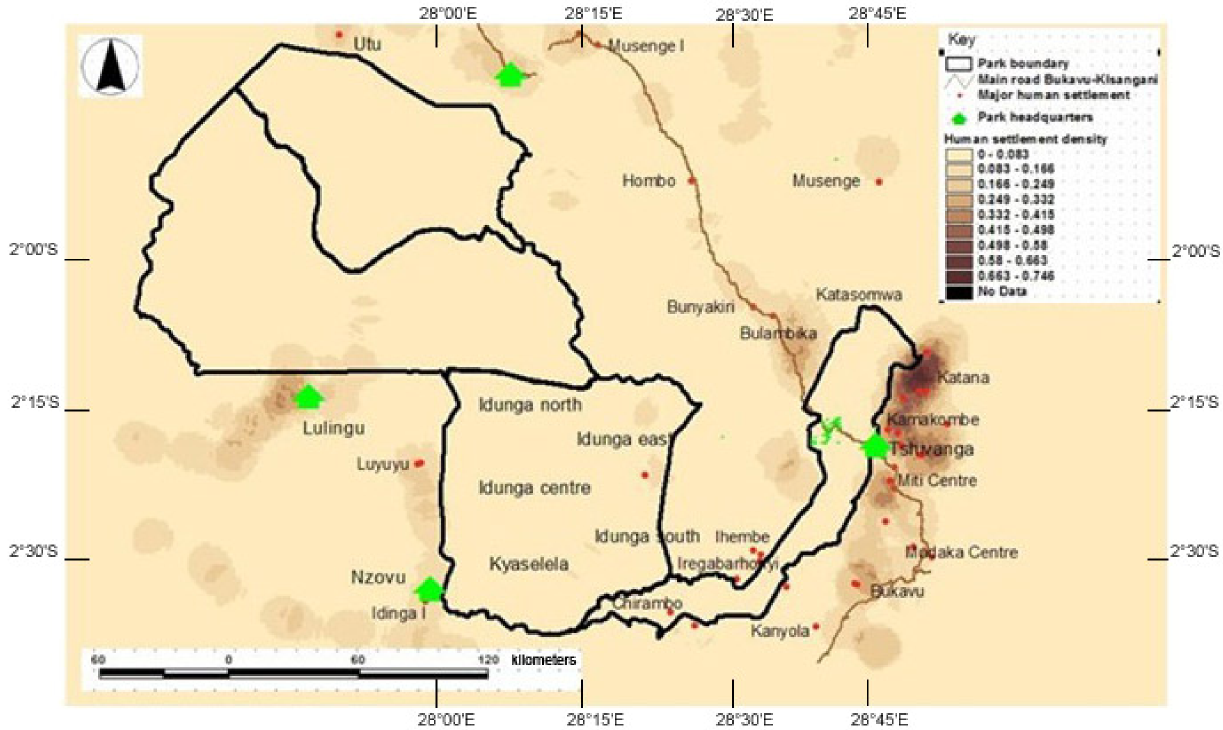


Figure 3. 22. 3 *Human settlements density within and around the park.*

Poverty, lack of significant health care, and lack of educational and economic opportunities is often combined with high fertility to bring even more strain on the natural resources. This combination continues the cycle of poverty, as the resources eventually diminish (WWF, 2002). Increased poaching pressure was undoubtedly the result of the increase in human population around the park, poverty, and the need for protein. Basically, these are economic issues that need economic solutions, especially given the fact that the world economic slow-down halted new investment and development funding. In such context, it's been hard enough for local people here to make ends meet lately. Accompanying the human population growth has been expansion of agricultural land and increase in livestock numbers, resulting in increasing isolation of management areas and decreasing wildlife. With the tourism industry in ruins since the beginning of the wars while food and fuel prices nearly doubled, those people (and there are millions here) who tread the fine line between surviving and not, have had to find a way of subsidizing their existence. What the bush is expected to provide, be it from the meat of the animals or charcoal made from the trees; is a return to the hunting and gathering beginning as a race of people. For several people, wildlife is the essential elements of daily life. At this point, the inherent logic of freedom in commons remorselessly generates tragedy (Hardin, 1968).

It's likely that people will continue to settle and cultivate new areas as one of their primary responses to population growth and the crucial need for land. With a growth rate of 4%, for over 40 years (Wils *et al*., 1976), the increased desire by ever-growing local populations to exploit the park for fuelwood and land is likely to continue as the result of poverty when the need for protein particularly in the late dry season and early wet season (locally known as *Muhaho* – September-November) when the supply of the staple diet, including cassava (*Manihot esculenta* Crantz); beans (*Phaseolus vulagris*) and maize (*Zea mays* L) is low around the park. Under current harsh socio-economic conditions where large, impoverished rural populations – including landless, displaced peasants – use the park resource for basic subsistence: food, firewood, building materials. Small farmers will likely continue to practice intercropping because the latter involving (sweet potatoes (*Hypomea batata*), Sorghum (*Sorghum vulagris),* onion (*Alium cepa),* and Irish potatoes (*Solanum tuberosum*) makes more efficient and intensive use of available labor with cassava (*Manihot esculenta* Crantz) being well know as a hardy crop that can withstand very stressful conditions.

3. 22. 1 Nindja Ecological Corridor: bandages for a wounded natural landscape?

A corridor is defined here as a linear, embedded in a dissimilar matrix, that connects two or more larger blocks of habitat and that is proposed for conservation on the grounds that it will enhance or maintain the viability of specific wildlife populations in the habitat blocks (Beier & Noss, 1998b). Human encroachment **(Figure 3. 12. 2**) leading to habitat fragmentation was identified as one one the greatest concerns for conservation biodiversity in KBNP. Habitat loss causes is one of the leading causes of recent wildlife populations declines and species extinction (Myers *et al*., 2000; Brook *et al*., 2003) by decreasing the amount of viable "core" area and increasing edge effects. It is widely accepted that landscape connectivity enhances population viability for many species and that, until recently; most species lived in well-connected landscapes (Noss, 1987; Hunter, 1996; Meffe & Carroll, 1997).

After humans disturbed the equilibrium, the forest often becomes a shrub forest with dense understory and many lianas. The best known secondary forest vegetation type is the *Hagenia abyssinica* forest. *Hagenia abyssinica, Neoboutonia macrocalyx* and *Croton macrostachys* tower over a herbaceous savanna consisting of *Hyparrhenia cymbaria*. This vegetation type is the result of minor intervention such as the cutting of undergrowth to make pastures for livestock. The existence of herbaceous savanna documented during recent joint military-guard patrols in 2009 in Kasirusiru patrol post area was due to massive deforestation. All the areas where light penetrates to the ground, such as all the clearings, are colonized by the ubiquitous fern *Pteridium aquilinum* which the livestock won't eat. The secondary forest created by the impact of humans *Myrianthuis holstii* predominates together with *Dombeya goetzenii*, *Macaranga*, *Sapium ellipticum* and *Neoboutonia macrocalyx*. The clearing and those zones that were completely deforested are invaded by lobelias (*Lobelia gibberoa*). At the end of the scale, repeated bushfires and cattle overgrazing created prairies of *Imperata cylindrical* var. *africana*, in the area between Ntulo and park beacon 102 where arguably things were 'too late' for the problems to be remedied.

The issue of corridor in KBNP has received considerable attention. The question I address here is whether the value of corridor in foresting faunal movement and reducing extinction probabilities is now better supported by available data, and whether the current emphasis on conservation corridors is justified. While movement thought of as minimizing the impacts of demographic stochasticity and inbreeding depression along corridor is frequently assumed to occur, there have been relatively few studies that have shown the role of Nindja corridor to counter potential effects of fragmenting actual wildlife populations into small, isolated units. This type of study requires establishing unequivocally that corridor is important for faunal movement is difficult and costly to design and implement and require intensive, long-term observations. There is a need to obtain hard data on corridor function and develop practical guidelines for corridor planning and design, and thus ensure that corridor planning is integrated into a broader conservation strategy. Evidence from well-designed studies supports the utility of corridors as a conservation tool. All else being equal, and in the absence of complete information, it is safe to assume that a connected landscape is preferable to a fragmented landscape. Natural landscapes are generally more connected than landscapes altered by humans, and corridors are essentially a strategy to retain or enhance some of this natural connectivity (Noss, 1987). In anticipation of increased isolation of habitat patches, Nindja corridor should be planned as last resorts ('*bandage for a wounded natural landscapes*' (Saoulé & Gilpin, 1991; Hobbs, 1992) given the fact that barrier effect tends to form metapopulation (Levins, 1969); although genetic is likely not a serious threat, local extinction of cut-off population might be, especially for elephant as the smaller the population, the more prone it is to extinction.

A rapidly increasing human population and the spread of agricultural development around the ecological corridor of Nindja are progressively isolating the fauna. The consequence is a reduction in the total area available to the wildlife and disruption to the movements of large mammals between the highland and lowland sectors of the park. Protection of the remaining natural corridor is therefore a high priority for the local conservation of the large mammal fauna (Newmark *et al*., 1991). The greatest challenge to the management and maintenance of this landscape link will be to ensure that further cultivation and settlement do not incrementally erode and sever this remaining connection.

Protection of movement paths is essential if connectivity is to be maintained in the long term. Where links are not protected so far, their functional role is inevitably lost because the incremental effects of human land use (such as clearing, cultivation and housing developments) eventually become barriers to free movement. Protection along movement paths from direct disturbance by poaching or hunting is also necessary in many situations (Bennett, 2003). Success in conserving Nindja's biodiversity will largely depend on the capacity of plants and mammals to survive in fragmented landscapes dominated by humans. However, corridor might increase the exposure of animals to human facilitating poaching. If the Nindja ecological corridor becomes thin enough, it would not be surprising if hunters use it it by stationing themselves at appropriate locations - Since animals tend to follow specific routes, and hunters exploit this behavior by monitoring these routes.

3. 22. 2 Boundary Demarcation Issue in the Kahuzi-Biega National Park: A Carrot and Stick Approach

The baseline data of the presidential ordnance No. 75/238 dated July 22, 1975 (**Annex 4**) which officially set up the boundary of the park misquoting some of the geographic landmarks leaving sections of the park without any demarcation is the key element from which current conflicts arose between park officials and surrounding local communities (Kasereka, 2003). Legal boundaries were not negotiated with local communities, as a consequence human population frequently violate park boundaries and regulations by hunting animals, cutting down trees and grazing their livestock inside the park. This loophole in the presidential Ordnance and in its implementation led to various interpretations, depending on whether one is a conservationist or a member of the local communities living near or inside the park. The conflict has arisen to the point that some traditional local chiefs bitterly complained of forceful land expropriation thus generating resentments and hostility following the displacement of people from their traditional lands leading to social and cultural disruption (Mugangu, 1997). The land-owners perceived the establishment of the park as an obstacle to their benefits from the resources of the area. As human population expand their increasing demands for land and resources will cause these conflicts between the park and the surrounding human people to escalade (Hough, 1988). As these conflicts appear to be disadvantages to both, it is useful to examine how such conflict might be resolved, or at least managed for the sake of existing biological diversity.

Having studied the factors affecting the boundary demarcation in the KBNP, Kasereka (2003) has provided an interesting logical model in the boundary demarcation process applying for the KBNP using 5 components, including sensitization, development input, law enforcement, boundary demarcation and interaction between the park and local communities living in the hinterland. The concept of integral protection of nature is difficult to apply and enforce because of population pressures and demands on this land (Maldague *et al*., 1997). Factors with direct effects on boundary demarcation include law enforcement, the participation of the influential traditional chiefs to boundary demarcation filed missions, as well as the park-population interactions. However, development inputs and sensitization had an indirect effect on boundary demarcation. One of the most major findings of Kasereka (2003) was that the park boundaries demarcation was successful when law enforcement increased and when the support from the local community was ensured. Law enforcement was stronger where the anti-poaching exercise was maintained for 10 years or more and where patrol staff density was as high as 1 ranger per 3.2 km park boundary section. This result compared well with PNKB-GTZ (2000) report which estimated that efficient law enforcement was a key to success of any park boundary demarcation. The study also found that without repression, the offenders of the park natural resources would not be involved in the boundary-related conflict resolutions and they would rather carry on with their illegal activities (Lewis, 1996).

The failure to demarcate the park boundaries was linked to weak law enforcement where the interests were claimed inside the park. That was the case in the lowland sector where law enforcement was present for only 6 years and where patrol staff density was as weak as a ranger per 21 km boundary section. Whenever the traditional chief willingly joined the park boundary demarcation team, the limits were implemented, and accordingly a report countersigned by him and KBNP officials was thereby produced, legitimating the acceptance of the park limits in that particular area (Kasereka, 1996). The presence of the traditional chiefs at demarcation missions, in turn, was proportional to the number of health clinics and small-scale agricultural projects sponsored in the area under consideration. The major claims from the community remain unsolved in Nindja area in which case traditional chief proved equivocal; while pretending to support the park boundary demarcation process through participation to boundary demarcation field trip, the traditional chief actively shared views expressed by vindictive 'urbanized natives' and other detractors against KBNP (Masheka, 1977). Traditional chief presence to the park boundary demarcation exercise has lead to successful boundary demarcation, where the local community has considered the development inputs more rewarding than poaching of natural resources. As far as boundary demarcation is concerned, there is a good prognosis in the highland sector where 30 km of the park boundary between Musenyi-Corrdior-Mugaba were documented in 2009, and 14 km in Kasirusiru area, 20 km in Mamba-Chazi and finally 12 km maintained at Tshibati (PNKB-Tshivanga, 2010). However, in the lowland sector, over 34 km of the park boundary controlled only 4 km were demarcated (PNKB, 2008).

Although Kendra (2009) results demonstrate that carrot strategies of increasing benefits of conservation are not effective in curtailing illegal resource use in the short term, this is not to say there is no benefit in such strategies. Local communities often bear the brunt of the costs of conservation and deserve to gain something in return for moral reasons if nothing else. For effective conservation, carrot strategies could be most successful if involving the user community in conservation efforts is seen as a long-term investment, with the ultimate goal of turning over conservation management and responsibilities entirely to the community.

3. 23 Natural resources Management and Conservation Implications

Though the newly establishment post conflict government of the DRC may formally devolve ownership and management rights to local communities, in the framework of the newly proposed wildlife Act (under consideration in the Parliament), none of its proclamations have so far demonstrated and intent to do so. If we are concerned about conservation of a globally scarce resource that is at present dwindling, it is essential that research on bushmeat production and consumption undertaken in the vicinity of the park pave the way for further aspects, including monitoring resources under different protection strategies. Pilot small livestock production projects should be supported to start the process of lowering demand for bushmeat given the fact that enough animal protein will be produced from rearing wild species as ‘minilivestock’ (Fa, 2000).

Conflicts between national park management and its surrounding human communities are apparently dysfunctional for both. Both groups would appear to have incentives to resolve or at least reduce these conflicts. A major difficulty remains the achievement of ready communication and trust between the powerful urban-based park authorities and the rural, possibly illiterate, local human populations who may have suffered at the hands of the park authorities in the past. Because of their greater power, the national park authorities are in the best position to take the first steps towards establishing trust- by making some positive concessions, and binding themselves in some way to real, rather than token, local participation in decision-making; such is currently the case with the Community Conservation Committee (CCC). Once effective communication is established and the early identification of areas of common interest is concluded, then positive actions to promote these in the framework of current Park Management Plan will continue the trust-building process and enable more difficult issues to be addressed.

Evaluating the status of populations of forest animals is difficult because the numbers vary from one year to the next. Thus, the status of prey species in a particular forest cannot be determined by conducting a single survey, which may explain why estimates of duiker or primate density vary greatly in the park. Once security is guaranteed, survey in several consecutive years will be necessary to evaluate the status of each keystone species at a particular park management unit. Identifying which groups of mammal are likely to be vulnerable to hunting is vital, because wildlife still provides an essential source of protein for many people in the park.

The study analyses of anti-poaching patrols suggest four major conclusions regarding their effectiveness. First, the frequency with which patrols associated to increasing coverage area and park staff number are undertaken is the main driving factor affecting the threats probability detection. Although the total number of arrests and seizures varied significantly by year, the probability decreased when several rangers took their annual leave or when more than 20 % of the field force were involved in non-patrol duties specified in Chapter 2. Involvement of large number of park guards in residence guardian and manning entrance barriers duties negatively impacted the efficiency of patrol deployment on the ground. Therefore there is a crucial need to ensure their redeployment at the site, all the more so since the primary task of a guard is patrolling in the park and not in the city (except when carrying out an intelligence task). In sum, the park is understaffed, and training and infrastructure are poor (Hart & Hall, 1996). Efforts here should be proactive so that staff are able to deal with the complexities of human conflict.

Second, we found that the high potential hotspot area for illegal activity was estimated to 156.4 km^2 representing 6.0 % of the study area. Threats specific WCH covered respectively 65.4 km^2 representing 10.9 % of the highland sector and 91.0 Km^2 covering 5 % of Nzovu lowland sector. Eco-tourism had a marked positive effect in habituated gorilla groups' area where poaching signs was less evident due to ceaseless surveillance. On overall, the striking finding shows that the park field force was working at only 59.3% of its capacity with mean duration of effective patrol-day was set at 4.2 ± 0.8 hours. The study suggests that the success of the anti-poaching effort could be increased by improving the mean duration of effective patrol-day from 4.02 ± 0.8 hours walking at a slow pace (approximately 2 $km/hour^{-1}$) along pre-established trails to recommended 6:00 hours of patrolling per day over much more coverage, and finally the patrol density effort from current 21.8 to 33 EPMD/km^2 per $guard/month^{-1}$ while staggering work schedules to avoid periods when there are too few park guards on hand to undertake patrols. The number of staff should be set at 12 per patrol post while the number of patrol posts should be reviewed taking into account the facility provided by both the results of RBM and the use of TrailGuard device as a feedback mechanism to steer and optimize field operations. In this regard, systematic future use of investigation operations remains crucial. The limited evidence of poaching within the ranges of more intensively studied gorilla sector supports the view that monitoring by researchers and tourists provides important conservation benefits. However, the latter doesn't apply the need of eco-tourism approach all over the park. The efficiency of investigation-based operations over conventional patrols, in terms of offenders' arrests and recovery of firearms/ammunitions was evidenced in this study.

Third, the encroachment of the park by the population was, first and foremost, caused by the ambiguity of the Congolese legislation concerning PA and the lack of alternative economic resources. Because of the importance of Nindja corridor, the parliament should clarify the wildlife Act to win back this vital strip of land. The above enforcement measures are the pre-requisites for the park's survival. However, they are not sufficient as they should be coupled with social actions that will allow people to become less dependent on the forest assets. So far, few if any projects have managed successfully to balance the dietary needs of the local people and the conservation of prey species. In KBNP and surrounding areas, defaunation is probably more of a critical worry than deforestation (Fa *et al*., 2000). Balancing human needs and protein demands throughout the ecosystem is a much taller order, otherwise, there will be nothing left to conserve if people are not assisted in meeting their daily needs. It is though that lasting changes should come from fundamental alterations in attitudes and behavior. As Hardin (1968) notes the population problem has no technical solution; it requires a fundamental extension in morality in order to counteract offenders who seem to have struck oil in the park.

Four, the research findings underline the importance of a monitoring program to detect continous changes in wildife distribution and relative abundance and its inter-relationship with human activities and presence. They further suggest that the LEM can provide a basic yet useful tool providing threats patterns and the distribution of wildlife through time and on spatial basis, thus helping guide PA managers in making decisions on surveillance activities by determining which areas are most affected by which kind of threat. Identifying threats and then deciding which ones are the most significant is an important exercise when building an anti-poaching conceptual model. Understanding not only the range of threats but also how they interact and influence one another is critical as it enables wildlife managers to articulate clearly the vision of why the need to take certain actions to conserve a particular species at risk or habitat. It further allows pinpointing where and why law enforcement operations are likely to have the most success and the greatest conservation payoffs as the anti-poaching teams keep dogging the rule-breakers'steps in and out of PA.

Poaching has an economic basis and, without changing the economic incentives system for the local people, all efforts will bear little result. The approach suggested above is not without risk both to park authorities and the local communities; but clarification of both conservation and development objectives should reduce such a risk and help to identify the local and analytical need for working towards a mutual beneficial solution. The challenge ahead still remains to sustain the achievements of the current outcome of the RBM Program, to identify long-term solutions to counter the persistent threats to the site and to develop strategies and action plans aimed at restoring the site ecological integrity. The fate of the remaining elephant population described here is more problematic. As things stand right now, even if the Park Service's enforcement capacity is buttressed in the park, serious questions remain about the population's long-term survival because of intense land use, isolation and its small size. The successful conservation of the endangered elephant population will necessitate a multi-disciplinary approach as species with small home ranges will be most susceptible to hunters, since a restricted ranging area makes their movements more predictable (Kuchikura 1988). However, as Hall *et al*. (1998) note, the apparent success of the Park Service in maintaining the Grauer's gorilla population within the highland sector boundaries suggests that they serve as a core conservation for the subspecies. Nevertheless, the understanding of the mechanisms that link species biology with vulnerability to extinction is still relatively poor. This is a question of fundamental importance, since differential patterns of vulnerability across multiple threats must play a central role in determining the overall pattern of global extinction risk for many species.

The above mentioned findings have important policy and procedural implication in the law enforcement statute. Along these lines, what account for these results and to what extent is social necessary for long-term improvements in biodiversity? There are a number of possibilities to consider, though in all likelihood more than one factor is at play. First possible explanation for these findings is that wildlife staff lack means to enforce and even if offenders were in restricted areas, law enforcement agency may lack the resource in its bit to properly tackle the threats by pursuing their location in a systematic manner. Without changes in social norms, people often revert to old ways when incentives end or regulations are no longer enforced, and long-term protection may be compromised (Pimbert & Pretty, 2000). What, then, should be done to develop and spread forms of social organization that are structurally suited for natural resource management? For people to invest their time, they must be convinced that the benefits derived from collective approaches will be greater than those derived solely from individual ones (Pretty & Smith, 2004).

The security situation in the whole region is still fluid and as a result it has been difficult to achieve all the anti-poaching objectives as outlined in the wildlife Act (**Annex 1**). The presence of *Interahamwe* and *Mai mai* militias embedded in highly mineralized areas means that the park field teams have had to be flexible and were not able to access all areas as planned. As a consequence, many of the threats to the integrity and values of the site still persist and some even have intensified. The challenge ahead is to sustain the achievements of current management plan, to identify long-term solutions to counter the persistent threats to the site and to develop strategies and action plans aimed at saving the ecological integrity of the site.

CHAPTER 4

MONITORING LAW ENFORCEMENT AND ILLEGAL ACTIVITY IN THE VIRUNGA NATIONAL PARK

Conservation efforts are only as sustainable as the social and political context within which they take place. The weakening or collapse of sociopolitical frameworks during wartime can lead to habitat destruction and the erosion of conservation policies…

- Thor Hanson et *al*., 2008 -

4.0 Introduction

Massive over hunting of wildlife for meat and voracious appetite for almost anything that is large enough to be eaten, potent enough to be turned into medicine, and lucrative enough to be sold is stripping wildlife from wild areas, leaving empty forest shells and unnatural quiet (Robinson & Bennett, 2000; Burgess *et al*., 2006). Wild animals are important source of protein for rural peoples living in or near tropical forests, but, in many areas, this important source of food and income is either already lost or is being rapidly depleted (Lahm, 1993; Robinson & Redford, 1994; Milner-Gulland *et al*., 2003b). The likelihood of civil war in developing countries is positively correlated with the importance of natural resource commodities in the national economy (Collier & Hoeffler, 1998), thus rampant poaching is an ever growing epidemic that plagues the VNP. Human beings are treated as driving forces of biodiversity loss (Saoulé, 1991, WRI *et al*., 1992), yet there are few systematic studies on how anthropogenic factors affect biodiversity within PAs in the context of repeated episodes of violent conflicts and how increased or limited access for patrolling might outweight these negative impacts.

Predictive understanding of either poaching pattern or wildlife occurrence remains a challenge when both hunter and hunted are elusive (Sanchez-Mercado *et al*., 2008).The stimulus of this LEM study was to determine spatial factors driving key large-bodied mammals poaching and identify illegal activity incidents that are clustered around a particular place of interest within the study area. Though the weakening or collapse of sociopolitical frameworks during wartime can lead to defaunation, habitat destruction and the erosion of conservation policies, growing evidence suggests that political instability should not preclude conservation efforts from being continued.

4. 1 Study Area

Virunga National Park (VNP), formerly called Parc National Albert (PNA), was created on April 21, 1925 by a King's decree (Delvingt *et al*., 1990). The first reserve of 20,000 ha including Mounts Karisimbi, Mikeno, and Visoke, was created with the aim to protect the mountain gorillas (*Gorilla beringei graueri*) and the flora and fauna for tourism and scientific purposes.

The VNP covers an area of 7,844 km^2 and is situated astride the equator in the east of DRC (Languy & de Merode, 2009a), along the borders of Rwanda and Uganda (**Figure 4. 1. 1**). It's a region of varied habitats including open grassland, grassland with thickets, thick bush, forest, swamp and lakeshore. The VNP is contiguous to the Queen Elisabeth National Park (QENP) in Uganda, and together the two parks completely encircle Lake Edward in the western Albertine Rift Valley. The park extends for about 300 km north south, but averages 23 km east to west. In the north (00º 56'N), the park is bordered by the river Puemba and in the south (01 º 39's) by Tshegera island in Lake Kivu. In view of its complex shape, the park has an exceptionally long boundary of 1,150 km (Languy & de Merode, 2009a). The elevation varies from about 680 meters above sea level at the confluence of the Puemba and Semliki rivers to the highest Marguerita Peak at 5,119 meters above seal level (the highest point in the country). There are two rainy seasons (March-May and September-December) and two dry seasons (January-February and April-August). In 1979, VNP was inscribed on the List of World Heritage in Danger at the 18th Session of the World Heritage Committee (UNESCO, 1994; UNEP-WCMC, 2008) in the wake of the war in neighboring Rwanda and the subsequent massive encroachment by refugees and local populations which led to massive deforestation and poaching at the site.

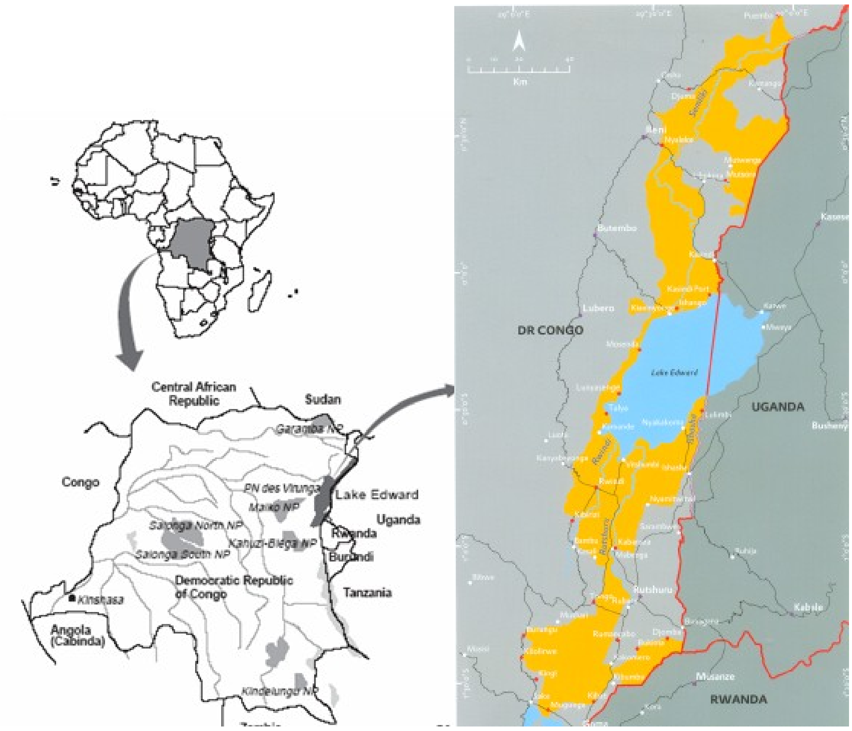


***Figure 4. 1** Study area and Map depicting the location of the Virunga National Park.*

4. 1. 1 The main types of vegetation

The main habitat types of the park are summarized in **Figure 4. 1. 1. 1** as follows:

The open land habitats grade from steppe to savanna to swamp, the result of low rainfall, soil type, grazing and fire. (i): grassy *Chrysochloa orientalis* steppe to bushy steppe with *Carissa edulis, Capparis tomentosa, Maerua* spp.and *Euphorbia candelabrum*; (ii): low savanna with *Themeda triandra* and *Imperata cylindrica*; (iii): grassy savannas of three types - *Pennisetum* in the Semliki valley, *Cymbopogon* on the plains around the lake and *Hyparrhenia* in the far north; (iv): bushy savannas - Combretum-wooded *Hyperthelia dissoluta* savanna and *Acacia seiberiana-A. gerrardii* woodland, both on the Mitumba foothills west of the lake; (v): transitional grasslands - *Craterostigma nanum* prairies and *Sporobolus* spp. savanna; (vi): riverine grasslands - *Cyperus papyrus* marsh, *Phragmites australis* marsh; and (vii): aquatic vegetation.

Forest habitats grade from thickets to dense forests. (i): thickets around the lake and on Mt. Misali; (ii): thick sclerophyllous forest of *Euphorbia dawei* in the southwest; (iii): lava plain pioneer species in all stages of recolonization, culminating on loose soils in *Neoboutonia macrocalyx* forest; (iv): dense equatorial forest over half the northern sector; (v): gallery forests – shade-loving forest on the upper Rwindi, a fringe of *Phoenix reclinata* on the lower Rutshuru and drier forests on the upper Semliki; (vi): dense montane forest from 1,800 to 2,300 m on Rwenzori (known as the 'Mountains of the Moon') and on Mt. Tshiaberimu west of the lake, on Mt Kasali south of the plains, on Mt. Kamatembe in the southwest and on the Virunga massif between 1,750 and 2,600 m.

Montane habitats grade from transitional foothill forest to alpine zones. (i): *Sinarundinaria alpina* bamboo woodland on the slopes of all the larger mountains; (ii): *Hagenia abyssinica* woodland becoming bushy, mixed with large hardy perennials like *Peucedanum kerstenii*; (iii): a high scrub layer, then tree heath of *Erica* and *Philippia* species, associated on the Virungas with *Podocarpus latifolius,* on the snow-capped peak of Rwenzori with *Hypericum rwenzoriense*, *Hagenia abyssinica* and *Rapanea rhododendroides*; and a low and grassy understorey layer; (iv): afro- alpine groves of *Senecio stanleyi* with giant *Lobelia wollastonii* in clearings; (v): sparse vegetation above 4,300 m mainly of lichens and spermatophytes, although grasses have been found growing over 5,000 m. The sclerophyllous forest covering the relatively recent lava fields of Mount Nyamulagira are an important feature of the southern sector. These lava flows are widespread and extend as far north as the latitude of Rutshuru town. Mount

Nyamulagira (3,056 m) and Nyiragongo (3,470 m) are the most active volcanoes on the planet (Languy & de Merode, 2009a).

Source: Languy & de Merode, 2009a

Figure 4. 1. 1. 1 *Map showing the vegetation types of the Virunga National Park.*

4. 1. 2 Park Biological Values

In terms of biological diversity, Virunga is by far the richest PA on the African continent (de Merode *et al*., 2009a). Dramatic habitat variations caused by the extreme altitudinal and climate gradients are largely contributing factors explaining the park's exceptional species richness. The park is home to more than 700 species of birds, and 220 species of mammals (the highest for any African PA). In addition to its unparalleled specific richness, the park includes a very large number of species that are endemic to the Albertine Rift. It also harbors an uncommonly larger number of species listed as vulnerable or endangered on the IUCN Red List (de Merode *et al*., 2009a; IUCN, 2006) including the Rwenzori duiker (*Cephalophus rubidus*).

The VNP is the only PA in the world with three taxa of great apes, namely the Mountain Gorilla (*Gorilla beringei beringei)*, the Eastern Lowland Gorilla (*Gorilla beringei graueri)*, and the Eastern Chimpanzee (*Pan troglodytes schweinfurthii)*. There are an estimated 720 Mountain Gorillas left in the world, of which around 380 are in the Virunga volcanoes (Gray *et al.*, 2005). Elephant (*Loxodonta africana* sp) and African buffalo (*Syncerus caffer*) are among the number of iconic large savanna species. Ungulates form clearly a key group of mammals in the park with the Common hippopotamus defining Virunga more than any other ungulates. Uganda kob (*Kobus thomasi*) remains the most abundant of large mammals' species on the savannas, and can be found in both the central and northern sectors. VNP is a rich bird life region; being recognized as a site of international significance for the conservation of birds as such it is known as an Endemic Bird Area (EBA) as well as an African Important Bird Area (IBA) by Birdlife International. VNP is host to a diverse range of vegetation and habitat types owing to both its rich geologic history and the presence of several permanent water bodies; fact which largely contributed to its nomination as a RAMSAR site under the Convention on wetland sites of international recognition (Ramsar was ratified by DRC on September 15, 1994).

4. 1. 3 Statements of Park Significance

VNP is notable for its chain of active volcanoes and the greatest diversity of habitats of any park in Africa: from steppes, savannas and lava plains, swamps, lowland and Afromontane forests, to the unique Afro alpine vegetation and ice fields of the Rwenzori Mountains, which culminate in peaks above 5,000 m. The site includes the spectacular Rwenzori and Virunga Massifs, including Africa's two most active volcanoes (Nyiragongo and Nyamulagira). The great diversity of habitats harbors an exceptional biodiversity, including endemic as well as rare and globally endangered species, such as the mountain gorilla (*Gorilla beringei beringei*).

White & Vande weghe (2008) state that the VNP was designated World heritage Site in 1979 building, at this time, upon UNESCO Exceptional Universal Value (EUV) criteria *vii* (representing natural phenomenon or area of natural beauty and of exceptional aesthetical importance, *viii* (being an highly example representing great evolution in the world history, including the testimony of living world, geological process taking place in the framework of the development of different terrestrial forms or geomorphologic and/or physiographical elements of significant impact, and *x* (contain highly and important natural habitats for the *in situ* conservation of biodiversity, including those where threatened species embedding EUV as far as science and conservation are concerned). These criteria are well explained as follows:

Criterion (vii): VNP presents some of the most dramatic mountain scenery in Africa. The rugged Rwenzori Mountains with their snowcapped peaks and steep slopes and valleys and the volcanoes of the Virunga Massif, both with Afro alpine vegetation with giant heathers and Lobelias and densely forested slopes, are areas of exceptional natural beauty. The active volcanoes, which erupt every few years, form the dominant landforms of the exceptional scenery. The park contains several other spectacular landscapes such as the erosion valleys of the Sinda and Ishango areas. The park also contains great concentrations of wildlife, including elephants (*Loxodonta Africana*), African buffalo (*Syncerus caffer*) and Uganda kob (*Thomas's ko*b), and the highest concentration of hippos in Africa, with 20,000 individuals on the shores of Lake Edward and along the Rwindi, Rutshuru and Semliki Rivers.

Criterion (viii): VNP is situated at the heart of the Albertine Rift sector of the Great Rift Valley. In the southern section of the park, tectonic activity resulting from crystal extension of this area gave rise to the Virunga Massif, composed of eight volcanoes, of which seven are situated or partly situated in the park. These include Africa's two most active volcanoes, Nyamulagira and the neighboring Nyiragongo, which alone account for two-fifths of the historical volcanic eruptions on the African continent. They are especially notable because of their highly fluid alkaline lavas. The activity of Nyiragongo is globally significant for its demonstration of lava lake volcanism, with a quasi-permanent lava lake at the bottom of its crater, periodic draining of which has been catastrophic to the local communities. The northern section of the park includes around 20% of the Rwenzori Massif, the largest glaciated area in Africa and the only truly alpine mountain range on the continent, and adjoins the Rwenzori National Park World Heritage Site in Uganda, with which it shares Mount Margherita, the third highest peak in Africa (5,119 m).

Criterion (x): Due to its variation in altitude (ranging between 680 m and 5,119 m), rainfall and soils, VNP contains a very high diversity of plants and habitats, resulting in the highest biological diversity (or more simply, biodiversity) of any national park in Africa. More than 2,000 higher plants have been identified, of which 10% are endemic to the Albertine Rift. Approximately 15% of the vegetation is Afromontane forests. The Albertine Rift has also more endemic vertebrate species than any other region of mainland Africa, an important number of which can be found in the park. The park harbors 218 mammal species, 706 bird species, 109 reptile species and 78 amphibian species. The park is home to 22 species of primates, including three great ape species: mountain gorilla (*Gorilla beringei beringei*), eastern lowland gorilla (*Gorilla beringei graueri)* and eastern chimpanzee (*Pan troglodytes schweinfurthii*), with one third of the remaining mountain gorilla population in the world. The savanna areas of the park are home to a diverse population of ungulates, with one of the highest biomass densities of wild mammals ever recorded on Earth (314 tons/km^2). Ungulates include the rare Okapi (*Okapi johnstoni*), endemic to the DRC, and the Rwenzori duiker (*Cephalophus rubidus*), endemic to the Rwenzori mountains in DRC. The park contains significant wetland areas, particularly important as wintering grounds for palearctic bird species.

4. 1. 4 Park Management Sectors

The VNP is made of three sectors, the Northern, Central and Southern, as defined by park management requirements. The VNP strides five administrative territories (**Annex 13**).

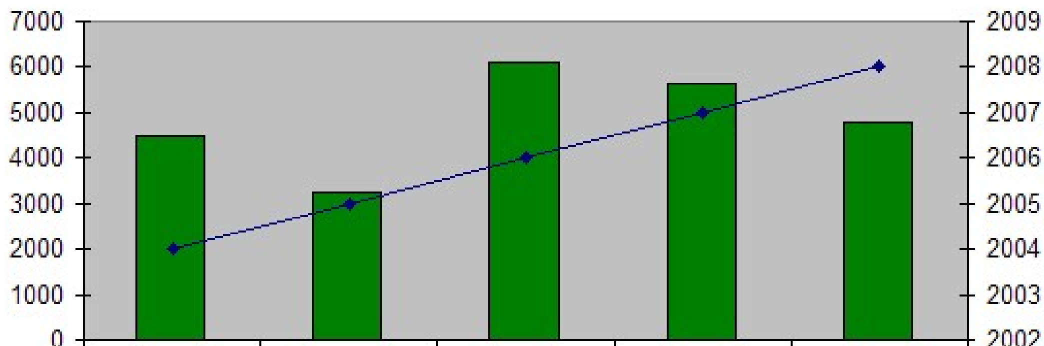
Covering an area of 2,995.23 km^2 (of which 223, 24 km^2 are part of Lake Edward), the Northern sector is the most extensive area of dry land within the park. The sector extends from the Puemba River to Lake Edward, and it is defined by the Semliki Valley, the Rwenzori Massif and Mount Tshiaberimu (Languy & de Merode, 2009a). Mutsora (**Figure 4. 1. 1. 1**) is the headquarters of the northern sector.

The Central sector is made up of the western and southern banks of Lake Edward and the plains of Rwindi-Rutshuru through to Mabenga. It covers an area of 3,391.73 km^2, of which 1,445.48 km^2 is part of Lake Edward. This sector includes as well the Lulimbi region, which forms the international boundary with the QENP (Uganda) through Ishasha River. Rwindi is the headquarters of the central sector and Lulimbi headquarters’s zone is currently referred to as the Eastern sector. Rwindi-Rutshuru-Ishasha plains cover 1,250 km^2. Kabaraza and Rutshuru (**Figure 4. 1. 1. 1**) are part and parcel of the Rutshuru Hunting Domain (RHD).

The Southern sector of VNP covers an area of 1, 456.72 km^2, stretching from the south of the Kasali Massif to the northern shores of Lake Kivu, thereby encompassing both active volcanoes, Nyamulagira (3,056 m) and Nyiragongo (3,470 m), together with the dormant volcanoes of the Mikeno sector. The headquarters of the southern sector is located in Rumangabo (**Figure 4. 1. 1. 1**).

4. 2 LEM Sampling Design

The instability in the Kivu region has a great impact on VNP management: the violence in and around the park has made monitoring of the area very difficult. When the Congolese war began in 1997, large areas of the park became off-limits to guards from the ICCN. Surveillance patrols were limited to certain parts of the park because elsewhere, it was too dangerous to reach. Dangerous places were heavily mined and infiltrated with large forces of militia. Almost all conservation and protection activities were brought to standstill, especially in area highly suspected to be a hide-out for the militia gangs, thus paving the way for intensive poaching. One hundred and twenty rangers died on active service since the outbreak of armed conflict in the region (de Merode & Languy, 2009b) to protect the park during one of the most difficult periods in DRC's history. Since that time, park guards' accommodations were destroyed and a lot of transport and communication has been stolen. Overall, the security situation around VNP remains very volatile and deteriorated again recently. Late 2006, insurgent forces led by the dissident General Laurent Nkunda and his rebel militias from the CNDP (Congrès National pour la Défense du Peuple) invaded VNP's southern sector. In January, May and September 2007 hostilities took place again, forcing ICCN's park staff and their families to flee several of the park's patrol posts, leaving the park's resources totally unprotected.



	1	2	3	4	5
Coverage	4475	3224	6100	5650	4800
Year	2004	2005	2006	2007	2008

Figure 4. 2. 1 *Patrol coverage over the years in the Virunga National Park*

Against this background, the park forces from different management units were unable to carry out their own mandate, thus reducing the patrol coverage from one year to another (**Figures 4. 2. 1 & 4. 2. 2**). In fact, patrol coverage decreased at 39% from 2004 to 2005 then substantially increased at 47% from 2005 to 2006 which was the peak reached during the study period. From 2006 and 2007, patrol coverage decreased at 8% followed by 18% between 2007 and 2008. These trends are summarized in **Figure 4. 2. 1**.

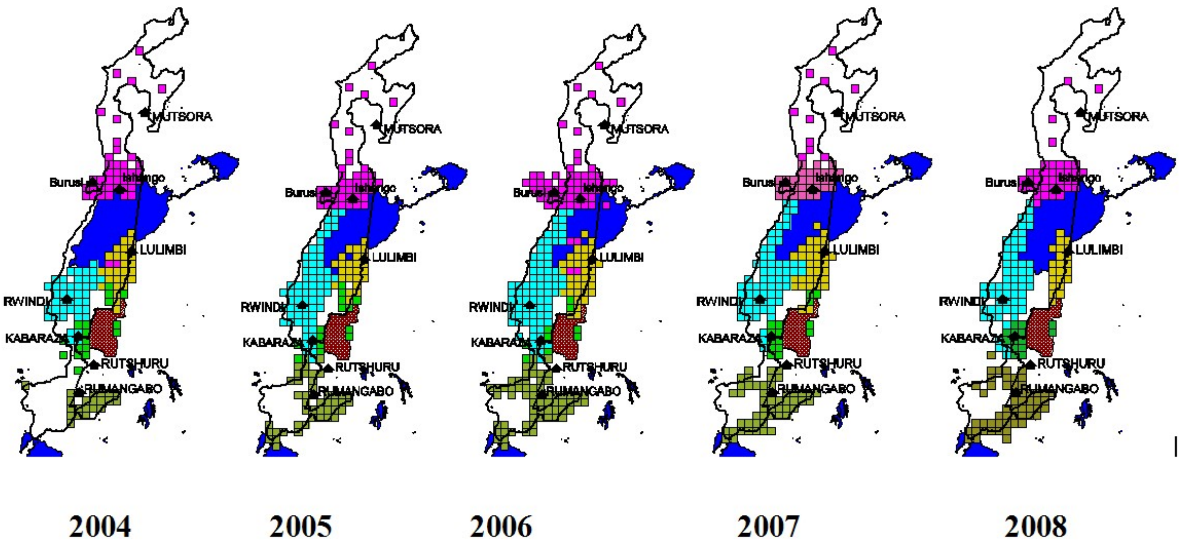


Figure 4. 2. 2 *A 5x5 grid Patrol Coverage and Law enforcement monitoring in the Virunga National Park - Five different grid colors representing the five management units and the water body in blue color.*

4. 3 Human Threats Distribution versus Habitat Preferences

Herbivore distribution and associated impacts on vegetation are scale-dependent (Senft *et al*., 1987; Bailey *et al*., 1996). Large herbivores generally have extensive ranges, and therefore their management tends to be focused at a large scale, which may not be the most appropriate scale of management for the resource themselves (Palmer *et al*., 2003). Ecological research has shown how key responses such as vegetation, water and shelter together with aspects of herbivore sociability and gregariousness all drive both the distribution of both herbivore and poacher, and thus the impacts of the latter on resources at a range of scale. Much of this research suggests that the distribution of herbivores is primarily determined by abiotic factors such as terrain or distance to shelter/water.As such, herbivore responses to vegetation heterogeneity operate within this these higher level constraints (Bailey *et al*., 1996). Herbivores are generally attracted to preferred vegetation, but the spatial relationship between preferred and non-preferred vegetation is of paramount importance in driving the system dynamics (Palmer *et al*., 2003). Recent research has clearly shown that different spatial behaviour and their concomitant impacts on the dynamics of the vegetation itself (Oom *et al*., 2002). It is therefore fundamentally important to understand the scales of impact driving vegetation or landscape change in large herbivore dominated ecosystem.

Key human threats were observed in different habitat types of the VNP. Poachers' habitat threats preferences (PI) in both seasons are presented in **Tables 4. 3. 1 & 4. 3. 2 and Figures 4. 3. 1 & 4. 3. 2**). Their PIs differed significantly within and between seasons ($P < 0.05$). Fuelwood collection was sighted particularly in two main habitat types, including drought-resistant sclerophyllous brush, and wooded and grassland savannas while snares were most frequent in *Hagenia* and gallery forest and, particularly near the boundary in the southern sector where bamboo is available to use in snare constructions well as in the mountainous forest dominated by *Podocarpus* and *Neoboutonia* and in the grassland and bush savannas.

Table 4. 3. 1 *Offender's habitat preferences through fuelwood collection distribution in different vegetation types in wet and dry seasons*

Vegetation type	*Area (km²)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/ r+p*
Afro-alpine zone	1.4	0	0	0	0	0	0
Afro-subalpine dominated *heathers*	2.8	0	0	0	0	0	0
Montane forest dominated by *Podocarpus* and *Neoboutonia*	11.2	36.4	0.36	0.364	-0.004	0.724	-0.00552486
Drought-resistant scerophyllous bush	12.3	24.7	0.25	0.247	0.003	0.497	0.006036217
Hagenia forest	0.4	1.3	0.013	0.013	0	0.026	0
Lowland humid forest	11.8	0	0	0	0	0	0
Gallery forest	1.4	3.2	0.032	0.032	0	0.064	0
Grassland and bush savanna	35.7	27.9	0.28	0.279	0.001	0.559	0.001788909
Recent lava flows	2.3	6.5	0.065	0.065	0	0.13	0
Lake and River	18.3	0	0	0	0	0	0

Key   *r = the ratio of habitat type where fuel wood collection occurred*

p = the proportion of occurrence of fuel wood collection

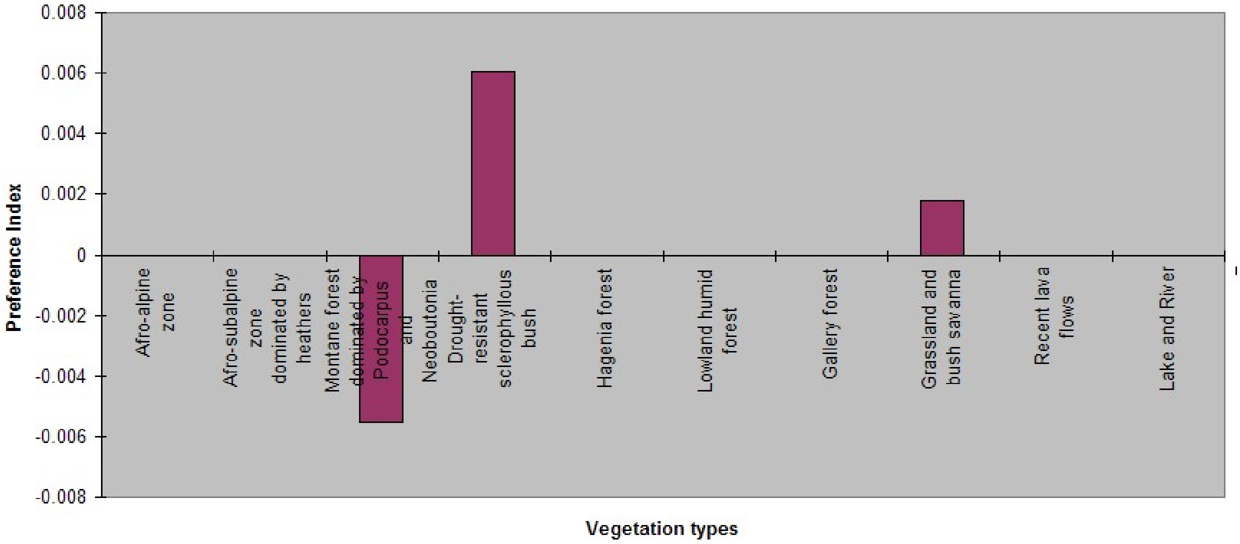


Figure 4. 3. 1 *Offenders' habitat selection for fuelwood collection in both dry and wet seasons.*

Table 4. 3. 2 *Poacher's habitat preferences through snares distribution in different vegetation types in wet and dry seasons*

Vegetation type	*Area (km²)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/ r+p*
Afro-alpine zone	1.4	0	0	0	0	0	0
Afro-subalpine dominated heathers	2.8	0	0	0	0	0	0
Montane forest dominated by *Podocarpus* and *Neoboutonia*	11.2	57.54	0.575	0.5754	-0.0004	1.1504	-0.000348
Drought resistant sclerophyllous bush	12.3	5.63	0.056	0.0563	-0.0003	0.1123	-0.002671
Hagenia forest	0.4	3.16	0.032	0.0316	-0.0004	0.0636	0.006289
Lowland humid forest	11.8	0	0	0	0	0	0
Gallery forest	1.4	2.36	0.024	0.0236	0.0004	0.0476	0.008403
Grassland and bush savanna	35.7	31.31	0.313	0.3131	-1E04	0.6261	-0.000161
Recent lava flows	2.3	0	0	0	0	0	0
Lake and River	18.3	0	0	0	0	0	0

Key   *r = the ratio of habitat type where snares occurred*

p = the proportion of occurrence of snares

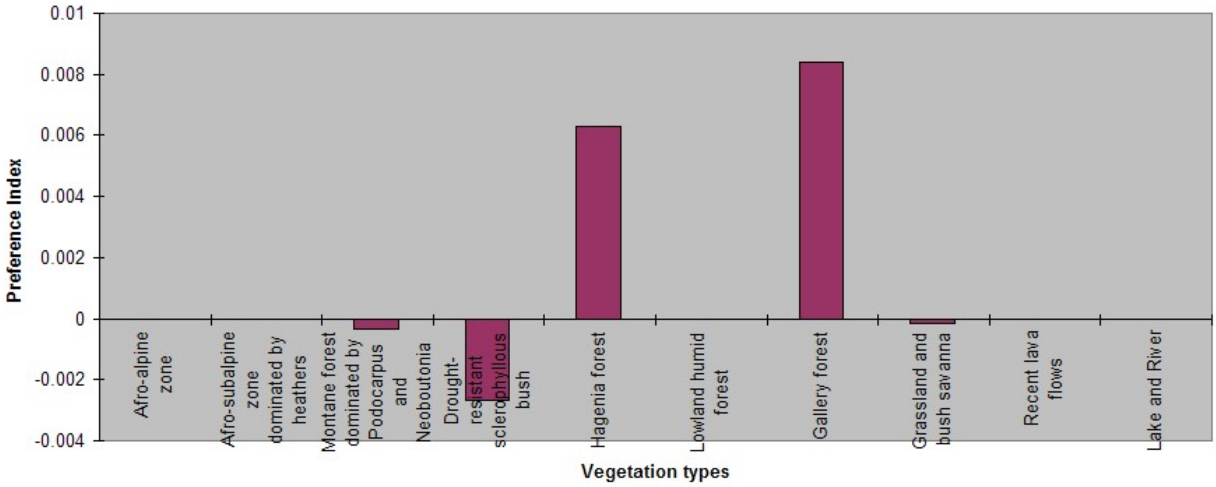


Figure 4. 3. 2 *Offenders' habitat selection through snaring in both dry and wet seasons.*

Both **Table 4. 4. 3. 2** & **Figure 4. 4. 3. 1** indicate that there was no poachers' habitat preference through carcasses spatial distribution in different vegetation types. This pattern is very different from the evident correlation shown by offenders' habitat preference through both snares and fuelwood (**Figures 4. 3. 1 & 4. 3. 2; Tables 4. 3. 1 & 4. 3. 2**). An unusual type of gallery forest lines the northern part of the upper Semliki. Covering both riverbanks side, are large acacia rooted in somewhat swampy ground. This habitat type is not easily penetrated by man and provides refuge for elephants, African buffaloes and giant forest hogs (*Hylochoerus meneirtzhageni*). Large mammals were more abundant in this habitat than in the *Cynometra alexandri*-dominated primary forest (Languy & de Merode, 2009a). Wildlife carcasses were very rare in such natural habitat along with the falls of Lusilube with a valley extremely steep and waterfalls at the confluence of the Butahu and the Lusilube Rivers.

Given the fact that habitats in VNP are dynamic and responding to many three key factors, including climate change, anthropogenic activities and induced fluctuations in large herbivore populations, it is strongly recommended that the park's management authorities keep track of quantitative observations of the vegetation on regular basis in order to achieve long-term habitat monitoring, including vegetation types, temperature, rainfall, and relative humidity. In this regard, I would like to kindly encourage the LEM-Habitat monitoring project recently initiated by the Belgium Royal Institute of Natural Science (IRScNB) and the ICCN to consolidate existing data on habitat dynamic in these sites and elsewhere.

4. 4 Quantifying Law Enforcement Effort in the Park

4. 4. 1 Foot Patrols an Illegal Activity Patterns

A total number of 14,143 LEM patrol forms from different management units collected by the park guards were considered during the study period. Patrols departed between 6:00h and 18:00 h and consisted of average patrol group size of 4.5 (+/0.5) park guards (range: 2-12). Patrols were limited in terms of time (mean 4.30 ± 0.2 hours) as a result of too many widespread unsafe areas (Mubalama & Mushenzi, 2004). The optimum duration of an effective patrol day is about 6:00 hours, walking at 3 km/hour in flat terrain and about 2 km per hour in undulating terrain (Jachmann, 1998).

Overall, only 7.2 % of patrols have caught illegal armed hunters and recovered weapons/ivory during successful encounters. Recovery of elephant ivory was mostly observed in 2007 when there were a higher number of armed contacts between guards and offenders (**Table 4. 4. 4. 1. 1**). The majority came from the patrol launched in the vicinity settlements apart from the well-armed gangs operating from their barracks located within and/or near the park boundary and a limited number of wandering Bakiga poachers (Verschuren *et al.*, 2009) originating from unspecified villages in Uganda. An illegal hunter's home village had an average distance to the closest PA border of 0.1 ± 0.7 km (range = 0.1-5.6 km, n = 136).

4. 4. 2 Foot Patrols and Dynamic in Illegal Trends

Table 4. 4. 4. 1. 1 summarizing the overall protection effort shows that with exception of charcoal making events (though higher events occurring in 2005), encounters with illegal activities were not evenly distributed over five year study period. There was a clear evidence that much more numbers of patrols (one and multiple-day patrols) were noticed in 2006, thus explaining the higher numbers of arrests, human encroachment, bushfire and poacher's camps (**Table 4. 4. 4. 1. 1**) recorded as compared to other years. The high number of gunshots heard could explain that armed poaching superseded the number of snaring occurrence in 2006.

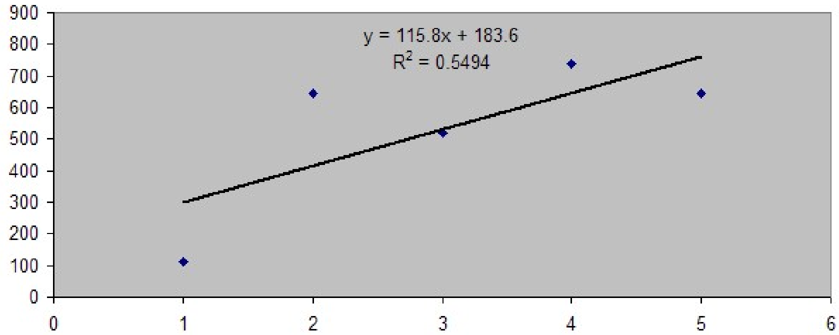


Figure 4. 4. 2. 1 *Dynamic of snares in Virunga National Park.*

Forty eight percent (**Figure 4. 4. 2. 2**) and 23% of the variation of respectively the human encroachment and bushfire in the park is explained by the guards' protection effort over the years. One of the consistent efforts of the law enforcement in VNP was directed towards addressing agricultural encroachment in a densely populated area. Some success was achieved although such efforts were few and far between. Indeed, one should bear in mind that African inhabitation has always been mobile, with continuous departures and arrivals. The permanent availability in usufruct of the ground, or the right to use the ground which does not belong to anyone, is behind the settlement of human groups. With different externalities (anthropogenic pressure, political interference and influence, low institutional capacities), it has been difficult for VNP authorities to effectively manage these forests as they are considered by local communities like their forest reserves without restriction where they can go to collect fuelwood and other materials. It is necessary to realize this context in order to understand the absurd character of borders transposed from Europe onto Africa – geometric borders, artificial and sometimes imaginary (Ki-Zerbo, 2004; Van Schuylenbergh, 2009). In the light of such reality it is easier to realize why some populations have difficulty regarding the respect of boundaries around a space that has become in some way private and the free use of which is forbidden to them (Leyens *et al*., 2009). The fact that PAs are often called 'reserves' is an indication that the resources they are protecting may be considered as a strategic reserve in times of emergency. While such ecologically diverse areas are often particularly important for conservation, they were also frequently sanctuaries for combatants in wartime. The fact that game is is perceived as being open access resource is a major obstacle to sustainable management of hunting.

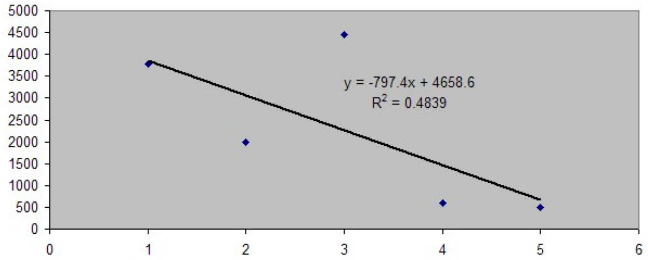


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Figure 4. 4. 2. 2 *Dynamic of human encroachment in Virunga National Park.*

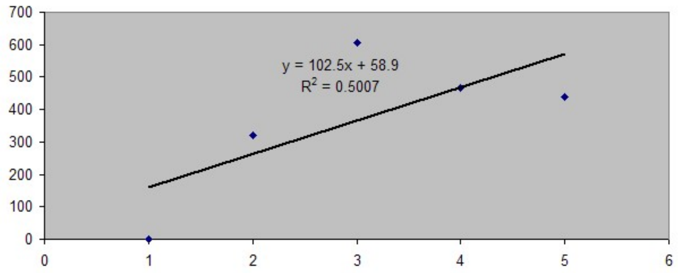


Figure 4. 4. 2. 3 *Dynamic of arrested poachers in Virunga National Park.*

More importantly, 55% and 50% of the variation of respectively the rope snares (**Figure 4. 4. 2. 1**) and arrested poachers (**Figure 4. 4. 2. 3**) in the park is explained by the protection effort over the years. Only twenty three percent of the variation of wire snares is explained by the patrol encounters. Both rope and wire snares were mostly encountered in 2007 (**Table 4. 4. 4. 1. 1**), explaining the snaring increase of 70.3% from 2006 and 41.6% increase as compared to 2008.

The study results show that there was a consistent effort from the park management with tremendous support from NGOs in successfully tackling the human encroachment occurrence, including the unprecedented invasion of the park involving 23,107 hectares and 88,100 people (Languy *et al*., 2009f). Thus, the declining trends in terms of human encroachment as indicated by **Table 4. 4. 2. 2**. Resettlement of population illegally settled at Kilolirwe and the western shore of Lake Edward as well as the finalization and consolidation of the boundary demarcation remain priority issues in the near future. They should be integrated into the VNP management plan that should stymie efforts to advance conservation and sustainable development.

One of the outstanding findings associated with illegal activity occurrence shown by **Table 4. 4. 4. 1. 1** & **Figure 4. 4. 3. 0** is the clear relationship between on the one hand, the EPMD per km^2/effective investigation per km^2 and the budget operation (total patrol cost ($US), patrol day expenditure per km^2/cost of patrol per guard per year), and on the other hand, the relationship between EPMD per km^2/effective investigation per km^2 and the protection effort translated by the seizure of 4 firearms and 153 ammunitions in 2008. Furthermore, human encroachment and soldiers' camps which were very common three years before were less encountered in 2008 when there was higher increase in both the number of EPMD per km^2 and the operation budget. The highest number of patrols launched in 2006 coincided in with the highest level of coverage and (**Table 4. 4. 4. 1. 1**) the highest number of poachers arrested. Not surprisingly, it was the only year when pieces of elephant ivory were seized over the five years. Moreover, there was a clear relationship between the highest number of patrols in 2006 and the highest encounter rates of bushfire, gunshots heard, and poachers' camps as compared to other respective years (**Table 4.4.4.1.1**).

4. 4. 3 Relating Illegal Activity to Patrol Effort, Enforcement Costs and Budget Operating Costs

Staffing density and the measure of patrolling effort were used to quantify the law enforcement effort in the park. For this purpose, it is necessary to establish a sound manpower management system for efficient deployment of the field force (Jachmann, 1988). In the VNP, out of 484 staff only an average of 362 park guards on effective permanent field duty worked a total of 34,180.8 EPMD for the protection of the whole ecosystem, which translates into 7.9 man-days per guard /Month^{-1}, implying that the staff force was working at 53% of its capacity (7.9 out of required 15 days per guard). The reduced staff force working capacity as compared to KBNP might be explained by several sporadic attacks launched by militias against patrol posts and park staff over the study period. A case in point in line with VNP patrol posts attacks is exemplified by a total of 10 furious attacks launched in a single year (2005) by FDLR and *Mai-Mai* groups (SYGIAP, 2006b). In addition, the difference of staff that was not effectively involved in protection effort was higher in VNP (122 guards) as compared to KBNP (23 guards), thus further reducing considerably the working force on the ground. Team patrol effort for the whole study area was set at 22.3 EPMD/Km²/year^{-1} per effective park guard. Once again, this figure is well below the one of 33 EPMD/Km² per guard suggested by Bruner *et al*., (2001). Yet with a total patrol cost of \$U 89.3 per Km², under-funding still jeopardizes the ability of the guards to safeguard park biodiversity. However, when analyzing separately the southern sector, about 61% of maximum capacity (9.1 out of required 15 days requested per guard) of the guard force was achieved in the only VNP southern sector where patrols augmented by dedicated foot searches basically conducted by well organized and motivated monitoring field teams. Thus, explaining the less clustering level of human disturbance as compared to other sectors (**Table 4. 5. 1**). Indeed, it should be mentioned that the Virunga Massif of which Mikeno is part and parcel is home to the mountain gorilla, which attracts international attention has the potential to generate over \$US 13 million dollars per annum in revenue from tourism (Hatfield, 2003). Not surprisingly, current estimated cost of the program in the Virunga Massif only amounts to \$U 126 /km^2/yr (Gray & Kalpers, 2005a). A plausible explanation is that mountain gorillas have enormous ideological significance for conservation internationally offering a highly potential for tourism to provide funds for conservation (Adams, 2003).

Patrols were usually very risky operations and human resources represented essential asset in this regard. Although quantity does not necessarily mean quality, there is a crucial need to ensure transparent restructuring of park personnel by rejuvenating the staff force and probably establishing a reduced number of staff in a way that is more manageable and complying with national policies regulating the public service.

In addition, while less than 20% of the field force should be involved in non-patrol duties (Jachmann, 1998), in VNP, a total of 25.2% of the field force was involved in non-patrol duties, including escort (time spent escorting chief park warden and assistant park warden), driving and guardian (time spent guarding offenders, property or park entrance gates) duties. To optimize staff density efficiency, I do suggest that all park staff be fully dedicated to anti-poaching exercises thus complying with their professional job description set in writing. To that end, reorganising of patrol posts should be undertaken through redeployment of human resources and their integration into a very simple and flexible management plan (de Merode & Languy, 2009b).

Figure 4. 4. 3. 0 indicates that though there were 12% of the variation explaining the increase of effective patrol man-days/km^2 following the related increase in the enforcement budget, however no significant relationship between the budget operating budget cost and the EPMD/Km^2 (y = 31692.622 + 183.335x; R2 = 0.12; P > 0.05) was noticed.

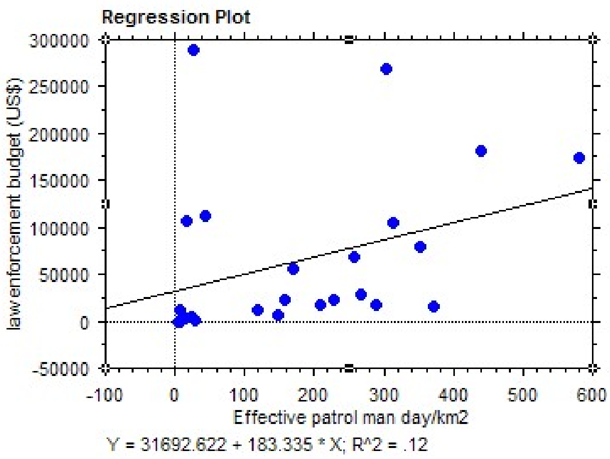


Figure 4. 4. 3. 0 *Correlation between the law enforcement budget (US$) and EPMD/km* ^{2}.

Figure 4. 4. 4. 1. 2 shows that the relationship between average patrol group size and the poachers arrested during successful encounters is not significant (y = 4826 + 0.002x; R^2 = 0.027; *P* = 0.434). With the ratio of offenders to park guards being higher during unsuccessful encounters (0.68) and the patrol group slightly outnumbering the illegal hunters by a factor of approximately 1.88 during successful encounters, which is smaller compared to the factor (2-3) suggested by Jachmann (1998), it is clear that there was no evidence for the effectiveness of wildlife protection laws aimed at preventing the butchering of wildlife in the VNP. During the 284 unsuccessful encounters, where the entire group of illegal hunters managed to get away

and/or park guards retreated (given high poachers fire power), the average size of patrol group was 5.0 ($^+$/0.5), which is slightly lower, but not significantly different from the average patrol size of 6.4 ($^+$/- 0.5) during 22 successful encounters. The average size of a group of poachers during unsuccessful encounters was 3.4 ($^+$/-2.1) while it sky rocketed to 12.0 ($^+$/-1.6) during successful encounters. Hence, the ratio of poachers to patrol members was higher during unsuccessful encounters (1.47) than during successful encounters (1.0). At first sight there seems to be a straightforward explanation for the above encounters to have been unsuccessful. It is important to emphasize the catastrophic plight of the large mammal populations following recent poaching onslaught by both the rebel groups and some blackguard elements of the FARDC operating in large groups associated with carriers recruited among local populations. In the area to the south of Lake Edward characterized by grassland and wooded savannas, through which the Rwindi, Rutshuru and Ishasha Rivers flow and where the terrain is relatively open and the sighting distance is great, park staff often did let themselves be taken advantage of when they often lit into the heavy armed offenders' groups. The average group size of heavy armed poachers was 40.4% higher during unsuccessful encounters as compared to successful encounters; this may explain why guards could often beat a hasty retreat after they shot it out with the gang. However, on no opportunity did the park staff surrender nor lay down their weapons. A peak in the encounters with armed offenders occurred between 5h45- 6h57 and much of these took place in Rwindi-Lulimbi plains, Mikeno massif and Ishango-Burusi areas. A monthly average armed encounters was set at 12.2 ± 2.3 (range 1-91, n = 25) with Rwindi sector holding highest encounter rates (4.05 ± 0.5) while average hunters arrested inside the park was set at 73.3 ± 0.2 (range 2-553, n = 25) per year with Rwindi sector once more holding the higest encounter rates (26.3 ± 3.3).

Although the optimum patrol size was estimated at approximately 12 members per patrol post with 6 staff for routine patrol and no more than 15 members during sweep operations, an increasing size of the poachers group will result in an increasing probability of guards being forced to escape during confrontations with ennemy armed with heavier weaponry. Therefore a patrol group in VNP should not be too small, but also too large beyond the figures above mentioned. Fire and maneuver are the two primary elements of any land combat power. Intelligence meaning gathering of information to use against an enemy or potential enemy should seek to develop plans that will be useful in defeating a potential or real enemy. In the VNP context, information on enemy capabilities should include numbers, weapons, and style of operating, organization, and location. To this must be added battlefield, constraints of terrain, weather, light, and the sociopolitical environment. Intelligence operation alone will not guarantee combat success. Presuming the information is correct; patrol leaders must have the understanding and courage to use it to the best advantage. The aim is to measure what an enemy can or will do while the park staff are hot on the heels of the poachers' gang.

Table 4. 4. 3. 1 *Snare specific hotspot in Virunga National Park*

Park Management Unit	Year	Illegal activity	Poaching Hot spot (sq km)
		Snares occurrence	KHR (50%)
Northern	2004-2006		90.39
	2007		42.92
	2008		38.26
Central	2004-2006		47.16
	2007		33.84
	2008		97.61
Southern	2004-2006		27.63
	2007		35.11
	2008		22.89
Lulimbi	2004-2006		96.96
	2007		10.74
	2008		10.52
DCRKZ	2007		37.79
	2008		72.3
Average			**47.44**
STDEV			29.96

Snare specific hotspot covered 47.44% of the park with the central sector having the highest snare distribution area (**Table 4. 4. 3. 1**) respectively in 2008 in Rwindi area and 2004-2006 (**Table 4. 4. 4. 1. 1**) in Lulimbi savanna dominated habitat. Overall, threats specific hotspot covered 3,169 km^2 which represents 40.4% of in the entire park with four key threats identified, including charcoal kilns (48.5%), gun shot (48. 1%) and snaring (47.4) being the major threats followed by human encroachment (36.5%), illegal fishingactivities (35.7%) and poachers' camp (29.2%). The quite similar figures between the charcoal kilns occurrence and gunshots heard may be explained by the involvement of military in charcoal making activity. They have equally been reportedly quoted as main drivers of illegal fishing on Lake Edward along with park staff.

The concentration of wildlife crime suggests significant crime prevention potential for such strategies as hotspot patrols (Sherman & Weisburd, 1995; Weisburg & Braga, 2006), which focus focus patrols resources at specific locations with largeencounter rates of illegal activities. If poaching hottespot shifts rapidly from place to place to make place coolspot, it makes little sense to focus crime control resources at such locations, because they would naturally become free of illegal offtake (Spelman, 1995). The most comprehensive examination of the stability of crime at place over time conducted by Weisburd *et al*. (2004) suggests tremendous stability of crime across crime hotspots; hence crime hotspots appear to remain hot over longer period of time. Support for this argument is found in a number of arrestees elaborated, "*You really can't deal in areas you aren't living in, it ain't your turf*". It is simply that offenders come to feel comfortable with their home turf and the guards that they encounter. Basic quantitative findings suggest that for the wildlife crime hotspots (WCH) examined, illegal activities did not simply move around the corner in response to protection efforts, but rather the study supported the position that the most likely outcome of patrol deployment is a diffusion of crime control benefits to nearby areas.

Table 4. 4. 3. 2 *Poacher's habitat preferences through carcass occurrences in different vegetation types in wet and dry seasons*

Vegetation type	*Area (km^2)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/r+p*
Afro-alpine zone	1.4	0	0	0	0	0	0
Afro-subalpine dominated *heathers*	2.8	0	0	0	0	0	0
Montane forest dominated by *Podocarpus* and *Neoboutonia*	11.2	49	4.02	0.49	3.53	4.51	0.7827051
Drought-resistant scerophyllous bush	12.3	22	1.8	0.22	1.58	2.02	0.782178218
Hagenia forest	0.4	5	0.41	0.05	0.36	0.46	0.782608696
Lowland humid forest	11.8	0	0	0	0	0	0
Gallery forest	1.4	67	5.49	0.67	4.82	6.16	0.782467532
Grassland and bush savanna	35.7	1045	85.73	10.45	75.28	96.18	0.07826995106
Recent lava flows	2.3	0	0	0	0	0	0
Lake and River	18.3	31	2.54	0.31	2.23	2.85	0.78245614

Key *r = the ratio of habitat type where carcasses occurred*

p = the proportion of occurrence of carcasses

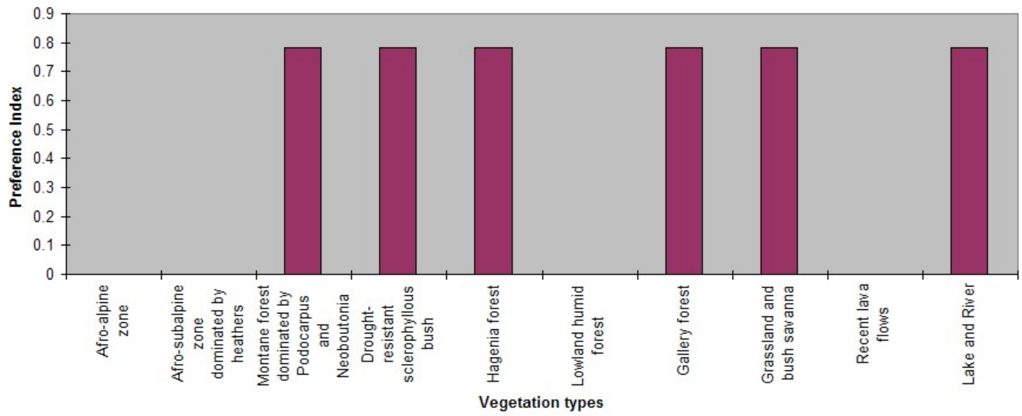


Figure 4. 4. 3. 1 *Carcasses distribution and habitat types.*

As can be seen from **Figure 4. 4. 3. 2** poachers' camps distribution was most widespread in the central sector in 2006, thus corresponding to the period of the study when there was highest numbers of poachers' camp, gunshot heard, human encroachment, and bushfire occurrences. Not surprisingly this period coincided as well with the highest numbers of offenders' arrests and firearms recovery (**Table 4. 4. 4. 1. 1**). With respect to indirect poaching indicator, on average, poaching camp specific hotspot covered 64. 1% of the park (**Table 4. 4. 3. 3**). Both rope and wire snares occurrences in the park were most noticed in the central sector of the park **(Figure 4. 4. 3. 7**). The figure is up significantly from previous year and fair higher than in 2004.

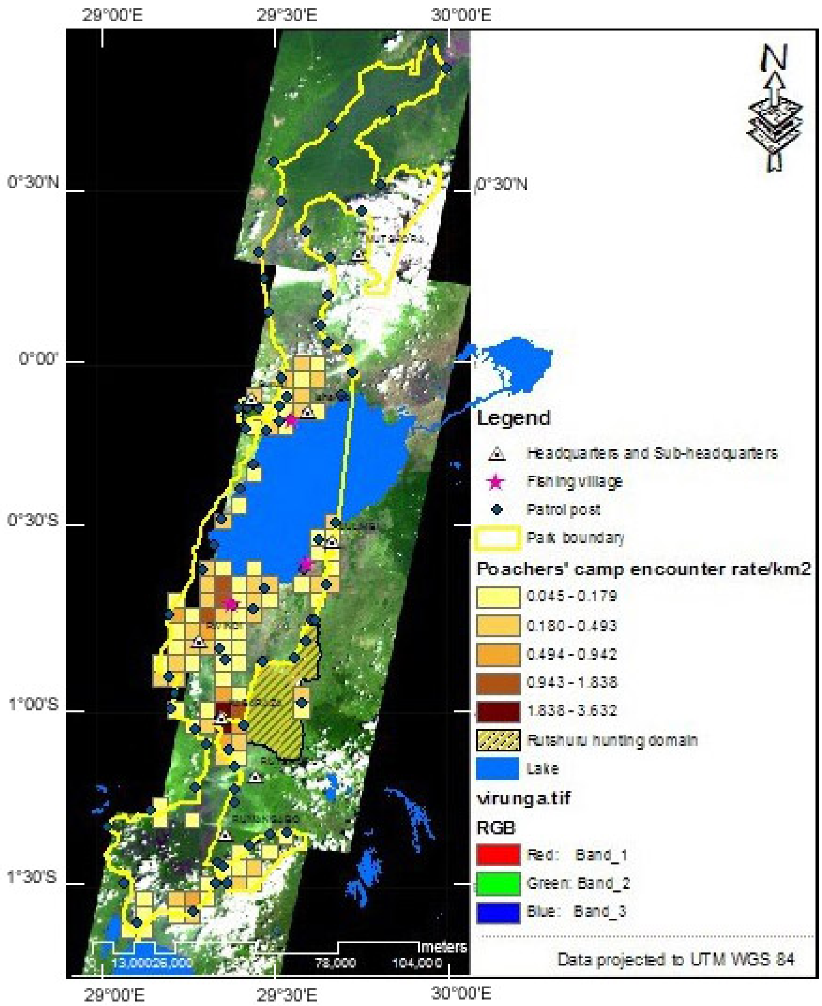


***Figure 4. 4. 3. 2** Poachers' camps encounter rates in Virunga National Park.*

In termes of practical conservation, these results suggest that, while current levels of hunting may be reducing the abundance of some large mammals, this study is therefore limited in its ability to make in depth assessment of the likely sustainability of current hunting practices in the park. Indeed, when a wildlife population is exploited, population size will be reduced, and does not in itself indicate unsustainable hunting (Mulner-Gulland & Mace, 1998; Sutherland, 2001). Only if a wildlife population continues to decline over time, can unsustainable hunting be demonstrated. It is well known that teasing apart the factors that determine abundance is notoriously difficult (White *et al*., 2007), and species abundance can be affected by a nmber of anthropogenic threatening processes (Issac & Cowlishaw, 2004), habitat factors (Peres, 1997), natral stochasticity (Beddington & May, 1977), and species interactions (Karanth *et al*., 2004). Without further monitoring over time it is difficult to assess whether current hunting is unsustainability. However, despite this limitation, the study results have practical implications for the management of hunting in the VNP especially when undertaking considering the update of the park management plan in the near future.

Table 4. 4. 3. 3 *Poacher's camp specific hotspot in Virunga National Park*

Park Management Unit	Year	Illegal activity	Poaching Hotspot (sq km)
		Carcass occurrence	KHR (50%)
Northern	2004-2006		34.61
	2007		36.25
	2008		64.70
Central/Rwindi	2004-2006		47.26
	2007		90.32
	2008		56.39
Southern	2004-2006		80.91
	2007		93.7
	2008		59.65
Eastern/Lulimbi	2004-2006		17.8
	2007		58.48
	2008		70.43
Rutshuru hunting domain and Kabaraza	2007		18.55
	2008		22.44
Average			64.08
STDEV			41.53

Fuelwood collection and illegal fishing occurrences were most noticed in 2005 (**Table 4. 4. 4. 1. 1**) with respectively 46% and 22% of variation explained by patrol encounters. Although few human signs could be directly attributed to fuelwood collection as compared to charcoal kilns distribution, it was considered a major threat to the VNP's future ecological integrity especially in the face of the growing number of illegally fisheries (**Figure 4. 7. 4. 1**) spreading over on the shores of Lake Edward and the severe destruction of *Olea africana* habitat. From that prospect, there is an overriding need to re-establish of the illegal fishing settlement on the Lake Edward through the following activities (i) zoning system in officially recognized fishing villages, (ii) demolition of illegal fishing settlements, (iii) re-negotiation of agreement with the Coopérative de Pêcheurs de Vitshumbi (COPEVI) and other stakeholders and last but not least, (iv) lauching the study on the potential fishing yield of the Lake (de Merode & Languy, 2009b).

Patterns of arrests show that mean number of arrests made within years by guards were realized with about equal frequency in each of the months, but tended to be lower in March and

September corresponding to the beginning of the rainy season. During the wet season patrols are often hampered by rainfall, flooded rivers and tall grass, which probably make capturing illegal hunters more difficult at these periods of the year. However, the number of arrests peaked in October through December. This apparent increase in the number of arrests per guard could have resulted from at least one factor. Increase in the number of hunters entering the park could likely lead to more frequent encounters between guards and hunters, and this might cause an increase in arrests even with no change in the number of efficiency of law enforcement. Indirect observations may vary with patrol effort and efficiency. Staff efforts, and thus data reliability, also change depending on performance incentives (e.g., Jachmann 2008*a*).

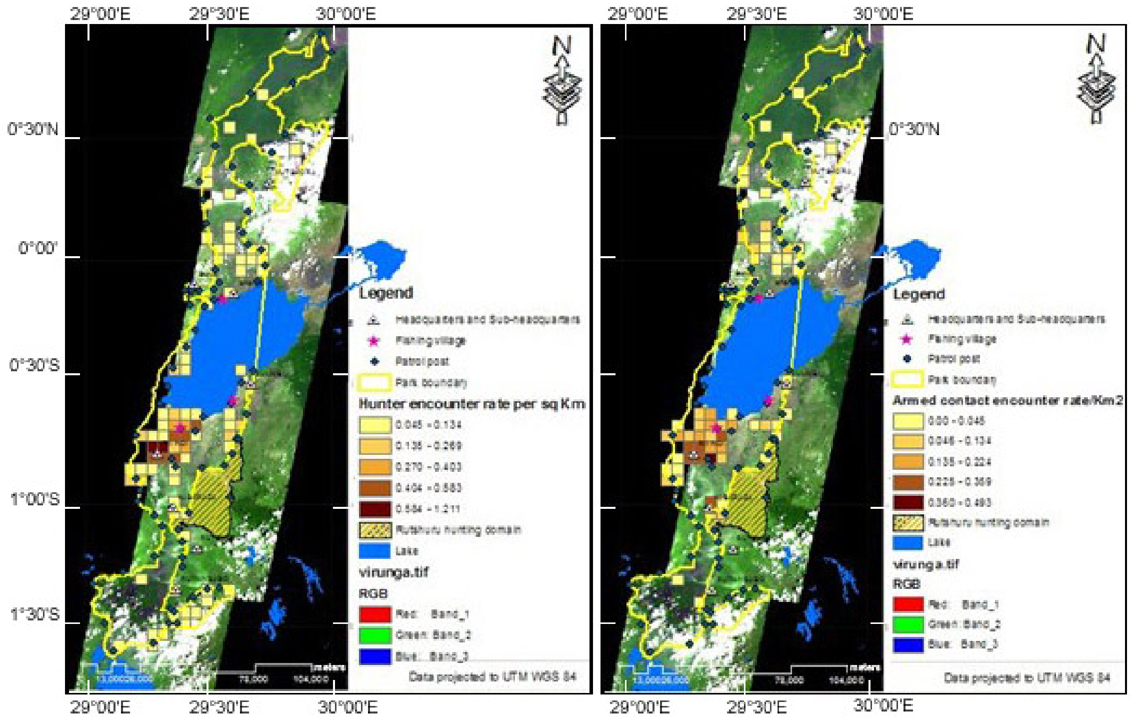


Figure 4. 4. 3. 3 *Map showing hunters versus armed contacts encounters rates in the park.*

Figure 4. 4. 3. 3 on hunters contact encounter rates shows that human incursions have penetrated deeper into the park; suggesting that the composition and *modus operandi* of the poaching gangs should have changed as a mean of adaptive strategy. It is also possible that law enforcement patrols have led to a diffusion of human activities, as any concentration of humans or long-term residency were more likely to be detected by the patrols (Blom *et al*., 2004). In order to distract the attention of park guards, Bakiga poachers coming from Uganda have developed another strategy aimed at putting the shoes the other way around so that the footprints may give the false impression of being back home across the ishasha river (making the border between the VNP in DRC and QENP in Uganda). The latter were actively operating in the core of Lulimbi sector where five patrol posts were operational; these were respectively Lulimbi, Kinyonzo, Nyakakoma, Ishasha and Ruti (Balole, pers.comm.). Owing to long-term field

experiences, guards finally managed to spoil that gang's shady game through dramatic encounters. Other outposts were not fully functioning. These were 7 traditional patrol posts in the central sector including Kasali, Rwehe, Linga, Taliha, Lunyasenge, Mosenda, Kisaka (**Figure 4. 1. 1. 1**) as well as 4 known patrol posts in southern sector (Kingi, Burungu, Mushari, Kanyangiri). Operational patrol posts in the northern sector were Cotongo, Mwalika, Vikingi, Muko, Boga, Lamia, Biangolo and Kikura (Mushenzi, pers. comm.). Huge swaths of the northern part of the park was occupied by National Army for the Liberation of Uganda (NALU) and various Congolese militia groups, with the onset of the civil strife in 1996 forcing withdrawal of a permanent ICCN presence in the sector for over a decade. Two ICCN staff were captured by the NALU while still dedicated to control this abandoned sector.

Table 4. 4. 3. 3 *Poacher's camp specific hotspot in Virunga National Park*

Park Management Unit	Year	Illegal activity	Poaching Hot spot (sq km)
Northern	2004-2006	Poacher camp occurrence	11.516
	2007		8.312
	2008		11.082
Central	2004-2006		23.126
	2007		68.27
	2008		101.272
Southern	2004-2006		35.824
	2007		66.69
	2008		8.844
Lulimbi	2004-2006		16.828
	2007		25.918
	2008		14.388
DCRKZ	2007		7.07
	2008		9.198
Average			29.17
STDEV			29.051

Table 4. 4. 3. 3 shows that poacher's camp specific hots pot covered on average 29.2% of the park with most incident distribution occurring in the central sector (**Figure 4. 4. 3. 2**), with emphasis in 2008. The highest EPMD/km^2 coupled with the highest patrol expenditure cost per km^2 (**Table 4. 4. 4. 1. 1**) could explain the poachers' camp and charcoal encounter rates over larger area.

Until recently, accessibility to the northern sector of the VNP, including the Watalinga forest was severely limited due to poor state of the abandoned Mbau-Kamango road (48 km) currently in a state of disrepair and which bissects the park between Djuma and Mukakati (**Figure 4. 4. 3. 4**). Overall, as documented elsewhere in the VNP, anti-poaching patrols have remained frequent during during the conflict (de Merode *et al.*, 2007) in the northern sector though at limited extent.

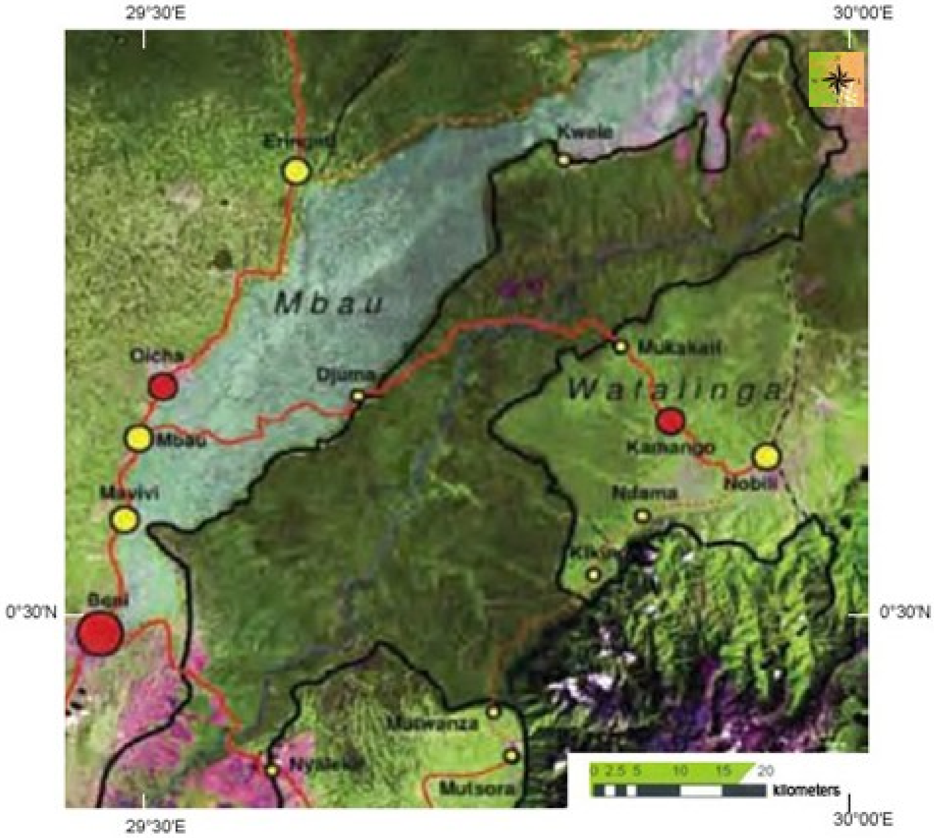


Figure 4. 4. 3. 4 Map showing the extreme northern sector of the park with patrol posts (yellow feature) and big cities (Red feature). Source: Nixon & Lusenge, 2008).

In 2006, WWF in collaboration with ICCN and Gilman International Conservation (GIC) field staff conducted a preliminary exploratory field survey of the Watalinga forest, recording okapi signs on the west bank of the Semliki and thus confirming continued presence of the okapi in the Watalinga forest (Bashonga, 2006). This field survey paved the way to subsequent surveys in 2007 by WWF (Bashonga, 2007), the Wildlife Conservation Society (WCS) survey in early 2008 as well as the Zoological Society of London (ZSL) survey between 19 January to 4 February 2008 the along with ICCN staff, and which further documented the continued presence of the okapi on the west bank of the Semliki river (Plumptre *et al*., 2008). These combined surveys with limited LEM data were the only data that provided reliable information on the wildlife and threats status in this remote extreme northern part of the VNP. Although no commercial bushmeat hunting was recorded probably on the eastern side of the Watalinga forest at Kamango (**Figure 4. 4. 3. 4**) due to the hidden nature of the bushmeat trade, the ZSL-ICCN field team observed the carcass and live infant of a female *Cercopithecus ascanius* shot locally by military personnel, heard gunshots in the Rwenzori Mountains while at Ndama and received reports that three chimpanzees (*Pan troglodytes schweinfurthii*) had been shot and eaten by military. **Figure 4. 4. 3. 5** below provides the threat patterns in Watalinga Virunga northernmost region.

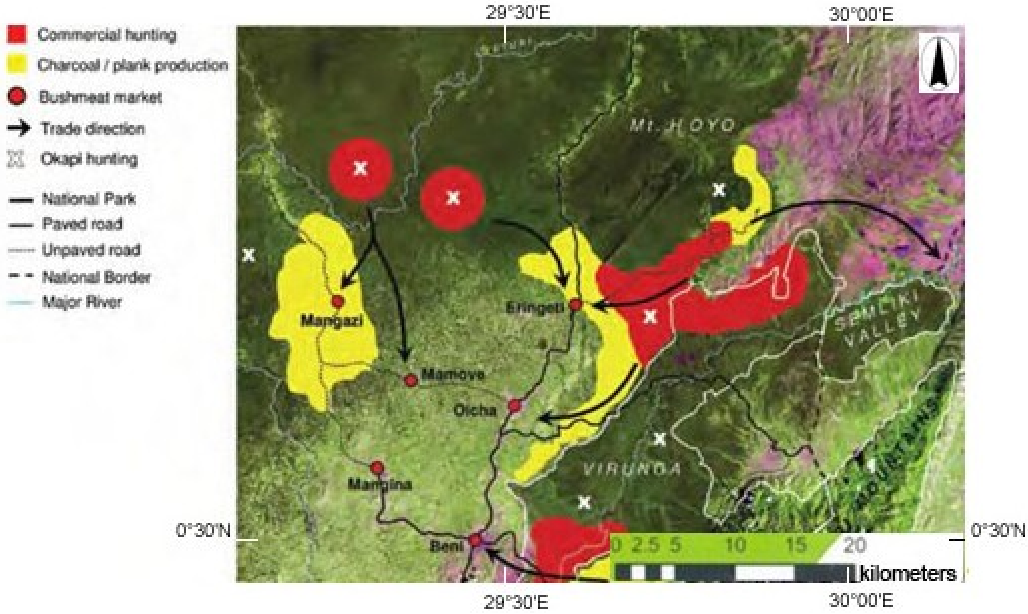


Figure 4. 4. 3. 5 *Map showing the Wildlife threats in Watalinga area. Source: Nixon & Lusenge, 2008.*

The ZSL-ICCN survey (Nixon & Lusenge, 2008) results show that the artisanal production of charcoal was a major regional income activity as evidenced in **Figure 4. 4. 3. 5.** Charcoal production was focused around the western park limits east of Eringeti and along an 8.5 km stretch of the Mbau-Kamango road. Major sites of charcoal production were also observed west of Oicha and along the southern park boundary near Nyaleke camp (**Figure 4. 4. 3. 4**). The most favored and heavily exploited tree species reported and observed during the survey period was *Cynometra Alexandra*, (known locally as '*tuna*'), a primary forest species associated with mature lowland formations and one of the prominent tree species in the Watalinga. It was estimated that 112-140 tons of charcoal are produced and sold on a weekly basis in the vicinity of the park; this translates into the felling and processing of 560 -700 tons of wood every week (Nixon & Lusenge, 2008). With the current lack of an ICCN presence in the Ndama area, this represents was serious threat in the area since no regulation of charcoal production was observed or reported in the region on a regular basis

One of the main threats to the wildlife in the northern area was the snaring to catch small ungulates, monkey and rodents. Most snares were set near the boundary (**Figures 4. 4. 3. 6 & 4. 4. 3. 7**). They (72% of which were active) were the most frequently encountered hunting signs, accounting for 94% of all observations made by the quoted field team in this sector (Nixon & Lusenge, 2008)

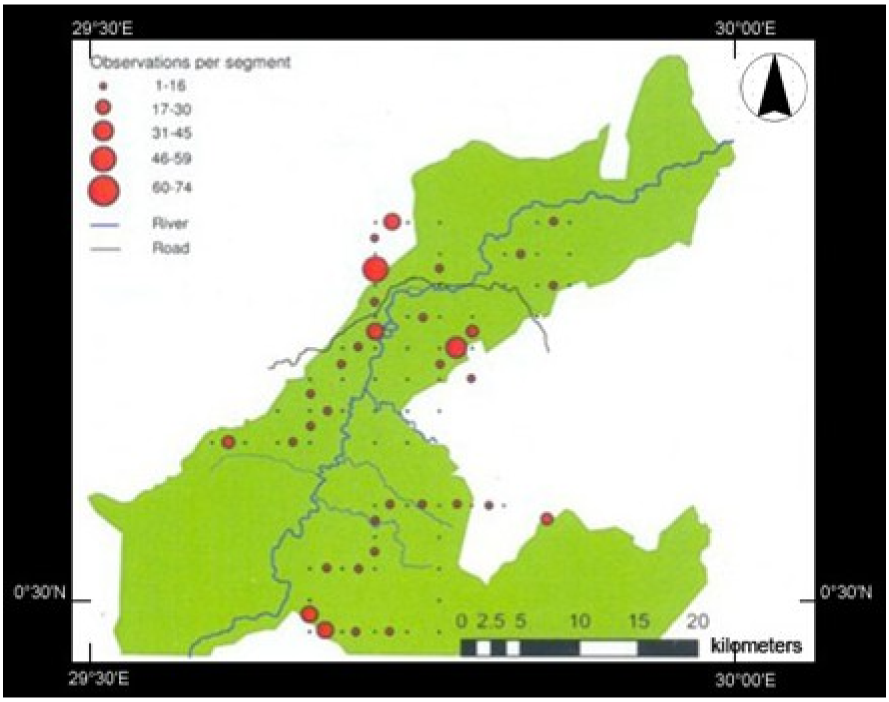


Figure 4. 4. 3. 6 *Map showing the distribution of hunting activities in the northern sector (Nixon & Lusenge, 2008).*

The protection of the Watalinga forest remains a serious challenge for ICCN as currently; only nine guards were stationed along the Mbau-Kamango road at the Mukakati and Djuma patrol posts while no park presence was noticed in the northern area of the Watalinga forest. This lack of ICCN presence does not fit into the Strategic Deployment Model (Tucker, 2003) which suggests that each patrol post is then staffed with two patrol units comprised of 6 guards, therefore it is too small to sustain sufficient monthly patrol coverage and accordingly, the relevant probability detection of illegal intrusion does not apply in this larger particular area, thus leaving staff exposed to gangs frequent attacks. These armies, be they rebel or government, were well equipped and often carried heavier weaponry to poach systematically forest species for food (bushmeat) or for commercial trade (e.g., ivory, trophies).

From the biological team surveys in the northern sector of the park where ICCN patrol field teams were almost absent, I draw the lesson that research programs carried out under relative security were able to provide another mean of verification of patrol data. Additional benefit deriving from research surveys was the inadvertent uncovering of information relevant to conservation gathered in remote area beyond the reach of patrol expeditions. If conservation personnel record signs of illegal activity simultaneously with biological data, investigators can obtain a more complete picture of the impact of illegal activities (Jachmann 2008*b*). Increased data collection requirements, however, can lead to personnel fatigue and reduce effectiveness of enforcement (Leader-Williams *et al.*, 1990). This reality applies as well for the KBNP where large biological survey teams were accompanied by 50 soldiers to be able to work (Shalukoma, 2000), implying that during wartime well-managed operations with field biological teams supported by military proved successful, but international support may also be required (Hart, 2005). One suggested way to achieve this might be to broaden the UN peacekeeping mission in DRC (MONUC, now MONUSCO) to include securing the country World heritage sites and other protected areas.

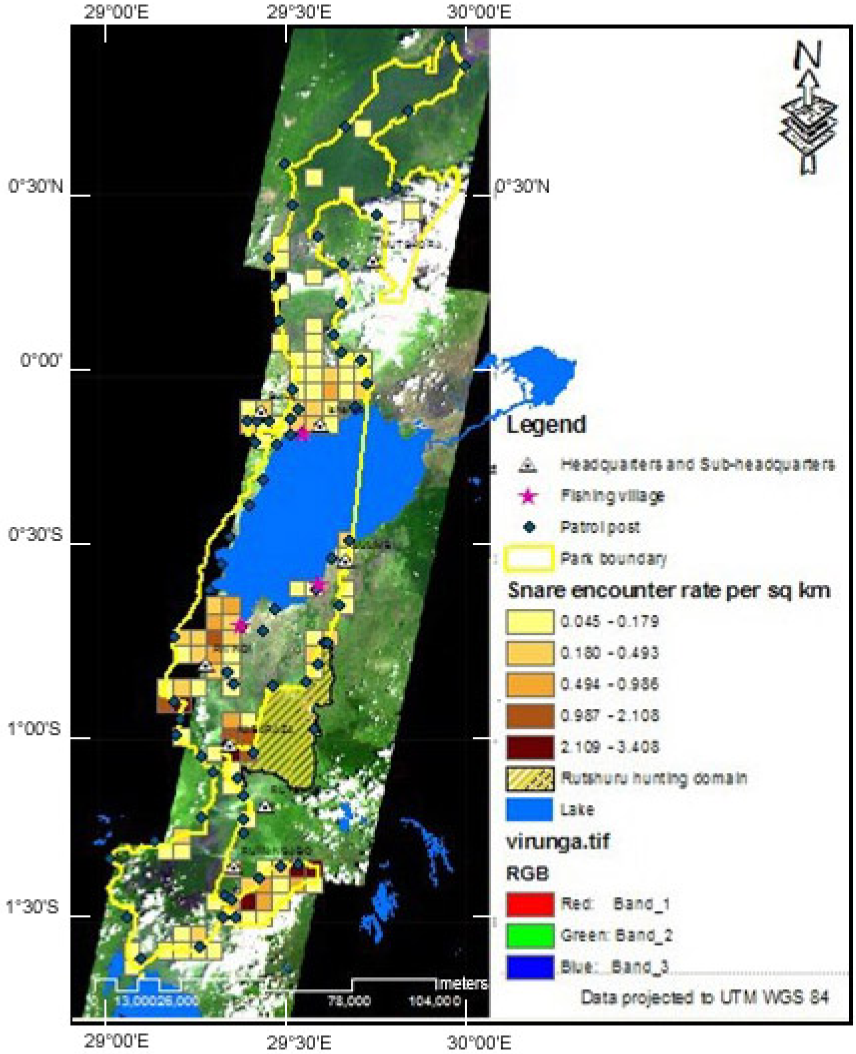


Figure 4. 4. 3. 7 *Snares setting encounter rates in Virunga National Park.*

To strengthen protection of the VNP, the advance force of ICCN staff has been set up in the beginning of 2006 with funding from the EU, and strong support from the (Frankfurt Zoological Society (FZS) and African Conservation Fund (ACF). The advance force was a group of 49 elite park guards who were given 6 months special force training, including a tough physical regime and firing lessons. The advance force guards were meant to be deployed only in emergencies, in order to help protect the mountain gorillas and Common hippos in VNP. The advance force was divided into three small mobile troops. When needed, they shared information with MONUC peacekeepers. They performed a different role that of regular ICCN guards. They were deployed throughout VNP as required by emergencies such as attacks to guard patrol posts and immediate threats to wildlife populations. They also protected civilians on the edge of the park, arrest illegal loggers, poachers, etc. (Wildlife Direct, 2007) and even covered the retreat of the women and children from the station as they fled into the park to escape the attacks. In order to improve anti-poaching performance, advance force should be rehabilitated as a strike force whose efficacy will depend on good communication and mobility. This strike force should provide a rapid response unit to reports or calls for assistance forwarded by the various armed and supplied with adequate weapons to ensure that it is at least struggling on equal terms or even better with heavily armed poachers (Mubalama, 2000).

Evidence is provided that the strategy of deploying guards in a series of limited well equipped patrol posts, strategically distributed over the conservation area, is more effective as deterrent than concentrate field staff in several centrally placed large camps, provided other factors determining the efficacy of law enforcement are catered for through on the job-training and adequate supervision my middle management staff (Mubalama & Mushenzi, 2004). A certain number of run-down or abandoned former patrol posts were no more contributing to field operations and accordingly need to be rehabilitated (some of them might now be used as observation posts). These include Kinigi, Burungu, Kilolirwe, Kakomero in the southern sector; Nyaruhange in the Rutshuru hunting domain; Mavivi, Kotongo and Vikingi in the northern sector, and Kasali, Rwehe, Linga, Taliha, Lunyasenge, Mosenda, Kisaka in the central sector (**Figure 4. 1. 1.1 & Annex 12**).

4. 4. 4 *Relating Illegal Activity to Detection Probability*

4. 4. 4. 1 *Detection Probabilities of Wildlife Carcasses by Patrols Deployment*

Quantifying the encounter rates of illegal activity per unit effort or catch per effort indices (CPUE indices) and the absolute quantity of illegal activity enabled to determine patrol areas most affected and the probability of finding carcasses. With about 53% of maximum capacity of the guard park force on the ground, the probability of detecting wildlife carcasses in the field did not significantly increase ($y = -0.383x + 225.58$; $R^2 = 0.077$; $P = 0.178$) nor did the probability of arresting offenders increase ($y = 4826 + 0.002x$; $R^2 = 0.027$; $P = 0.343$) with the increasing number of effective average patrol size (**Figures 4. 4. 4. 1. 1 & 4. 4. 4. 1. 2**). Although round-the-clock surveillance of all park sectors is required, there is a crucial to concentrate effort and be selective when resources are short (Leader-Williams et al., 1990).

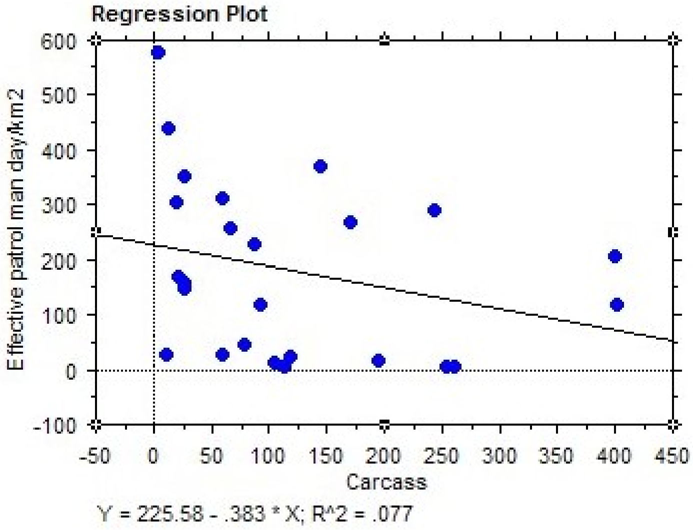


Figure 4. 4. 4. 1. 1 *Correlation between wildlife carcass detection and EPMD/ km^2.*

Probability of detecting carcasses increased with the enormous size of key large mammals' carcasses which attracted high concentration of vultures for prolonged period, thus making it relatively easy to detect a dead animal at a distance of sometimes as much as 5 km. In addition, illegally set fire was often used to herd wildlife toward traps or to lure them to potential areas of new growth. Leader-Williams & Milner-Gulland (1993) suggested that increasing detection probability was an effective way of reducing illegal bushmeat hunting originating from local villages surrounding the protected areas.

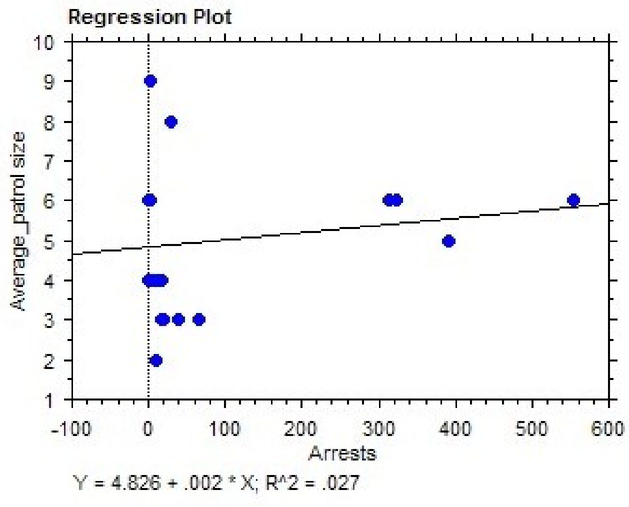


Figure 4. 4. 4. 1. 2 *Correlation between offenders' arrests and average patrol size*

Illegal hunters using wire snares mostly worked at night by themselves or in small groups and used inconspicuous hunting methods. For this reason the likelihood of illegal hunting activities being detected in dense vegetation areas and certain types of topography including humid forest in the northern and southern parts of the VNP. There is crucial need to concentrate effort and be selective when resources are short (Leader-Williams *et al.*, 1990). The use of the Trackguard remote electronic surveillance technology (**Box 4. 10. 1**) through real-time information obtained from the sensors allowing timely dispatching of patrols into areas under invasion is highly the way forward if we need to curb armed poaching in the VNP as well as in the KBNP. TrailGuards have evolved very much in the last year and since the magazine (**Box 4. 10. 1**) and was tested both in Ishango and Tshiaberimu (**4. 1. 1. 1 & Annex 12**) where Steve Gulick spent 6 months testing the electronic surveillance device.

During those visits, the need to add cameras into the system and to transmit the images of the intruders in real-time via cell or satellite was perceived. There are, of course, many advantages to receiving images before sending a patrol out, such as the certainty that it is not a "false alarm" and knowing class of intruders (e.g., are they villagers or renegade militia?) would contribute to the safety of the patrol. Importantly, advances in technology have made the equipment cost for sending images via satellite comparable with the previous system which only sent a short message as an alarm, thus deterring intruders from entering into PA with the intent to poach.

As a very rough figure now, each unit (camera/satellite modem/and associated other sensors) would be in the order of $US 1,000. It’s expected that there will be a number of different configurations possible (cost hardware) which could reduce the cost in certain conditions. Since the units would be hidden along those trails that are most commonly used by poachers (**Box 4.10.1**), even a small number of units could potentially detect a significant number of poachers now using a park (Steve, pers. comm.). Though the Trailguard device could not be taken as a surfire remedy at this stage, the system can increase ranger safety also, particularly in a place like the VNP since even before rangers are sent out, one would know from the transmitted images the kind of risks the patrol would be facing (e.g., subsistence poachers or heavily armed militia). In addition, TrailGuards could provide increased security for ranger stations in the park by providing an early warning in the event of a rebel attack as has happened in the park in the past. Park staff have been suffering incredibly from more than a decade. Hopes were high that the election would bring peace in the region- but the hopes have been dashed. Park staff were desperate as tensions increased. Although Traiguard was very effective in detecting the AK-47 assault rifles carried by the rangers (Gulick, pers.comm.), there are still several shortcomings of the current ‘blind’Trailguard sytem which could be solved by adding ‘smart’cameras – cameras that in addition to image recording also have the attached computing power to interpret the image content in situ (Gulick, 2008).

Table 4. 4. 4. 1.1 *Summary of the law enforcement effort statistics (2004-2008)*

Year	**2004**	**2005**	**2006**	**2007**	**2008**
Amount of patrolling					
Number of Patrols	1698	3570	4443	4168	3247
Number of Patrol days	2537	3836	5075	5115	3991
Effective patrol man-days per km²	14.7	27.38	20.15	18.75	30.38
Effective investigation day per km²	9	7	10	11	36
Coverage (km²)	4475	3224	6100	5650	4800
Man power					
Staff	484	484	484	484	484
Effective patrolling guard	464	464	464	454	444
Frequency of offences					
Elephant killed	25	37	5	46	35
Gorilla killed	0	0	9	7	0
Hippo killed	59	127	600	45	54
African Buffalo	28	75	71	55	57
Thoma's Kob	14	29	127	117	175
Heard gunshot	0	830	5126	1946	2921
Illegal fishing	192	781	544	487	667
Encroachment	3793	1979	4462	605	493
Fire	996	1709	2248	320	413
Charcoal	674	1598	1173	1547	649
Poacher's camp	34	615	1097	961	166
Wood collection	262	573	321	65	60
Rope snare	112	643	518	739	643
wire snare	148	355	17	1064	409
Armed contacts	0	61	117	56	72
Results					
Arrests	0	319	607	468	438
Firearms confiscated	0	0	2	1	4
Ammunition seized	0	0	0	0	153
Ivory recovered	0	0	15	0	0
Indicators (level per hundred effective patrol man days/km2)/ CPUE					
Elephant killed	0.0055866	0.011476	0.0008197	0.008142	0.007292
Gorilla killed	0	0	0.0014754	0.001239	0
Hippo killed	0.0131844	0.039392	0.0983607	0.007965	0.01125
African buffalo	0.006257	0.023263	0.0116393	0.009735	0.011875
Thoma's kob	0.0031285	0.008995	3.4	0.020708	0.036458
Gunshots heard	0	0.257444	0.0208197	0.344425	0.608542
Illegal fishing	0.042905	0.242246	0.0891803	0.086195	0.138958
Patrol arrest	0	0.098945	0.0995082	0.082832	0.09125
Encroachment	0.8475978	0.613834	0.7314754	0.10708	0.102708
Fire	0.2225698	0.530087	0.3685246	0.056637	0.086042
Charcoal	0.1506145	0.495658	0.1922951	0.273805	0.135208
Poacher's camp	0.0075978	0.190757	0.1798361	0.170088	0.034583
Wood collection	0.0585475	0.17773	0.052623	0.011504	0.0125
Rope snare	0.0250279	0.199442	0.084918	0.130796	0.133958
wire snare	0.0330726	0.110112	0.0027869	0.188319	0.085208
Armed contacts	0	0.018921	0.0191803	0.009912	0.015
Expenditure					
Total patrol cost (US$)	22689	218856.6	725961.45	282423.1	981903.7
Cost of patrol per guard per year	46.878099	452.1831	1499.9204	583.5188	2028.727
Patrol day expenditure per km²	5.0701676	67.88357	119.01007	49.98639	204.5633
Cost of effective investigation days per km²	1.7750893	0.103118	0.0840265	0.22006	0.175985

VNP and Uganda Wildlife Authority (UWA) managers are working with police and customs and the military to tackle some of the transboundary trade in ivory, timber and bushmeat but it is a constantly changing scene. This would point to the need for better intelligence or when, where and in what force the poachers intend to strike, the need to infiltrate the poachers' ranks and in particular get close to those who direct the poaching and reap the greatest benefits. The relative efficiency of investigation operations over conventional patrols, in terms of arrests and recovery of firearms and ivory, was demonstrated by Leader-Williams *et al*., (1990). Armed with information besides guns, our law enforcement teams would better be placed to head off the butchers before the carnage starts.

4. 4. 5 The Optimal Law Enforcement Effort in Virunga National Park

When using the measure of protection effort for foot patrols, each patrol GPS coordinates were available for the route followed. The grid being used for the project has fixed grid cell of 5x5 km, using UTM, WGS 84 projection as a reference base. Patrols without a GPS reading were discarded from coverage analysis. In order to estimate area covered, an estimate of the mean visibility profile was required. The mean visibility profile was 0.2 km (e.g., 200 m or 100 m on either side of the line of march), taking into account the difference in visibility between open woodland savanna and closed woodland savanna. Using this figure in combination an estimated mean patrolling distance per day of 15 km at 3 km per hour (Bell, 1979; Jachmann, 1998) gives a mean area surveyed of 3 km^2 per day or 0.6 km^2 per hour, or 0.2 km per km of travel. This meaning that to survey completely a square of 25 km^2 would require 8.3 days, or 41.7 hours or 125 km of patrolling, assuming no repetition of routes. Again, assuming no footpath repetition, complete surveillance of the VNP (7,844 km^2) would require 2,622.8 effective patrol days or 13,177.2 patrol hours of 39,500 km per year $^{-1}$ of patrolling (3,291.6 km per month^{-1}) instead of 12,945 km per year^{-1} or 1,078.7 km per month^{-1} documented over the five year study period (**Table 4. 4. 4. 1. 1**). Looking back over the performance realized, I strongly suggest that further protection effort carefully consider putting much emphasis on multiple days' patrols to increase the average multiple days' patrol deployment set at 464.6 with an average of 5.2 days per month^{-1} per staff to reach 615.1 multiple days patrols with an average of 6.9 days per year per year^{-1}(taking into account the required increase of optimum protection effort set at 32.4%), thus covering the ¼ instead of 1/6 of the required figure of 2,622.8 effective patrol days.

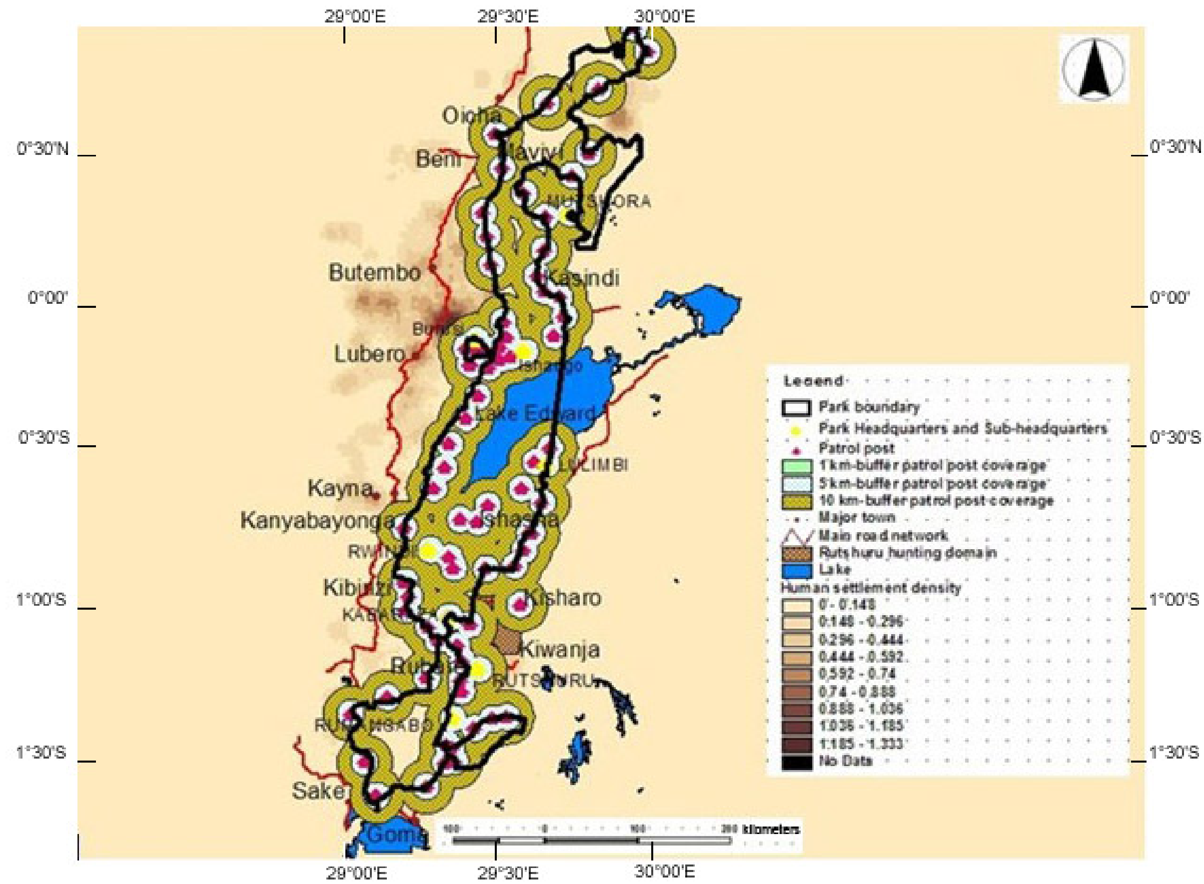


Figure 4. 4. 5. 1 *Map showing spatial pattern of protection effort from existing patrol posts in Virunga National Park.*

In comparison to KBNP, where effective spatial protection effort translated into 20 km-buffer from patrol post coverage in VNP (**Figure 4. 4. 5. 1**) 10 km-buffer from patrol post coverage proved sufficient to ensure full park spatial coverage. This means that existing patrol posts in VNP required only half of coverage effort as opposed to KBNP. This result can be explained by the elongate shape of the VNP stretching along 300 long (North-South) and 23 km (East-West) length. Not surprisingly this may explain as well the higher mean distance covered by patrol per day in VNP set at 7. 3 km ($^+$/- 4.4) as opposed to KBNP which had 4.6 km ($^+$/- 0.39). However, this figure is smaller when compared to the mean of 18 km per patrol day suggested by Jachmann (1998) when a patrol field team walks approximately 6 hour patrol day in flat terrain at an average speed of about 3 km per hour.

The question of route repetition by patrols is worthwhile, especially in a natural ecosystem which lies within a region of political instability and because the existence of widespread hide-out for militia groups. The tendency of patrol to follow a limited number of familiar routes or footpaths in areas where deployment is difficult because of thick vegetation or broken topography was clearly noticed. The extent of routes repetition was examined, and it was found that during the five years, 32.7% of all patrol movements were on footpath used more than once, many being on footpaths used repeatedly. As a result, the 3,291.6 km per month^{-1}, which potentially could have been covered with no repetition route were reduced to 1,078.7 km per month^{-1}, thus representing a waste investment time evaluated to 32.7% of patrol hour spent on the same patrol coverage area. On average, 4,849.8 km^2 of the park was covered annually, which represents 61.4% of the park area per year^{-1}.

Limited operational capabilities of guards and the risk facing them out there in the bush due to their lack of adequate funding and equipment were noticed. In addition, they were subjected to poor living conditions in a harsh DRC environment where the House of Representatives continue to make slashes in the conservation budget. A large portion of both donations and the government budget for conservation should be used to provide the equipment needed (including weapons and ammunition that partners cannot provide as this is highly strategic input requiring strict liability and State responsibility) for anti-poaching operations: bullet-proof vests, reliable field 4WD vehicles equipped with VHF mobile radio, speed boats, communication means (hand held VHF for foot patrols), camping gear, rucksacks, raincoats, sleeping bags. Comprehensive training and recruitment programs for guards and park wardens must be given priority and funded. The social welfare of the park staff needs to be improved with the provision of good housing, clean water and health care. Remuneration packages should be worked out which will give them good prospects and provide an incentive to better perform their fieldwork.

4. 5 Large Herbivores and Hunting Patterns across the Virunga Conservation Area

The total numbers of carcasses recorded per EPMD per km^2 showed not significant monthly variation (Kruskal-Wallis H = 19.5, df = 4, P = 0.06), the same observation was made for the wire snares (Kruskal-Wallis H = 33.7, df = 4, P = 0.09) and woodcutting (Kruskal-Wallis H = 43.7, df = 4, P = 0.07). However, while the number of monthly arrests varied per EPMD per km^2 across the year (Kruskal-Wallis H = 21.4, df = 4, P = 0.0012), there was no significant seasonal pattern in hunters that were observed and subsequently arrested (Kruskal-Wallis H= 29.5, df = 4, P = 0.12). Therefore human threats were widespread continuously over the year.

4. 5. 1 Poaching Onslaught: The Last Big Rush for the Green Gold

During the recent conflict, both ivory and elephant meat were actively acquired as a source of revenue by military and militia and even the national police. Military and police bosses based in and around PAs hired professional hunters who recruited local guides and porters to find and kill large mammals and transport their meat and ivory. Congolese businessmen and women, including those in the transport sector, collaborated in a massive illegal trade in elephant meat and ivory. The' ivory chain' spanned DRC's border and implicated neighboring countries, in particular Uganda. Bushmeat was transported secretly and usually delivered to hunter's homes at night. While sales were secretive, transport used depended on where the meat or ivory happened to be, quantity, and how far it was moved. From **Table 4. 5. 1. 1** there was noticeable increase in poaching levels with the biggest overall drop (356%) in elephant population observed in 1981.

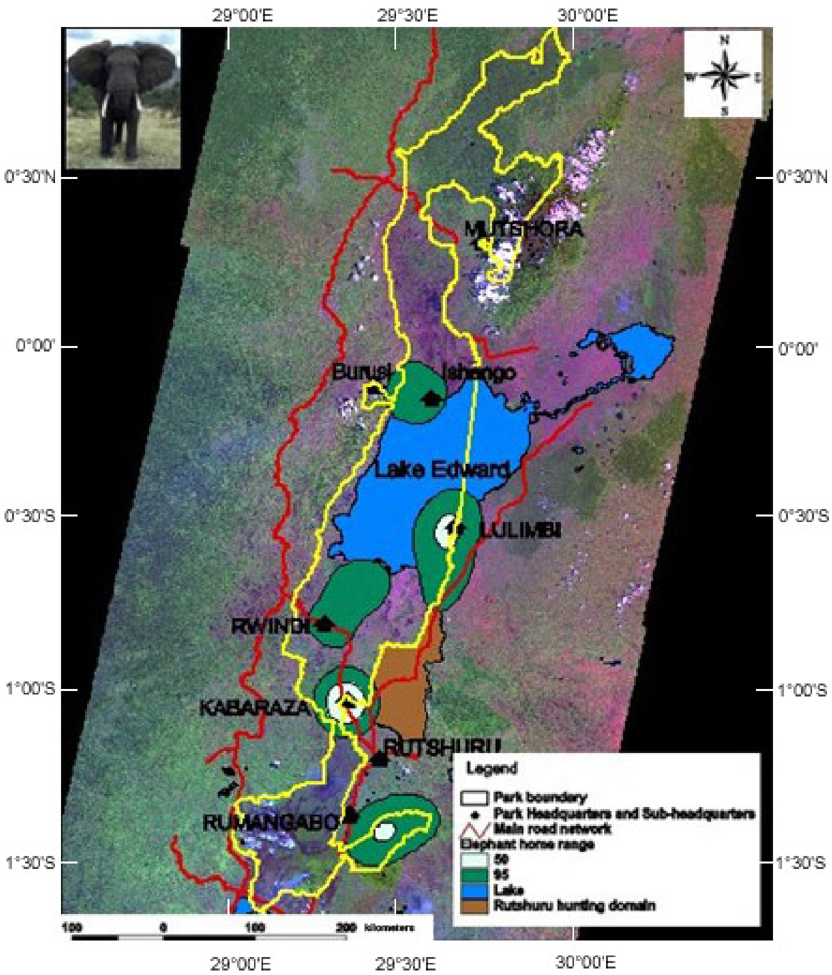


__Figure 4. 5. 1. 1__ Elephant home range in Virunga National Park

Elephants were not seen for a long time in some areas of the VNP, including the southern part of Kibirizi and the steep rocky slopes of the Mtumba Mountains between Lunyasenge patrol post (**Figure 4. 1. 1. 1**) and Tumbwe River. This distribution was almost similar to that observed by Verschuren (1993). Rutshuru River delta into Lake Edward covered by large Papyrus (*Cyperus latifolia*) formations, avoided by Common hippos served as refuges for stray elephants. Unbridled elephant poaching has altered the habitat of Lake Kizi covered with beds and floating water lettuce (*Pistia stratiotes*) through allowing the invasion of small acacias habitat.

Elephant home range (50-95% probability) varied varied between 32.05 km^2 and 282.4 Km^2 (**Figure 4. 5. 1. 1 & Table 4. 5. 3**) with noticed important migratory movement between the VNP and the QENP through Ishasha River (Mubalama, 2000; Blanc *et al*., 2007), movement may also take place between the Virunga northern sector and the Toro/Semliki range in western Uganda (Michelmore, pers. comm. 1998). Elephant populations vary between the three sectors including the northern with 21 individuals (Blanc *et al*. 2007), the central sector harboring 348 individuals from the last survey (Kujirakwinja *et al*. 2006a) and 75 individuals estimated for the southern sector (Mubalama, pers. comm. 2002). Though elephant population in VNP was as well hit by armed poaching, its chance to survive is higher than its counterpart in KBNP where core home range was limited to only 2.36 Km^2 and where, all else being equal, and in the absence of park staff accessibility, they movement was constrainted by the Nindja ecological corridor which currently seems to be providing less landscape connectivity passage between the highland and lowland park blocks in order to remain viable in ecological, genetic and demographic terms.

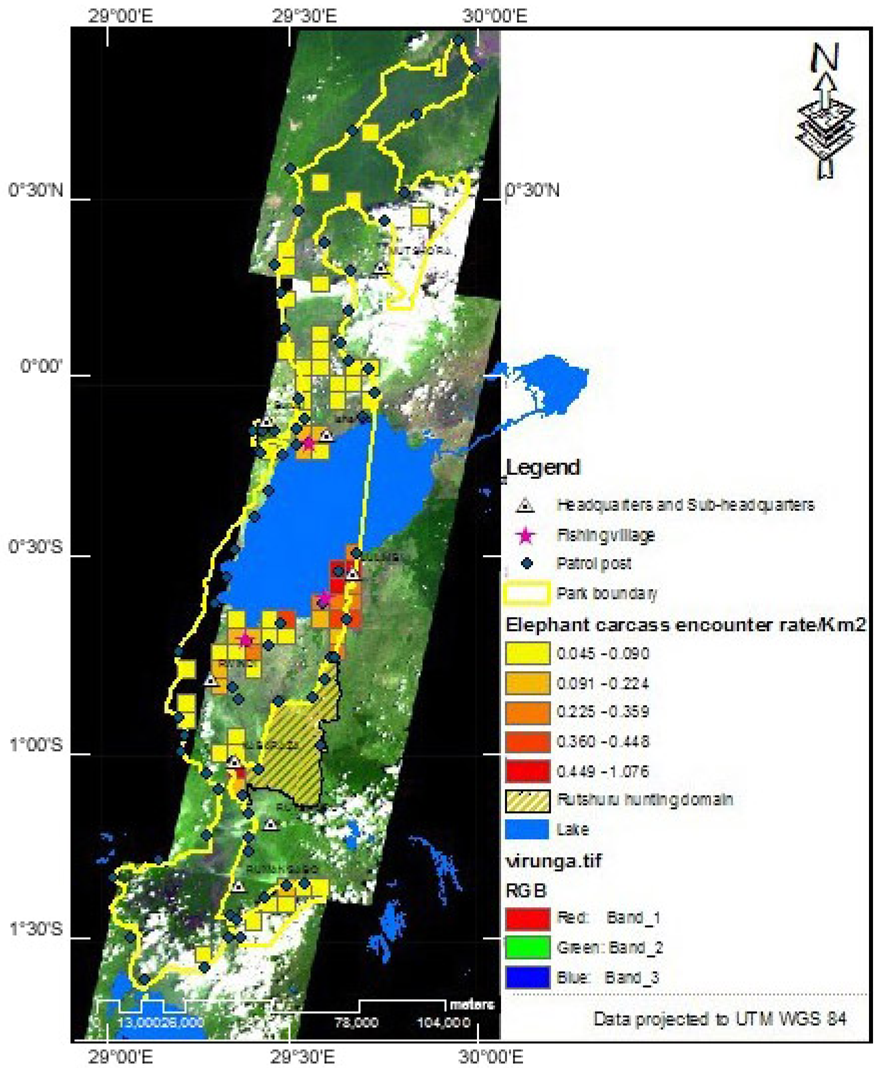


***Figure 4.5. 1. 2** Elephant carcasses encounter rates in Virunga National Park*

Figures 4. 5. 1. 1 & 4. 5. 1. 2 show the extent to which elephant home range overlap with elephant carcasses occurrence suggesting that poachers used as well the strategy aiming at monitoring these pachyderms' movements within the ecosystem. This applies as well for other targeted large mammals, including gorillas, Common hippos (**Figures 4. 5. 3. 1 & 4. 5. 3. 2**), African buffaloes (**Figures 4. 5. 4. 1 & 4. 5. 4. 2**) and Uganda kob (**Figures 4. 5. 2. 1 & 4. 5. 2. 2**). The correlation between the availability of firearms and ivory poaching described by Klitgaard (1990) and Douglas-Hamilton (1987) was also noticed in the VNP where civil strife prompted the facility of obtaining weapons (Barnes, 2000). In the short-term, there is a need to establish VNP elephant plan which should incorporate the park and hunting domain within a larger land use plan. Yet appalling though the situation is, it is by no means hopeless. Given the role played by the neighbouring PAs, in particular the QENP immediately adjacent to the central sector of the VNP. From the historical migratory movements of elephant populations taking place between the QENP and the VNP central sector, one can expect that various animals, and notably elephants, having found refuge in QENP, will return to the VNP once poaching has been stopped (Plumptre, pers. comm.).

Table 4. 5. 1. 1 *Evolution of numbers of three species of large mammal in the Virunga National Park plains of Lake Edward*

Species				South				North				Total
	1959	**1981**	**2003**	**2006**	**1959**	**1981**	**2003**	**2006**	**1959**	**1981**	**2003**	**2006**
Buffalo	23678	8916	2240	3748	4629	799	52	74	28307	9715	2292	**3822**
Elephant	2889	621	265	298	536	130	21	50	3425	751	286	**348**
Thoma's kob	10731	9750	11588	12399	487	550	533	583	11218	10300	12121	**12982**

Source: Languy, 2009

Elephants were particularly concentrated in the eastern part of the central sector (Mubalama & De Maeyer, 2009), even though a larger population of over 112 elephants was counted in the Kabaraza area in May 2007. Wooded savanna habitat located in Chanziko, Rukoro, Mabenga, Kalindi were basically spotted areas where large herds were found (Matungulu, 2007). In Mubalama (2000), I estimated the carrying capacity of the central sector of the park to be between 1,000 and 1,200 elephants with an average of 0.5 elephant per km^2, based on Pfeffer (1989) study. Given the present population, the central sector of the VNP could probably support another 565 elephants and it is conceivable that the population could reach these levels by 2020 assuming that full protection over the whole area is provided, and that the recruitment and population growth rate of between 7-10% per year in favorable conditions (Pfeffer, 1989) is maintained.

For a clear understanding of the social organization and migratory pattern of the VNP elephants, long-term observations, combined with thorough knowledge of most individuals in the population are absolutely necessary. How elephants use their range and how they interact with varied habitats both in VNP and QENP remain open questions (Mubalama, 2000). Understanding the ecological scales of ecosystem dynamics in conservation areas is fundamental to the conception of appropriate policies (Waithaka, 1977). Such in-depth research taken as an essential element of monitoring service clearly emphasizes the need for co-ordinated surveillance and research efforts in the VNP and the QENP and across international borders. The duties of field force require a range of professional capabilities including those of law enforcement, wildlife management, public relations and research. A range of operational procedures is required to guide staff in their duties, including those involving physical risks; these need to be developed along with the training system needed to ensure their use through the various field forces. The efficiency of each staff in carrying out these procedures should be subject to assessment and related to increment stoppages and efficiency bars. To pre-empt poaching incidents, intelligence gathering will become an increasingly important component.

4. 5. 2 Poaching and Thomas’s Kob ever Stable Population

The numbers of Thomas’s kobs were stable from 1981 census to 2006. It is most probable that this species, by far the smallest and cheapest (Olupot *et al*., 2009) of the five, is not favored target of poachers, who prefer to concentrate their efforts on larger game of greater commercial value. Core home range was 20.9 km^2 (**Table 4. 5. 3**). However, if poaching were to continue at this unbridled rate, with the increasing scarcity of larger ungulates, Uganda Kob would rapidly become a poaching target and accordingly suffer the same fate as the other species with the difference that Uganda Kob could reconstitute its population rapidly given its adaptable, fast-reproducing species able to withstand human activity as shown in **Table 4. 5. 1. 1**. They have high intrinsic growth rates (Estes 1991), which may explain their fast recovery amidst poaching upsurge, producing a statistically significant increase in numbers as high fecundity would always allow Uganda kob population to recover from low numbers despite poaching intensity. Other savanna antelope species around the Lake Edward include the Topi (*Damaliscus korrigum*) which are common on the Lulimbi plateaus, and in contrast completely absent in the north; Bongo (*Tragelpahus euryceros*) in the middle Semiliki inWatalinga area, waterbuck (*Kobus ellipsiprymnus*); bushbuck (*Tragelaphus scriptus*), and Sitatunga (*Tragelaphus spekii*). Uganda kobs are diurnal but are less active during the heat of the day, thus herd living ensures that many pairs of eyes and ears are on the alert for danger. In open habitats, they run a high risk of *predation* (being preyed upon). To survive they use several kinds of defensive strategy, including living in herds. However, the anti-paoching strategy does not work when hunted by rule-breaker because more individuals are being killed when a group living species is detected by hunters (Fitzgibbon et al., 1995).

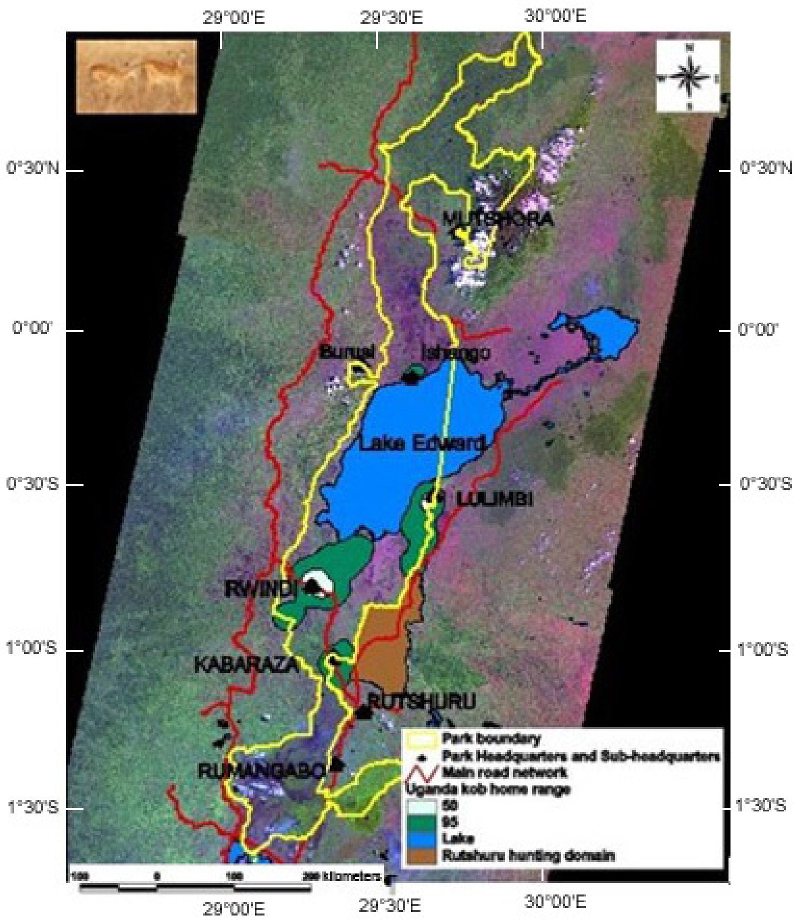


Figure 4. 5.2. 1 *Thoma Kob's home range in Virunga National Park*

Antelopes communicate with one another using a variety of sounds. Dik-diks, for example, whistle when alarmed, a habit that alerts other animals to danger and makes dik-diks unpopular with hunters. Duiker holds it head low and plunges into dense cover at the first hint of alarm. But for antelopes generally, sight is a much more important form of communication. When they are excited or alarmed, many medium-sized antelopes bounce up and down on all four legs, keeping their legs stretched out straight. This behavior, known as pronking or stotting, acts as an alarm display. Some biologists theorize that stotting also communicates a message to predators, showing that individual antelopes are fit and alert and therefore not worth pursuing. In addition to visual displays, antelopes use scent signals to communicate. Antelopes that live in herds have glands in their hooves that leave a scented record of their movements (Estes, 1991).

Scent signals have the advantage that they can linger for many days. Antelopes use these scented tracks to find their way back to the herd if they accidentally become separated from it.

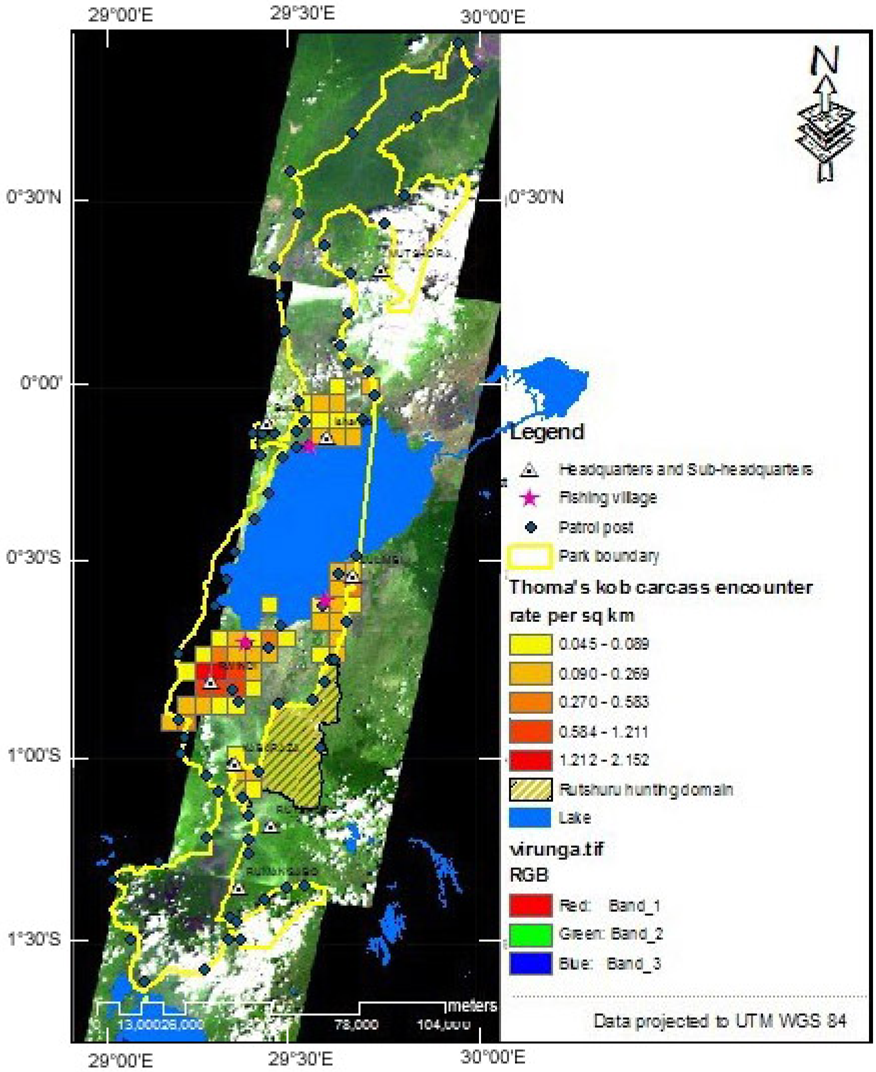


Figure 4. 5. 2. 2 *Uganda Kob carcasses encounter rates in Virunga National Park*

4. 5. 3 Wildlife Slaughter on the Shores of Lake Edward: Is the Tide Turning for Hippos?

Figure 4. 5. 3. 2. Shows that Common hippos' carcasses were most common near the fishing villages and patrol posts. Apart from the *Mai Mai* (The so-called *Mai-Mai* militia, a ragtag group of Congolese fighters with varying loyalties who operated across huge swaths of easten DRC, set up a base in the park from which they launched attach against wildlife and conservation staff). To give a few early examples, *Mai Mai* have almost exterminated the Common hippo population in 2006. As the ICCN tried to prevent from destroying the park, *Mai Mai* frequently attacked the guards and their positions while promising to put pressure on the park to move the park boundaries. This threats against the park translated into 3 *Mai Mai* furious attacks in May 2006 on Burusi patrol post leaving one guard dead,4 critically wounded and one wildlife officer kidnapped. Next step was the attack launched on Kabaraza patrol post

in August 2006 during which one guard was killed, one seriously and the houses looted, and finally the attack stagged in October 2006 during which one guard was killed in the area north of Rutshuru. *Mai-Mai* groups ate and sold Common hippo meat and ivory found in the Common hippo's canine teeth. To top it all, during a fortnight in October 2006, more than 400 Common hippos have been slaughtered (PNVi-ICCN, 2006). Indeed, that figure alone represents a lot of Common hippos to wave good bye to in one go. These results are consistent with both Nele (2008) & Olupot *et al*. (2009) stressing that fishing villages promote hippos poaching and exploitation of other wildlife resources in VNP and Kujrakwinja (2010) concluding that apart from poaching, the lack of knowledge of conservation laws by communities and poor law enforcement, and a weak institutional policy have contributed to the decline of Common hippo population in VNP.

The evolution of the Common hippo population in the VNP shows a period of growth as a result of substantial protection efforts, permitting the population to reach the peak of 30,000 individuals in the mid-1970s. This population was then the largest in the world, representing no less than 20 percent of the hippopotami world population. Starting in the 1990s, the dramatic decline is particularly shocking to the point where there were 1,309 and then 887 individuals in 2003 and 2005 respectively. Common hippo herds in VNP have been reduced by more than 95% (Muir, 2006) with a home range set at 7.8 km^2 (**Table 4. 5. 3**) a fact which led the species being registered as vulnerable on the IUCN Red List (IUCN, 2006) for the first time in 2006 to the point that the staccato huh-huh sounds of the hippo's as they were leaving the water were heard rarely (Mubalama, pers. comm.). Similar patterns have been recorded for other VNP key large mammals including the elephant and African buffalo (de Merode *et al*., 2009a). The quasi disappearance of this mega-herbivore is having a dramatic impact on the trophic chain of Lake Edward. As a matter of fact, a Common hippo can consume 30 to 50 kg of grass per night, which is expelled as excrement in the Lake Edward or in the rivers that empty into it. Before the population decline, the animals delivered more than 600 tons per day of essential nutrients to the plankton of the lake and therefore to the fish that feed on it.

The study results bear similiraties with that has been found by Olupot *et al*. (2009) in Uganda where common hippos ranked topmost in every respect and where surrendered poachers ranked it as their best source of income, the tastiest, most expensive meat, meat that provided the highest health benefits, and the most commonly available bushmeat in their villages.

Table 4. 5. 3. 1 *Numbers of Common hippos in Virunga National Park from1959 to 2010*

Sector	1959	1974	1981	1989	1994	2003	2005	2009*
Semliki River	8811	3852	2325	995	141	34	50	146
Lake Edward	7804	9638	7769	7019	4011	892	683	408
Rwindi River	1300	1278	920	2324	1314	78	35	7
Ishasha River	100	335	462	467	400	141	61	500
Rutshuru River	7340	10262	7337	9121	4417	164	58	99
Interior ponds	1175	3813	2282	2949	566	0	0	49
TOTAL	**26530**	**29178**	**21095**	**22875**	**10849**	**1309**	**887**	**1209**

Source: Languy, 2009; * Kujirakwinja, 2010

Censuses carried out in 2003 and 2005 (**Table 4. 5. 3. 1**) indicate that there was zero Common hippo in the interior ponds of the park and the sight of a large hippo pod plastered in the mud became uncommon contribution to the wildlife animation on the Rwindi-Rusthuru plains. Most hippos counted were on the south and eastern shores of the Lake Edward, followed by Ishasha River (which forms the border between the VNP and QENP), Rutshuru River and upper Semliki River (Languy, 2009).

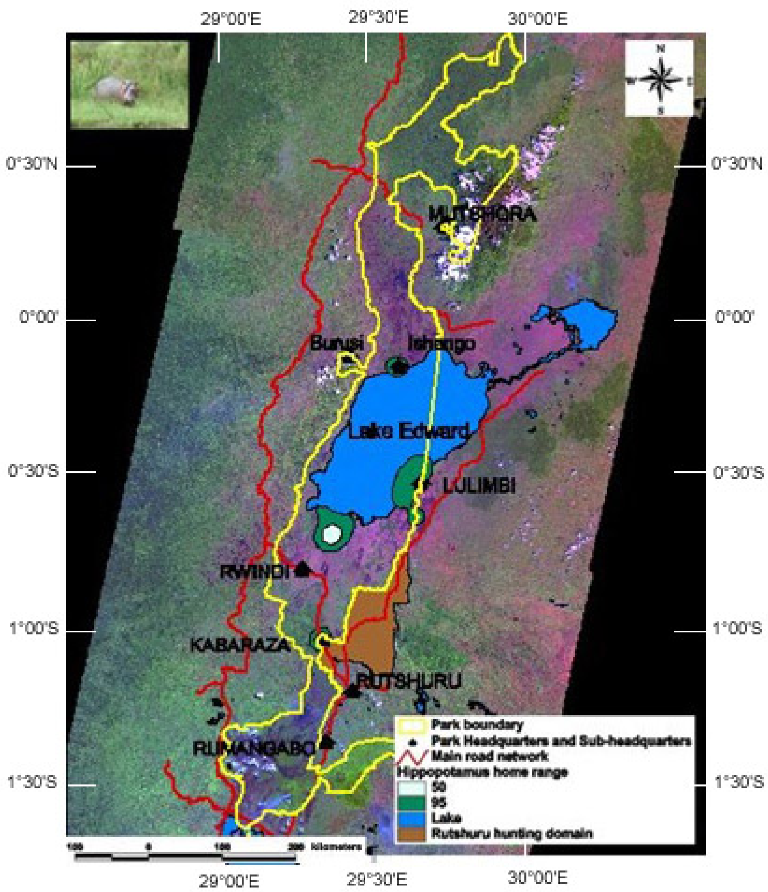


Figure 4. 5. 3. 1 *Common Hippo's home range in Virunga National Park.*

The hippo poaching is not a new phenomenon and goes back a long way ago. Starting in 1992, military camps were set in VNP.There were numerous military bases in the park and

As the result, poaching activities sky rocketed. At this time, there were already large batches of ommon hippo canine teeth on sale in Goma (nearly 10,000 teeth in all) representing at least 2,500 individuals. In 2003, the discovery of groups of more than 30 butchered hippos on the Rutshuru River and whose canines were removed indicaing unequivocally a substantial trade in hippo ivory. Yet the hippo was also poached for its meat, which was sold in many villages bordering the park and within the fishing villages (Vitshumbi, Kyavinyonge and Nyakakoma). At the beginning of 2005, poaching was so intense that the price of hippo meat did not exceed one $US per kilo while in 2002 along the west coast of Lake Edward a whole hippo would sell for $US 50 (Languy, 2009). This pricing figure draws a stark contrast with Olupot *et al*. (2009) suggesting that during the civil strif, bushmeat may commonly available and less expensive.

A recent report from IDPE (2010) on the upsurge of poaching in the central and eastern sectors of the Park highlights the involvement of the Integrated 15th and 18th FARDC Brigade in widespread hippos killing activity using local people as meat carriers. This ongoing large-scale hippo's butchering by armed gangs is an indication that the tide is not yet turning.

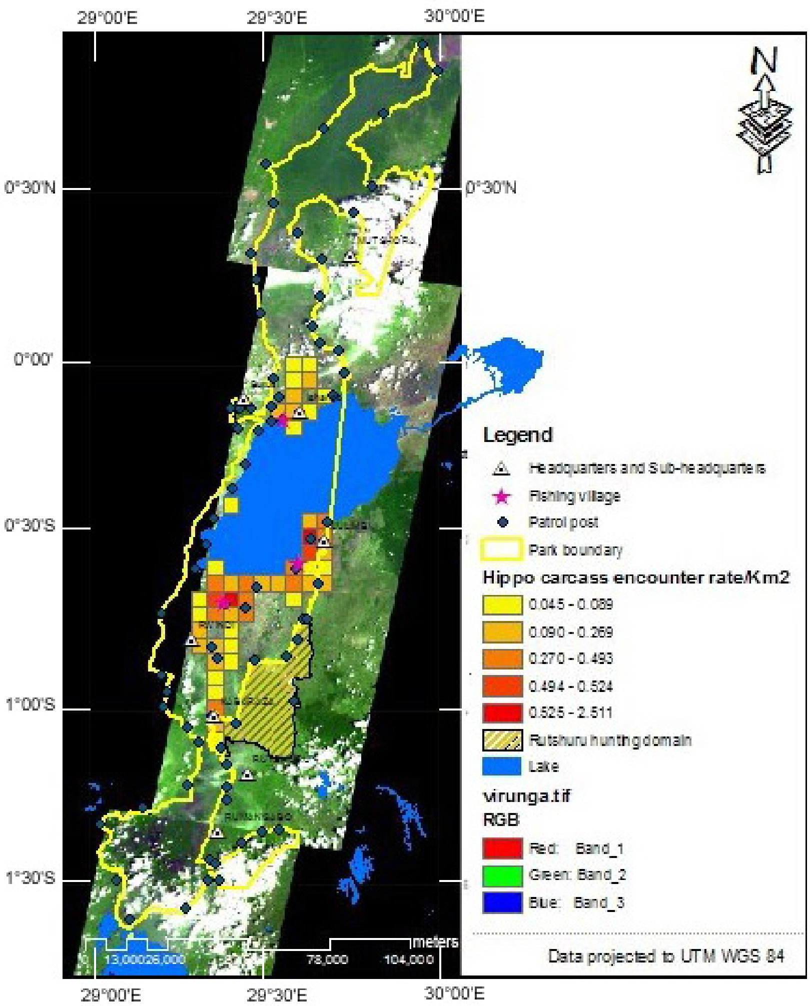


Figure 4. 5. 3. 2. *Common hippo's carcasses encounter rates in Virunga National Park.*

4. 5. 4 Poaching Scourge and African buffalo Stable Population

Figure 4. 5. 4. 2 shows the high African buffalo carcasses occurrence in the central sector with higher concentration in Lulimbi and Rwindi management units. This pattern is similar to the one observed for the hippos with the exception that the African buffalo carcasses occurrence were smaller as compared to Common hippo. African buffalo represents one of the five species of ungulates who has been regularly surveyed with 3,822 counted (**Table 4. 5. 1. 1**) during the last survey in June 2006 (Kujirkakwinja *et al*., 2006). Once security resumes, it would certainly be useful to repeat the surveys of all five key species on biannual basis in order to provide regular assessment using transect method, this will help wildlife managers to understand where the main priority areas and issues are, and accordingly help improving the law enforcement strategy. In the broadest sense, the geographical distribution of African buffalo has not changed over the past five years and may be wider than previously thought with dense African buffalo populations confined within Lulimbi and Mikeno sectors and further nord Ishango (**Figure 4. 5. 4. 1**).

Both the gorilla and African buffalo home ranges overlapped in the Mikeno sector (**Figures 4. 5. 5. 1 & 4. 5. 4. 1**). Total core African buffalo home range in VNP was 20.6 km^2 (**Table 4. 5. 3)**. The core home range figure found in this study is similar to Chapman & Hall (1996) which states that total buffalo numbers in Manyara (Tanzania) remained constant between 1985 and 1991 and around 17.9 ± 8.5 km^2. Home range in the dry season was much smaller than in the rainy season when the herds were restricted to riverine grasslands. Large herds being often made of up of subgroups of about 100-200 animals, each of which preferring certain parts of the complete home range. Herds will stick together and may charge as a unit when threatened, a tactic which ensures that predators, including hunters have difficulty preying on even young and feeble animals. Cattle egret (*Bubulcus ibis*) feed and typically forage in flocks often associated with grazing animals and pick off parasites on African buffaloes (*Syncerus caffer*), it plays a key role in preventing them against any predator through sound cry alarm while feeding on ticks. It’s noteworthy to mention that the restricted figures on key core large mammals’ home range might be explained by the restricted movements of park staff. The latter who are the eyes and observers of any ecosystem change could only be deployed in limited park sectors as they avoided some places known too dangerous to reach, including heavily mined and infiltrated areas acting as hideouts for gangs.

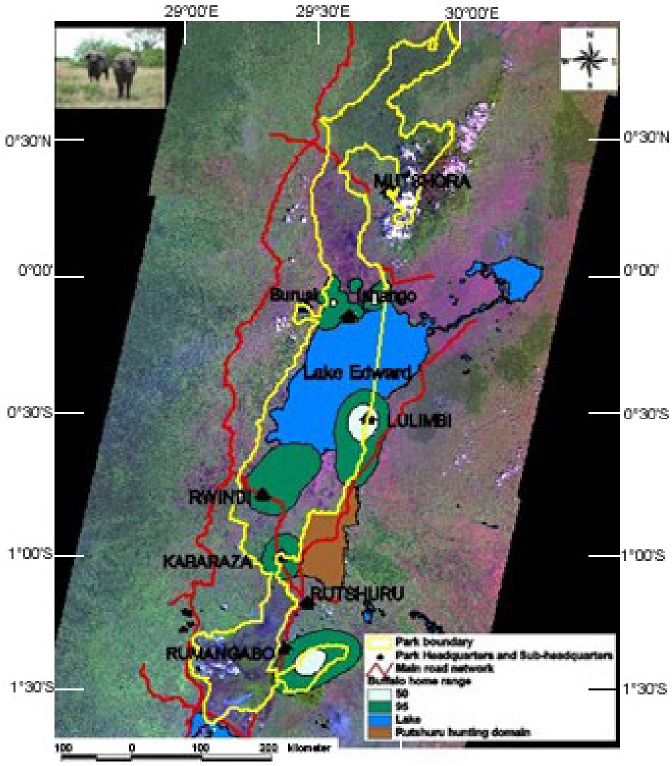


__Figure 4. 5. 4. 1__ African buffalo home range in Virunga National Park.

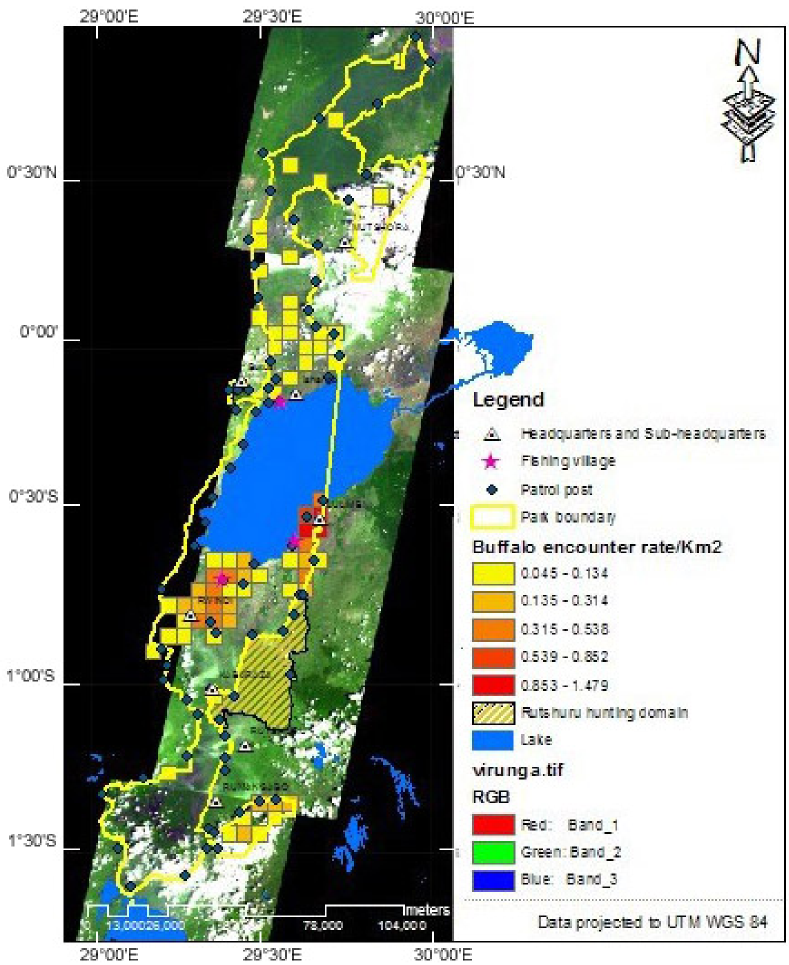


__Figure 4. 5. 4. 2__ African buffalo carcasses encounter rates in Virunga National Park.

4. 5. 5 Poaching Plague and Battle for the Gorilla and Eastern Chimpanzee

The 2003 gorilla census (**Table 4. 5. 5. 1**) was the last one carried out in the Virunga volcanoes massif. The most recent global survey shows that the VNP supports one of the most important concentrations of of mountain gorilla with an estimated population of 380 individuals (Gray *et al*., 2005b). Compared to the 1989 census, this represents an increase of 15%, or an average annual growth of 1.15%. The increase in the population of Mountain gorillas, despite many years of intense political insecurity, is a remarkable conservation achievement; it is a tribute to the phenomenal dedication and devotion of its park guards and the VNP partners, and of the collaboration of three countries (DR Congo, Uganda and Rwanda) to achieve a transboundary approach to conservation (de Merode *et al*., 2009a). The higher mountain gorilla core range (58.3 km^2) as depicted by **Table 4. 5. 3** might as well be explained by the patrol coverage by dedicated staff in the well funded Mikeno sector (Hatfield, 2003; Gray & Kalers, 2005b). Apart from from Plumptre *et al*. (2009) there is no accurate estimate for the number of chimpanzees in VNP, because of the years of insecurity which made a thorough survey effectively impossible. Recent data from collected by WWF/PEVi project, in collaboration with ICCN, estimates the minimum number of chimpanzees in VNP is at least 300 (de Merode *et al*., 2009).

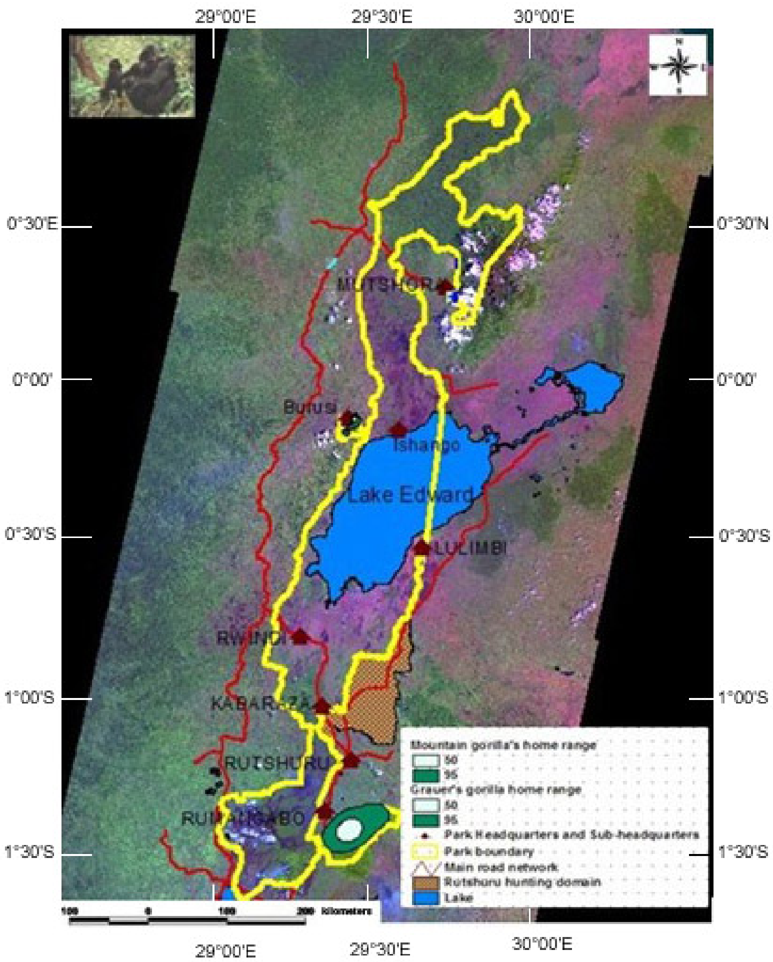


***Figure 4. 5. 5. 1** Gorillas' home range in Virunga National Park.*

One of the greatest threats that mountain gorilla faced was the repeated setting of snares for ungulates by the local community living adjacent to the southern park limit. The gorilla density was considerably higher in the Mikeno massif (**Figure 4. 5. 5. 1**) where core home range was set at 58.3 km^2 (**Table 4. 5. 3**) such areas received additional protection as a result of the monitoring exercise. However, core grauer's gorilla home range (2. 2 km^2) in Mount Tshiaberimu was smaller as compared to the mountain gorilla (**Table 4. 5. 3**). A Friedman's ANOVA of the combined data on snares distribution shows that there were significant differences between periods ($\chi 2$ = 9.27, df = 2, $P < 0.05$) in Mikeno sector with the peak of the rainy season (September-October and April-May) being the period when large amount of snares were set. Large numbers of snares, in areas such as the northern part of Mikeno **(Figure 4. 4. 3. 7)** are likely to be indicative of high levels of disturbance in general, which do have some impact on the wildlife population. The gorillas which do use these areas will inevitably be at higher risk of being caught in snares than that elsewhere. Therefore it is important for the conservation of the mountain gorilla that snares continue to be found and removed since gorillas may receive serious injuries and in some cases were known to have died as a result of being caught in snares set for African buffalo (Plumptre *et al*., 1997; Mudakikwa *et al*., 2001).

***Table 4. 5. 5. 1** Evolution of Mountain and Grauer's Gorilla numbers in Virunga National Park*

Species	1972	1978	1981	1986	1989	1996	2002	2003	2006	2008		Notes
Mountain Gorilla	274	268	254	293	324	-	-	380	-	-	South	
Grauer's Gorilla	-	-	-	25-30	-	31	19	-	21	20	North	Cornet d'Elzius (1996); Aveling (1990); Chifundera *et al*., 2003
Chimpanzee	-	-	-	-	50	-	-	-	-	-	South	Rumoka-Tongo, Katwa-Mulalamule
	-	-	-	-	-	-	-	-	26	-		Flank of Nyiragongo (Maroba)
									17			Kitiriba, Taliha, Kamandi
	-	-	-	-	-	-	-	-	Present	-	North	Presence not estimated Balega, Bamundjoma, Kikingi, Bahatsa

Table 4. 5. 5. 1. 1 shows that the park is known for harboring many small populations of chimpanzee (*Pan troglodytes schweinfurthii*). The population at Tongo (Rumoka volcano) area extending from Katwa and Mulalamule to the upper Rutshuru and those of the western shore of Lake Edward (Taliha, Lunyasenge and Kamandi) are however, very probably threatened by human encroachment (**Figure 4. 8. 2. 1**). Apart from Chimpanzees observed on

Mount Nyiragongo (Maroba) with 26 individuals (Languy, 2009), Plumptre *et al*. (2009) found a conservative figure of between 950-1050 chimpanzees occurring in patchy distribution.

The eastern chimpanzee is currently classified as Endangered on IUCN's Red List of Threatened Species (IUCN, 2006) and so far there are large areas of the VNP where we know very little about this ape. Effort to assess the status of eastern chimpanzees using existing LEM data (**Figure 4. 5. 5. 1. 2**) will help researchers to identify key areas for future surveys that are likely to be of importance for chimpanzees, thus allowing wildlife managers to focus conservation actions more effectively with emphasis on illegal hunting and trafficking. In addition to targeting two of the greatest threats to the species mentioned above, the objectives should include reducing the rate of forest loss in chimpanzee habitats; increasing knowledge of chimpanzee distribution, status, and threats; improving the understanding of health risks to chimpanzee populations sharing 96 percent of the same genetic material with human (Keogh *et al*., 2005), including human-transmitted diseases; increasing community support for chimpanzee conservation; and, securing sustainable financing for chimpanzee conservation units.

Eastern chimpanzees are found up to about 2,900 metres altitude in montane forest and coexist with both Grauer's and mountain gorillas in these forests. Given the data gathered from the areas where fairly extensive surveys have occurred, I do share the point of view expressed by Plumptre *et al*. (2010) that chimpanzees' numbers have probably been underestimated in the past. Therefore there is a need to fill major knowledge gaps in chimpanzees' distribution, status, and human threats across their estimated range and accordingly implement a monitoring strategy.

Overall, as far as packaging, concealment and transportation of the bushmeat is concerned, there was no clear pattern of disguise or concealment. Bushmeat was packaged and transported ordinarily. For example, it was hidden in produce in a truck carrying charcoal, cassava (*Manihot esculenta* Crantz) or maize (*Zea mays* L) or fish or tomatoes (*Solanum lycopersicon*). In a passenger vehicle, it was carried as luggage. In construction trucks it was hidden under timber or stones. Bushmeat was most frequently packed in sacks or gunny bags, and boxes and usually disguised as charcoal, fish, firewood or agricultural produce, and it was usually moved out of hunting areas at night. There was no clear pattern to modes of bushmeat transportation and transport used depended on where the meat happened to be, quantity, and how far it was moved. Movement over longer distances was done using whatever form of transport hunters or dealers found most convenient. From the hunting sites to major cities (Goma, Beni, Butembo, Rutshuru), meat was transported on foot, by bicycle, boat, raft, canoe, or motorcycle.

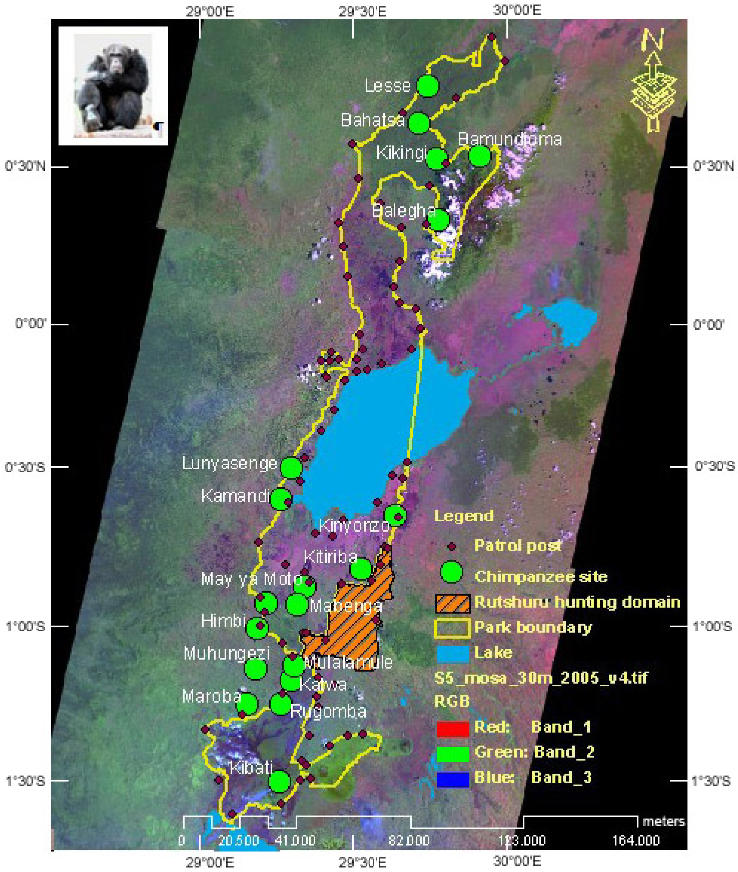


Figure 4. 5. 5. 1. 1 *Distribution of chimpanzee population sites in Virnga National Park.*

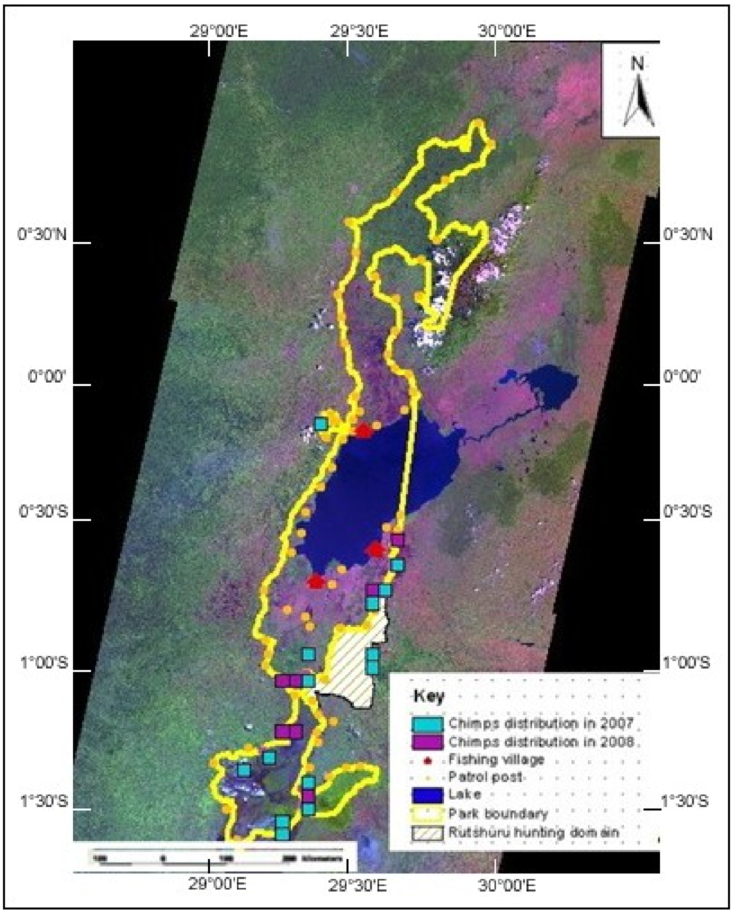


Figure 4. 5. 5. 1. 2. *Chimpanzee's distribution from LEM data in VNP during 2007-2008.*

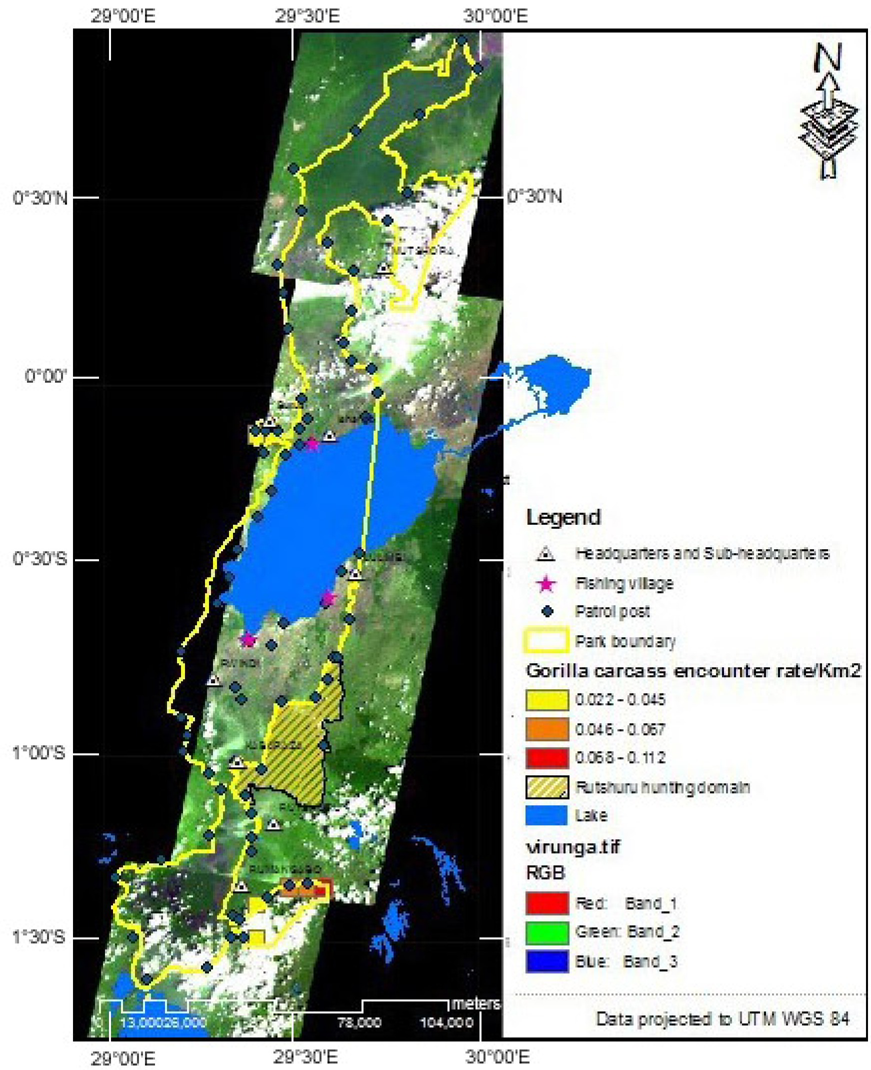


Figure 4. 5. 5. 2 *Gorilla carcasses encounter rates in Virunga National Park.*

Both the mountain (*Gorila beringei beringei)* and the lowland gorilla (*Gorilla beringei graueri)* experienced loss, albeit smaller as compared to other species. Most of the gorilla carcasses and snares (**Figures 4. 5. 5. 2 & 4. 4. 3. 7**) encounter rates were observed near the park boundary where more bamboo was available to use in snares construction. This might explain the relationship between snare and gorilla presence as shown in **Table 4. 6. 1)**

WCS surveys in Mt Hoyo (Plumptre *et al*., 2008) shows that illegal activities which were predominantly poaching signs were relatively high in the Semuliki forest block and at the same time sightings of large mammal sign and captures on camera traps were very low indicating that poaching has probably had a major impact on the large mammals in this forested part of the park. Given that the area has been inaccessible for over 10 years and also that armed groups, particularly the NALU/ADF have been hiding here and hunting wildlife to feed themselves this is not surprising. There is a need to establish regular patrolling further north in the park as well as on the northern side of the connection to the Rwenzori massif.

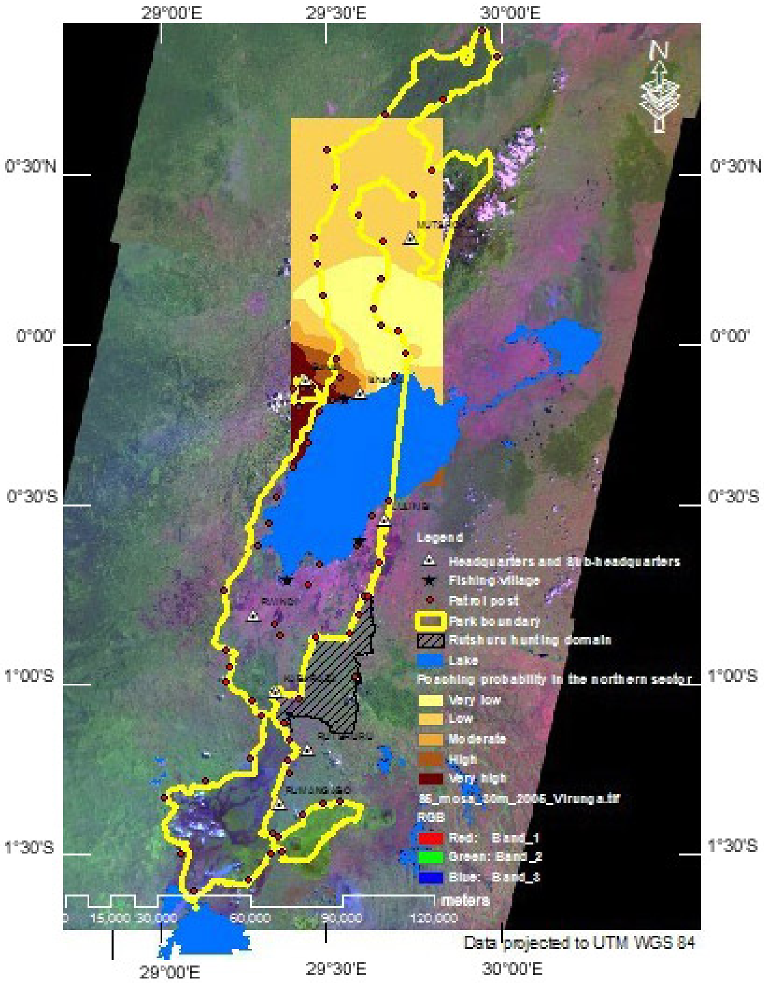


Figure 4. 5. 5. 3 *Map illustrating predicted poaching risk to key large mammals in the northern sector of the Virunga National Park.*

Table 4. 5. 1 *Threat analysis from the law enforcement monitoring data*

Park sector	Moran's Index	Z-score (SD)	Significance Level	Critical Value
Kabaraza-Rutshuru hunting domain	0.47	8.32	0.01	2.58
VNP North (Mutsora)	0.08	2.33	0.05	1.96
VNP East (Lulimbi)	0.04	0.12	0.01	2.58
VNP Centre (Rwindi)	0.42	15.95	0.01	2.58
VNP South (Rumangabo)	0.03	0.59	0.10	<1.65

Table 4. 5. 2 *Threat analysis from the socio-economic survey data*

Park sector	Moran's Index	Z-score (SD)	Significance level	Critical value
Northern sector (Mutsora-Ishango-Burusi)	0.22	1.46	0.01	2.58
Central sector (Rwindi-Lulimbi-Kabaraza-Rutshuru hunting domain	0.55	9.35	0.01	2.58
Southern sector (Rumangabo)	0.26	3.59	0.05	1.96

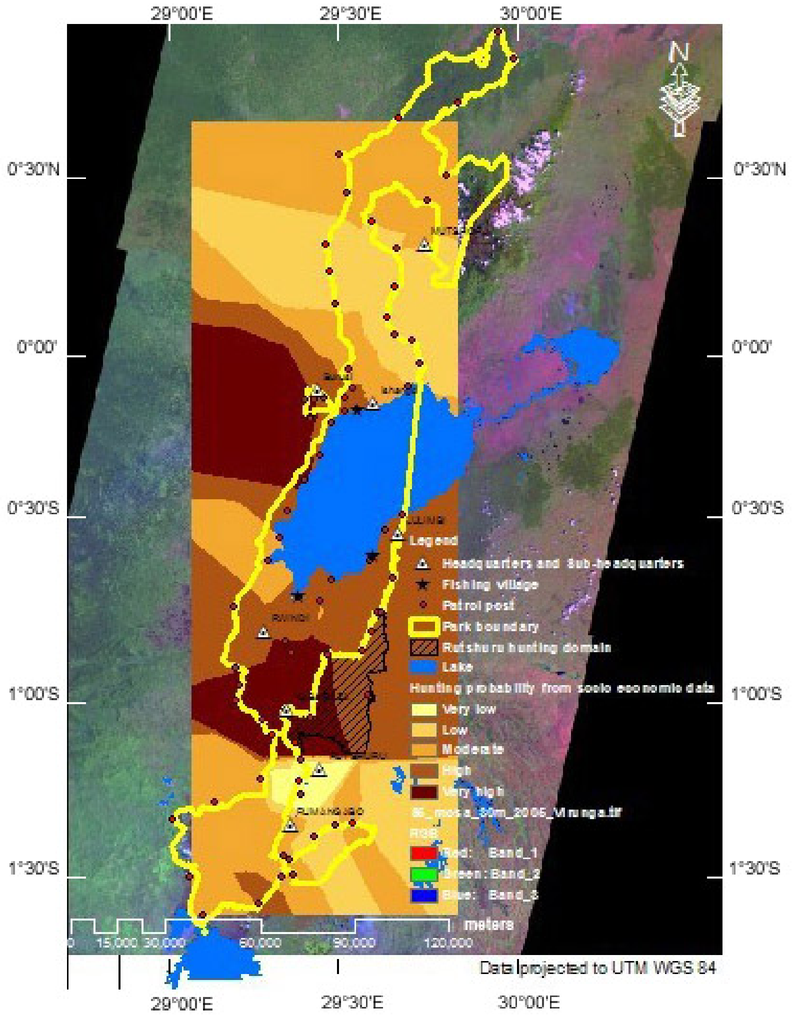


Figure 4. 5. 5. 4 Hunting probability pattern from socio economic data in Virunga National Park.

From the threat analysis in **Figures 4. 5. 5. 3; 4. 5. 5. 4** & **Table 4. 5. 1** there was less than 1% likelihood that key threats (encroachment, wildlife carcass, illegal fishing, charcoal kiln, snaring, and woodcutting) cluster pattern could be the result of random chance particularly in the central (Rwindi), eastern (Lulimbi) and Kabaraza-Rutshuru hunting domain sectors while there was less than 5% likelihood that threats clustering pattern could be the result of random chance in the northern (Mutsora) sector. However, in the southern (Rumangabo) sector somewhat clustered, the threats pattern may be due to random chance. The critical Z-score when using a 95% confidence level was higher in central sector including Kabaraza and Rutshuru hunting area (**Tables 4. 5. 1 & 4. 5. 2**) indicating the more intense clustering of high values in the central sector followed by Kabaraza and Rutshuru hunting area. The slight discrepancy observed from **Figure 4. 5. 5. 4 & Table 4. 5. 2** in terms of significance of clustering pattern in the southern sector may be explained by the difficulty faced by the monitoring of public attitudes towards conservation and wildlife management around PAs, because the communities involved frequently perceive their own attitudes towards wildlife to be at variance with official attitudes, so that genuine opinions may not be freely expressed. In this regard and sharing Bell (1983) feeling, once must recognize that those conflicts of attitudes and objectives are based on subjective value judgements or aesthetical decisions.

Moreover, belief in nutritional qualities lies in the logic that wild animals are exposed to a wider nutritional base as they feed on a wider range of plants compared to domestic animals. This belief was widespread among surrendered poacher groups and appears to bear some scientific truth. For example, game meat is nutritionally superior and contains far less fat compared to livestock meat (Hoffman 2008), and ungulates yield greater amounts of edible protein per unit of live weight than domestic animals and it has been that the fat content of the carcass is 7.7 times greater in domestic than wild animals so that humans would be healthier eating wild meat over livestock meat (Barnett, 2000). It would be useful to conduct a study to show whether or not this is indeed the case among the species most preferred in this study. Weapon use in hunting remains a serious threat in the VNP where they have become more readily available (Barnes, 2002) and are virtually universally adopted by anyone who can afford to buy one (or hire one from an entrepreneur) to increase hunting success. For small investment, the economic pay-off is substantial, and uncontrolled hunting becomes widespread

In the final analysis, the null hypothesis was rejected implying a statistically significant spatial pattern with different threat clustering levels. The study most striking finding is that the poaching hotspots were the areas between Kyavinyonge-Muko-Mount Tshiaberimu (northern sector); Mosenda - Lunyasenge on the western shore of the Lake Edward; Kibirizi; Bambu-Kasali-Mabenga and the triangle Nyakakoma-Kinyonzo-Birwa (central sector) as awell as Kibumba (south Mikeno) (**Annex 12**; **Figures 4. 5. 5. 3; 4. 5. 5. 4 & 4. 5. 5. 5**). The finding in Mikeno sector compares well with and is closely akin to those of Kayijamahe (2008) stressing that human impact (2004-2005) core areas overalaid on Mountain gorilla habitat suitability mentioning the VNP and Rwandan Volcano NP park boundary. In addition, law enforcement data show the LEM gap between the central (south Mabenga) and southern (Tongo) sectors (**Figure 4. 5. 5. 5, Annex 12**).

Although the results of this study has provided further support that conservation personnel record signs of illegal activity simultaneously with both biological and socioeconomic data may help investigators to obtain a more complete picture of the impact of illegal activities (Jachmann 2008*b*), the shortfall in terms of the LEM gap between the central and southern sector needs to be filled up in the near future to better reflect the scope of the park LEM activities. This applies as well for the northern sector of Nzovu lowland sector (**Figure 3. 15. 3**).

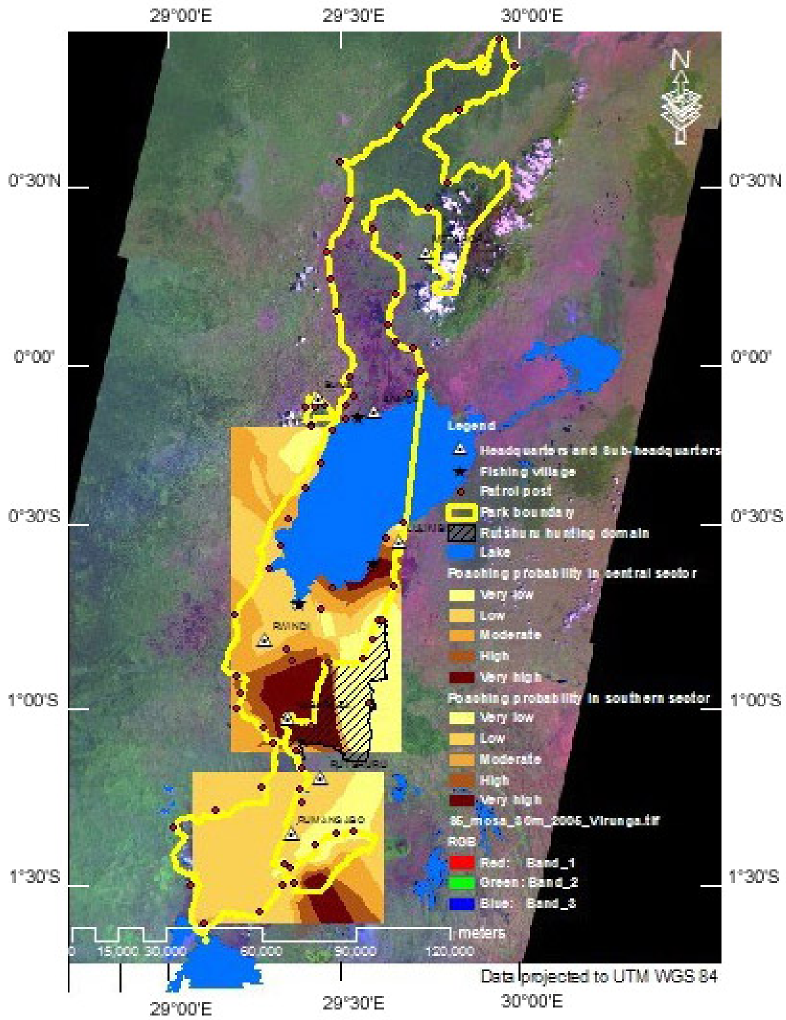


***Figure* 4. 5. 5. 5**. *Map illustrating predicted poaching risk to key large mammals in the central and southern sectors of the Virunga National Park.*

Table 4. 5. 3 *Keystone species home ranges in Virunga National Park*

Species	Home range probability	
	95	50
Buffalo	46.9	20.5
Chimpanzee	15.6	14.2
Elephant	282.4	32.05
Hippo	9.8	7.8
Thoma's kob	84.8	20.9
Grauer's gorilla	18.5	2.2
Mountain gorilla	64.8	58.3

Comparing the distribution of human disturbance with that of the gorilla population indicates that gorillas tend to be found in areas with lower levels of human disturbance in the central part of the volcano massif, with fewer gorillas to the south of Karisimbi (4,507 m) and Mikeno (4,437 m) and in the eastern section around Mount Muhavura, where higher levels of human disturbance were found (**Figure 4. 5. 5. 5**). This suggests that human disturbance is having a negative impact on the population and could therefore be a constraint on population growth rates. However, it possible that areas with high gorilla densities (particularly habituated groups) tend to be better patrolled, and therefore experienced less frequent hunting, wood and bamboo cutting and other forms of illegal activities than the ones with less gorilla densities. If this is the case, the presence of gorillas would be, indirectly, driving the lower levels of human disturbance, rather than high human disturbance causing low gorillas densities, and some other factors would have to be limiting the gorillas' use of certain parts of the park. These results corroborate that found during the 2003 Virunga volcanoes range gorillas census (Gray *et al*., 2005b). However, gorillas groups range over quite large areas, and the locations where each was found during the census represent just a snapshot of the distribution at one point in time

Mikeno has been particularly badly affected by insecurity and has been inaccessible to staff patrol exercises for much of the last two years. Recent patrols continuously report signs of intensive human impacts, including cattle grazing in this part of the volcanoes massif. While the fact that areas used by gorillas tended to be better patrolled might reduce levels of illegal activities; it is highly unlikely that this is the only reason to the negative correlation between gorillas and human disturbance. The following section will elaborate on the Mikeno crisis and the usefulness and necessity of spatial imagery to enhance the protection of the VNP.

4. 5. 5. 1 The Mikeno Human Encroachment Crisis: A Case Study of Spatial Imagery Solving-problem to Enhance the Protection of a Protected Area

The Mikeno sector (250 km^2) is entirely located in the southern tip of the VNP. The Mikeno sector is geographically separated from the rest of the Park and it represents about 3. 2% of its total area. It runs along the Rwandan border and consists of a range of five volcanoes intertwined with high altitude forests (**Figure 4. 1. 1. 1**). It harbors the largest population of the endemic mountain gorilla (*Gorilla beringei beringei*) in an area commonly referred to as the `gorilla sector'. The foothills of the volcanoes outside the park are heavily populated rural lands, with estimated 80,580 people living in a 10-km belt around the Mikeno sector (Lanjouw *et al*., 2001).

The Mikeno sector has recently experienced changes to its natural habitat that have been unprecedented in historic time (Mubalama & Mbula, 2005). Habitat fragmentation was widespread and profound and has taken a heavy toll on wildlife, including the small population of elephants (*Loxodonta africana* sp). Reports of extensive destruction of habitat and land conversion by pastoralists were received in Goma in June 2004 when approximately 6,000 people accompanied by Rwandan military personnel were said to have moved into the Mikeno sector of the VNP, cutting down trees and rapidly destroying large expanses of bamboos and alpine forest (Franckfurt Zoological Society-FZS *et al*., 2004). Large herds of livestock were reportedly introduced in the park. Sources pointed the presence of numbers of armed, uniformed personnel, apparently protecting people and their livestock (FZS *et al*., 2004). In response to these reports, an aerial reconnaissance was undertaken by on June 12, 2004, through the European Commission's Development Office (ECDO) in Goma, DRC. The area was flown over twice at an altitude of about 1,000 m above the ground level. **Figure 4. 5. 5. 1. 1** illustrates that the situation was desperate as it was found that habitat destruction occurred at a rate of up to 2 km^2 a day (the whole gorilla sector being 250 km^2). Furthermore, approximately 15 km^2 of the park was destroyed between 28 May 28 and 12 June 2004 (ECDO, 2004). The former local chief of Kibumba (**Annex 12**) benefited directly from this illegal land use, receiving a daily wage for forest clearance of Rwanda francs 8,000 ($US 8) per hectare of park land cleared while workers employed to carry this large scale-clearing received Rwanda francs 800 ($US 0.08) per personnel per day from Rwanda side (FZS *et al*., 2004; Muir & de Merode, 2009). Subsistence and conclusive evidence indicates that these invasions were orchestrated by relatively wealthy Rwandan land brokers with Congolese collaborators, and this invasion was deliberately timed to coincide with the political turmoil instigated by Laurent Nkunda and Mutebusi, two former FARDC commanders whose dissident forces had stormed into South Kivu province only a few days before the Mikeno crisis broke out with rebel troops haunting the volcanoes mountains.

Five key factors were catalyzing the habitat destruction in the Mikeno massif, including (i) clearing for cultivation; (ii) grazing and dry-season burning stimulating new growth of grasses for cattle grazing at a time when other fodder was scarce; (iii) attempting to destroy the refuge of the undesirable *Interahamwe* and to improve visibility in tall grass area suspeceted to be hide-out; (iv) collecting firewood; (v) increasing the supply of tall thatching grass, and finally setting bushfires to collect honey from the trees by smoking the bees out, and then get out of control but also burning wood to create charcoal in the forests also created wildfires.

Elephants (*Loxodonta africana* sp) and gorillas (*Gorilla beringei beringei*) are dependent on habitat since by downing trees, elephants help create gorilla feeding areas. Once the forest is converted to agriculture it rarely revers to natural vegetation, unless it is left for hundreds of years (Mubalama & Mbula, 2005). Degradation was ongoing in an area where the carrying capacity was estimated to be 120 elephants, calculating an average of 0.5 per km^2 (based on Pfeffer, 1989) meaning less room for elephants (Barnes, 1990; Mubalama & Mbula, 2005). The further spread of agriculture is likely to continue to increase competition between humans and elephants for land in the Mikeno massif, resulting in loss of habitat (Mubalama, 1995).

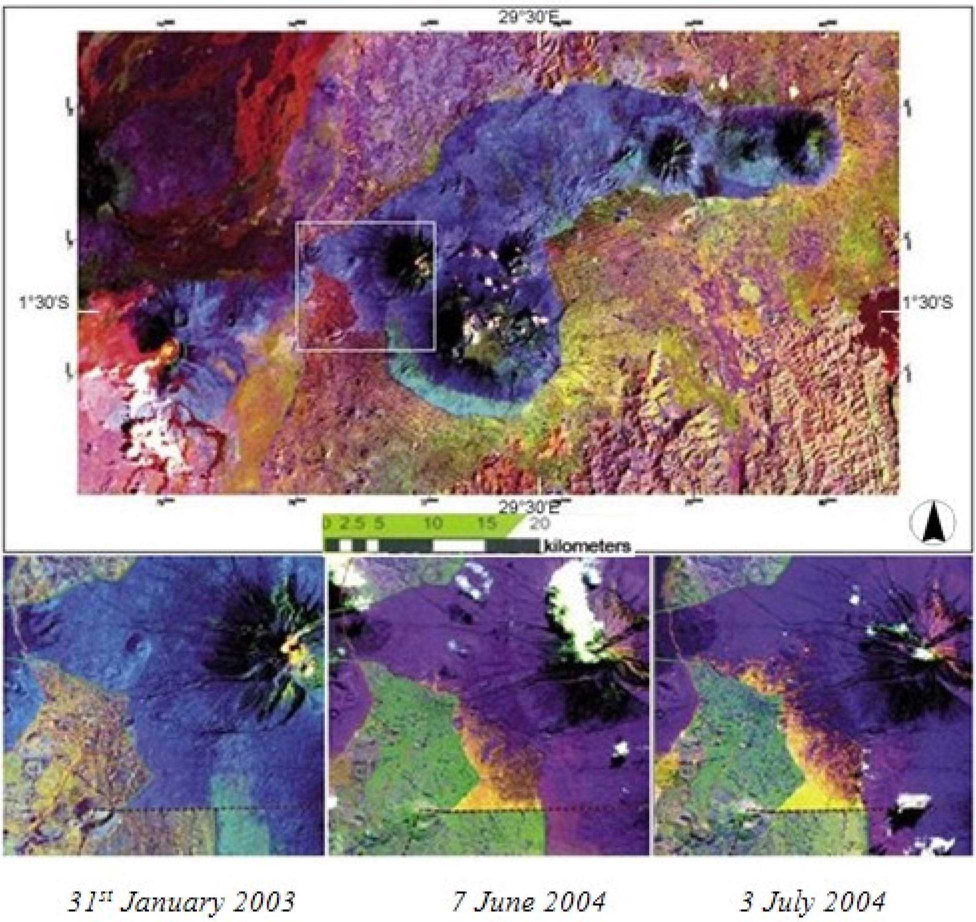


Figure 4. 5. 5. 1. 1 *Map showing the human-induced deforestation during the Mikeno massif crisis: Source: Leyens et al., 2009*

The combination of a high rising population density, the strong reliance on resources and the enormous need for energy in the form of firewood and charcoal, all lead to a very high pressure on the natural resources in this region. This has accumulated to a situation in which almost every piece of land was in use, including steep hill slopes and swamps, which are drained and transformed into farming (Boffa *et al*., 2005) with staple food crops dominated by maize (*Zea mays* L), sorghum (*Sorghum vulagris*), Irish potatoes (*Solanum tuberosum*), cassava (*Manihot esculenta* Crantz), bean (*Phaseolus vulagris*), banana (*Musa paradisiaca*), sugar cane (*Saccharum officinialis*), cabbages (*Brassica* sp), onion (*Alium cepa*), leeks (*Alium porrum*), spinach (*Basela alba* and *Basela rubra*), pea (*Pisium sativum*), carrot (*Daucus carotta*) and sweet potatoes (*Hypomea batata)* (van de Giessen, 2008). Furthermore, such a situation developed a strategy in which fallow periods are shortened and eventually disappear in the face of human pressure.

Furthermore, the households generally did not have the opportunity to invest in anything other than their basic daily needs. With such a livelihood strategy focusing on survival, most people likely give low priority to activities such as planting trees and applying measures to prevent erosion and to improve soil fertility. This human pressure forces people to farm more marginal land, including the mountainous edges resulting as Morgan (1995) has found, in an increase in the erosion rate such as the recent landslide which has taken a heavy toll of sixteen people in Kibumba following a heavy tropical rain on 15 May 2010. The mudflow destroyed one part of the village and at least 1,500 people were affected, most of whom sought shelters in a nearby village where they are still at risk if rains continue to pound the area (La Reference plus, 2010).

4. 6 Relationship between Signs of Human Use and Mammal Signs

Table 4. 6. 1 on Spearman rank correlation coefficients (r_S) for the relationships between signs of human disturbance and large mammals shows that there were no significant correlation between signs of mining, wild fire and fishing with signs of any of the five large mammals. There were significant negative correlations ($P < 0.05$) between charcoal making and woodcut signs and signs of elephants. There were also significant negative correlation and between charcoal making signs and signs of Uganda kob. However, a significant positive correlation ($P < 0.01$) between signs of hunters arrested and four of the five large mammals with the exception of gorilla, as shown in **Table 4. 6. 1**. Significant and positive correlation between elephant, African buffalo and Uganda kob carcasses encounter rates and both the number of poachers' camps and heard gunshots strongly implies that, at least within the park, the increase in elephant slaughter was due to poaching. This finding is consistent with Dunham (2008) results in Sebungwe region in Zimbabwe where the mortality rate of elephants has positively correlated with the observed number of poachers' camps. A simultaneous increase in the number of human encroachment and charcoal making suggests that the problem was not just wildlife poaching but a wider problem of inadequate law enforcement as a result of insecurity, inappropriate resource allocations and budget pitfall. The estimate of the carcass observations ratio is of course subjective, but it is supported by a whole set of indices, direct and indirect (strong smell of decaying carcass in forest galleries, gunshots heard every day, mainly from war weapons, foorprints of military shoes, campsites and increasingly aggressive wildlife behaviour) that were collected in the course of daily park staff movement throughout the controlled park areas. The level of poaching has fluctuated a great deal, particularly according to the level of the anti-poaching efforts. 2006 and 2007 have been a *great year* for the poachers who have taken advantage of the military and militia gangs' high powered automatic weapons.

Table 4. 6. 1 *Spearman rank correlation coefficients (r_S) for the relationships between signs of human disturbance and large mammals 2004-2008. Correlation coefficients in* **bold** *have P <.05*

Human activity	Elephant	Buffalo	Hippo	Uganda kob	Gorilla
Camp	0.373	0.223	0.317	**0.624**	0.223
Charcoal	**-0.490**	-0.327	-0.386	**-0.439**	0.198
Hunter	**0.569**	**0.562**	**0.603**	**0.765**	-0.265
Circulation	0.257	0.214	0.159	**0.381**	0.052
Woodcut	**-0.436**	-0.333	-0.288	-0.363	0.311
Gunshot heard	**0.504**	**0.503**	**0.588**	**0.778**	-0.238
Encroachment	-0.329	-0.470	-0.092	0.040	**0.349**
Mining	-0.054	-0.230	-0.039	0.134	0.391
Wild fire	-0.141	-0.105	0.216	0.267	0.019
Fishing	-0.116	0.025	0.300	0.255	-0.239
Snaring	-0.128	-0.333	-0.314	-0.155	**0.613**
Sawmilling	0.101	-0.193	-0.038	0.258	**0.434**

From **Table 4. 6. 2** below, there was a positive relationship between carcasses and woodcut, fire setting and snare suggesting the potential of these anthropogenic activities *vis-à-vis* wildlife. Not surprisingly hunters, human encroachment and mining activities observations positively correlated with snare signs as shown in the **Table 4. 6. 1**, thus they had deleterious effects on wildlife populations in the park.

Table 4. 6. 2 *Spearman rank correlation coefficients (r_S) for the relationships among signs of human disturbance (2004-2008). Correlation coefficients in* **bold** *have P <.05*

Human activity	Camp	carcass	Hunter	Woodcut	Gunshot heard	Encroachment	Mining	fire	Fishing	Snare	sawmill
Camp	0	-0.063	**0.798**	-0.049	**0.848**	0.180	0.363	0.321	0.206	0.117	**0.462**
Carcass		0	0.096	**0.508**	0.201	0.264	-0.120	**0.508**	-0.739	**0.221**	-0.247
Hunter			0	-0.258	**0.939**	0.011	0.214	0.310	-0.360	**0.135**	0.199
Woodcut				0	-0.146	0.194	0.056	0.264	**0.414**	0.023	-0.013
Gunshot heard					0	0.145	0.218	**0.440**	0.427	-0.106	0.289
Encroachment						0	**0.542**	**0.514**	0.253	**0.622**	**0.553**
Mining							0	0.394	0.259	**0.494**	**0.670**
Fire								0	**0.654**	0.082	0.279
Fishing									0	-0.305	0.016
Snare										0	**0.538**
Sawmilling											0

The large mammals have been the subject of various censuses and studies over recent years. Large herbivores in the VNP have declined during the study period. Apart from the Uganda kob (*Thoma's kob)*, which population varied between 10,300 in 1981 and 12,982 in 2006, elephant population surveyed in the plains of the Lake Edward went from 751 in 1981 to 348 in 2006; African buffalo from 9,715 in 1981 to 3,822 in 2006. The drastic decline was also experienced by Common hippo population which went from almost 30,000 individuals in the mid-1970s to no more than 887 in 2005, representing a loss of 97 per cent of the population in 30 years. In 1986, Grauer's gorilla (*Gorilla beringei graueri)* estimate in the mountain

Tshiaberimu totaled 30 individuals, but very recently, proper censuses produced 19 individuals in 2002, 21 in 2006 and only 20 in 2008. The total number of Mountain gorilla (*Gorilla beringei beringei)* was estimated at 324 individuals in 1989 and 380 individuals in 2003.

The main cause of the dramatic decline of all the large mammals in VNP is unquestionably the unprecedented level of poaching in the park over the past 15 years (Languy, 2009). Poaching of wildlife has continued and the staff lacked the means of patrolling the park's 1,150 km long boundary (Languy & de Merode, 2009a). The limited accessibility of park and frequent disarmaments of the guards implying poor coverage of the park might be one of the key factors explaining the spreading of the wildlife slaughter. As an indicator of the coverage effort, on no occasion did the park reach the patrols number realized in 1980 when 4,777 patrols were launched in one single year (IZCN-DG, 1980). The highest level of patrol coverage during the study period has been 4, 443 patrols launched in 2006 (**Table 4. 4. 4. 1. 1**). In terms of performance achieved, 764 poachers were arrested in 1979 (IZCN-DG, 1980) while the best performance realized between 2004 and 2008 was set at 607 offenders in 2006. Ten firearms along with 350 ammunitions (IZCN-DG, 1980) and 66 firearms along with 88 pieces of elephant ivory were recovered respectively in 1979 and 1981 (IZCN-DG, 1982) while only 7 recovered arms were documented over the five year study period (**Table 4. 4. 4. 1. 1**).

***Table 4. 6. 3** Theoretical time required to achieve animal populations in the VNP*

Species	Earliest recorded population[1]	Current population[2]	Maximum growth rates (annual %)[3]	Minimum no of years for re-stocking
Buffalo	28,307	3,822	16	14
Kob	11,218	12,982	25	0
Elephant	3,425	348	8	32
Hippopotamus	26,530	887	9	6
Lowland Gorilla	31	21	7	0
Mountain Gorilla	274	380	7	2

[1]*All estimates are based on Cornet d'Elzius, 1959 except Mountain Gorillas (Webber, 1983) and Eastern Lowland Gorillas (Aveling, pers.comm.).*
[2]*All estimates are based on Kujirakwinja et al.(2006a), except for Mountain Gorillas (Gray et al., (2005b).*
[3]*Based on published maximum intrinsic animal population growth rates (max) for specific taxa (Rowcliffe et al., 2003).*

The drop in the park wildlife population as a result of human activity calls for investigation in terms of the future of large mammals in the park. When considering the indication of theoretical time required (**Table 4. 6. 3**) for the current wildlife populations to grow to the earliest known abundance based on maximum rates of population increase in the Virunga ecosystem, it appears that the wildlife prospect sounds bleak. Rowcliffe *et al*. (2003) assume zero mortality (**Table 4. 6. 3**) from disease or poaching, and do not take into account predation or a logistic reduction in the rate of increase towards the end of the time period. While some wildlife populations may partly recover through emigration from nearby QENP, it is likely that the time estimate can still be taken as a theoretical minimum for the park's recovery. On the basis of these data, one can safely assume that a strategy for restoring the park must work on a timescale of at least 30 to 40 years (de Merode & Languy, 2009b).

Therefore every effort should be undertaken from the government level as a follow up of the commitment of the Congolese government in Paris in September 2004 to support the action of UNESCO and its partners in the safeguarding of the World Heritage properties. This commitment was expressed in the following actions: (i) the evacuation of armed troops and other populations who threaten the integrity of the properties, (ii) contribution towards the restoration of the integrity of the World Heritage properties; (ii) payment of the salaries of the staff at the sites, (iv) facilitating the functioning of the Congolese National Parks Institute for the management of the properties, and (v) the constitution of a Trust fund for the rehabilitation of the World Heritage properties (UNESCO-WHC, 2009).

4. 7 Conserving Biodiversity in Violent Environment: Virunga National Park as a Battlefield of Ashes and Mud in Conflict and Post conflict times

4. 7. 1 The Political Opportunism and Poaching in the Framework of Democratic Elections Context

The 2006 first democratic presidential and parliamentary elections have offered the possibility of substantial economic and political gains to many candidates. Indeed, the new rules of the country participatory democracy allowed a tough competition among candidates who were forced to use every mean at their disposal to gain public vote. An increase in the number of constituencies meant the possibility of more candidates and better representation of local interests. However, the electoral rules created a new constellation or relationships between local community and parliamentary candidates. Local officials used their resources and personal influence to support certain individuals' campaigns, and they also solicited votes from other members of their respective political parties. Such activities could enhance or sabotage candidacies, as individuals running without the backing of the local party machine had a fighting chance of being elected to take part in the contest election. As a result, candidates frequently used bribes and other malpractices, including lobbying to get readily available chunk of the land in the park to secure nominations, thus promising the moon to their constituents. In fact, parliamentary candidates visiting or campaigning in their constituencies faced numerous complains regarding wildlife policy in the midst of the collapse of the country's domestic economy. Villagers griped about the lack of alternative sources of protein in their ever-growing human population in the region where the loss of jobs on the plantations and in small factories around the park, and the loss of most non-agricultural jobs were of far-reaching social consequences.

All these factors were carefully exploited by the political opportunism that gained ground in the region. Indeed, politicians, stakeholders from the civil society or leaders of environmental NGOs, developed a double languages as far as the park was concerned: on the one hand, they used an 'ecological' approach and a level of co-operation with the park managers and their partners/donors in order to receive benefits; and on the other hand, a 'military' approach, such as trade unions, demanding rights for the populations living around the park, thus justifying even the overrunning of the park's boundaries. One of the great ironies is that, more often than not, people who – given their political or social position – should be acting to save the park, were actually manipulating the local population, and indeed turning it against the park. As a result, this behaviour has generated resentment and hostility that has led to vandalism, such as setting of bushfires and damage or destruction of park property, and in some extreme cases, the murder of park employees. Indeed, between May and October 2006, three guards were killed and 6 others wounded by *Mai Mai* attacks spotting ICCN staff and patrol posts.

During the campaign, some candidates expressly vowed to fight against attempts to augment conservation policy stressing that once elected they will never support passing a bill intending to 'protect the animals at the expense of the people. One hundred and twenty park staff have been killed in skirmishes (de Merode & Languy, 2009b) and thirteen more severely wounded (Mubalama, pers. comm.). Such similar behaviour was already documented from the parliamentary debate over the 1982 Amendment to the National Parks and Wildlife Act in Zambia before the 1983 elections. Indeed, dissenting parliamentarians very often highlighted the basic political fact that people – not animals – vote: "*Mr Speaker, when the registration of voters was taking place, I did not hear of any animal being asked to go and register as a voter;*

I heard the campaigners ask only human beings. Maybe the animals were asked in a different language"; *I hope they (those who vote for the amendment) will have the strength to tell their people in their constituencies that they favour animals more than people; At no time did rhinoceros or elephants participate in the fight of our independence* (Kalenga, 1982).

Furthermore, such sentiment expressed was as well documented in Bwindi Impenetrable Forest in Uganda, including the following (Wild & Mutebi, 1996): "When you mention the national park we want to vomit." "Gorillas should be put in cages and taken to zoos". With the current Wildlife Act Amendment on the horizon, it is likely that the bill will be passed as the derogatorily named"*fortress conservation*" (Blaikie & Jeanrenaud, 1997) will be diluted by the community-based conservation becoming the central concept of participation in wildlife management (ICCN-DG, 2008). However, it should be noted that ICCN's mandate should be to improve its public image by presenting its staff as highly professional public servants rather than the economic development *per se* given the fact that it is in the capacity of other well known civil servant services within the government to promote for economic development. In the light of this, park wardens and assistants should be educated in co-management with the local population and brought up-to-date with information and communication technologies (Eloma *&* d'Huart., 2008).

4. 7. 2 Renegade Soldiers and Militia Gangs Lay waste to Africa's Oldest Park

Figure 4. 7. 2. 1 indicates that there has been considerable tangible proof of the direct involvement in poaching by men in uniform belonging to both the rebel groups and the regular army (Languy, 2009), thus making the VNP a battlefield of ashes and mud (Nietschmann, 1990). Better armed groups from the Eighth Military Region in Goma were considered to be important users of wildlife. They were believed to hunt mainly in the park, but passed regularly through neighbouring villages to trade supplies. It was alleged that a number of the park neighbourhood households facilitated the activities of poaching groups by providing porters and safe houses (*maisons d'accueil*), where arms and ammunition could be stored to minimise the risk of encounters with Congolese authorities. Congolese soldiers belonging to the FARDC were allegedly involved in large-scale hunting, although these tended to be lower ranking soldiers. A small section of about 12 soldiers was often spread over near and within the park, and these were known to be hunting in the park on a regular basis, thus throwing a monkey wrench into the works of the park staff management. In some cases, ballistic tests on a small number of captured AK-47s have revealed that the weapons never had been used before, indicating significant capital of investment in the poaching gangs by the FARDC dealers. Other weapons too numerous to

count have been traced to official highly placed in the army; unfortunately no offender was sentenced during the course of this study because the courts are completely separate from the wildlife authority and do not always set the same priority on protecting wildlife (Leader-Williams & Milner-Gulland, 1993). Such situation was perceived to be the final stroke in the park ruin. Furthermore, it should be noted that most well known awe-inspiring rule-breakers were part and parcel of the close-knit inner circle around the political power both in VNP and KBNP. Failure to establish a functioning national military force has recently been identified as one of the primary impediments to progress in the DRC. The DRC's inability to effectively control the monopoly of violence, coupled with the weakness in governance, have enabled a proliferation of spaces where various military groups have established alternative structure of governance with varying degrees of insecurity, including human rights abuses and war crimes.

The encounter rates of soldiers' camps per 100 effective patrol days show major fluctuations from 2004 to 2008, with peak in 2005 (**Table 4. 4. 4. 1. 1**). The average CPUE index for military's camp was 0.56. Military officers did not actively hunt, but were widely said to co-ordinate and regulate hunting activities. However, poaching levels in 2006 do not seem to be as high as in 2003-2005 period of the time, due to the withdrawal of military bases from some areas, and to the simple fact that there were fewer elephants killed. Poaching activities in the park calmed down, albeit for a short period only. After that initial lull, poaching activities picked up again and park staff resumed patrols in areas previously occupied by military.

Military and militia gangs were involved in commercial poaching groups using poaching as a money-making venture since they were driven not by the need to survive – but by a desire for financial gain and driven by sheer greed. They worked from a smaller scale to the large organized trophy poachers. Commercial poachers tended to target most of the species that are hunted by subsistence poachers and also, larger species - right through to animals like African buffalo, Common hippo and elephant. Both commercial and trophy poaching exist because there is a worldwide demand for the products. All forms of poaching continue to exist because there was an inadequate preventative strategy against poaching and an inadequate program to control poaching. How effectively scientists, conservationists, government and society at large will study, understand, collaborate and move forward to meet the cological needs of these large mammals will determine where and how many species and populations will survive (Karanth *et al*., 2004). Given the deeply traumatic national army involvement in wildlife crime, the government commitment to the highest level of the country must be unshakeable to curb armed poaching now than ever. In this regard, time is of the essence!

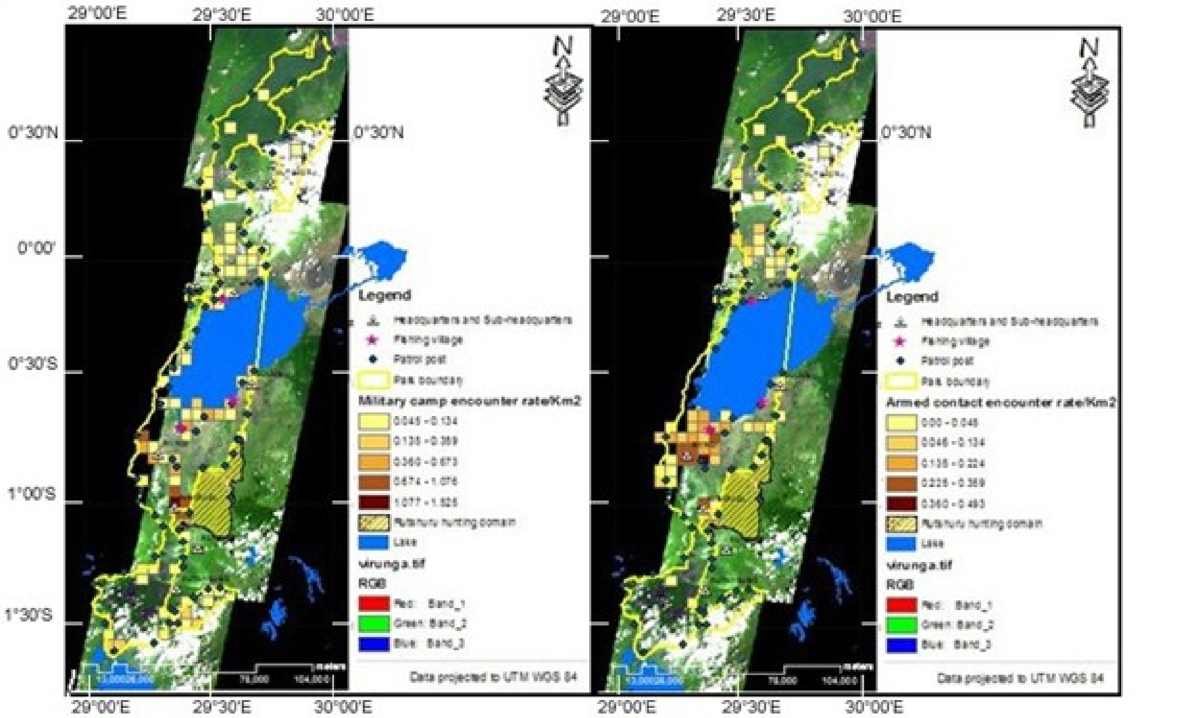


***Figure 4. 7. 2. 1** Military camps and armed contacts encounter rates in Virunga National Park.*

Wildlife crime presents a major problem for the park management with support from conservation NGOs trying to conserve its biodiversity. Indeed, substantial efforts have been made by numerous conservation organizations to maintain a conservation presence in the DRC, even under the most difficult of conditions (Hart & Hall, 1996; Hart & Hart, 1997; Drauland & van Krunkelsven, 2002). In their unabated attempts to fight this crime, the under-equipped, under-staffed and with partially skilled staff, the park administration wildlife enforcement remains out-manoeuvred by organized and technically sophisticated crime gangs operating freely from within as well as across borders. On several occasions, DRC soldiers have erected a blockade at the entrance to the park, making it next to impossible for park authorities to carry out their work. Rutagarama (1999) provides strong evidence of the presence of military units along with several thousand people carrying out agricultural activities in the Mikeno sector, and growing exotic plants such as sweet potatoes (*Hypomea batata*), tobacco (*Nicotiana tabacum* L), wheat and hemp (*Canabis sativa*). In this regard, the World Heritage Committee held in Australia (Christchurch) in 2007 during the 31st session has taken Decision **31 COM 7A.4** which recalled the Decision **30 COM 7A.7** taken durng the thirteenth session in Vilnus in 2006, and strongly expressing regrets that in spite of promises by the Minister of Defence, the Nyaleke army reunification and training camp (**Figure 4. 4. 3. 4**) inside the property was not closed down. Furthermore, the Decision reiterates the WHC request for an immediate closure and removal of the camp from the property. It’s unfortunate that both rebel groups and military targeted parks staff, killing 11 rangers in 2004 alone.

Non-payment of the military personnel is without any doubt the principal exogenous puzzle that VNP is faced with at present (Balole *et al*., 2009a). Since the soldiers do not have enough resources to live on and coupled with their very low morale, they are compelled to engage in the destruction of the park's resources at every level: animal poaching, exploitation of fuelwood and other natural resources, over-fishing and violation of park boundaries (Balole *et al*., 2009a). As per June 2010, there were six batallions (about 4,500 men) in the national park (**Figure 4.7.2.1**) who were largely unpaid and unfed. Last year, after the publication of a report on human rights abuses by the FARDC and a sustained campaign by international human rights organisations, MONUC was instructed by UN New York headquarters to suspend all but a very limited amount of their support in rations to the Congolese army. This led to a starved army, and ironically, a sharp increase in pillaging and other attacks on the civilian population. This further was mirrored by a very sharp increase in poaching in the park (de Merode, pers. comm.).

A similar military deployment was noticed near KBNP where there are currently one brigade on Mudaka-Kalehe axe; one on Kabare-Walungu-shabunda (**Annex 14**) and two on Lulingu-Nzovu axe, and one combat battalion in Itebero and three further companies at Kameli Myassa and Nguba (Radar, pers. comm.). The military command has very little control over its soldiers partly because they are not getting their pay and supplies and morale is very low. The other reason is that a significant proportion of the military was made up of recently integrated rebel soldiers (CNDP and PARECO), who clearly have no desire to follow orders.

In the face of such appalling situation, the park management did not sit back while the park was invaded, and accordingly adaptive management was initiated. In fact, a stabilisation plan was recently developed for the park jointly with the military command. It involves reducing military presence by 95%, with those remaining being under ICCN command, and fed properly by ICCN. It means that ICCN has to guarantee security in the park, meaning much improved surveillance and mobility, and a real capacity to confront and overcome the armed groups operating in the park (FDLR, *Mai Mai* and ADF/NALU). It is costing us about $US 90,000 a month, and success is not guaranteed (de Merode, pers. comm.). ICCN is toying with the idea of piloting another project which involves strengthening the army corps of engineers to repair the roads in the park. In essence, it involves engaging a company of soldiers currently in the park (120 men), taking away their weapons, but keeping them in their units and giving them road maintenance equipment, pay and rations. It's a bit ambitious, but if it works, it will certainly generate a lot of interest. This was a necessary compromise to achieve peace, but leaves the park mamagement with some very big challenges. Yet the price tag for getting the military under control would be outside of the range of conservationists in either PAs, thus emphasizing the crucial need of getting the personal involvement of the Head of the state and national army chief commander.

As I'm putting an end to this piece of research work, recent IDPE report (2010) in the central part of the VNP reveals that 7 Common hippos, 4 elephants, 2 chimpanzees and 4 baboons (*Papio doguera*) were killed by FARDC elements from the Integrated 15th and 18th Brigades operating in Vitshumbi between 7th and 25th February 2010. Common hippos were slaughtered respectively at Vitshumbi, Chondo and Mwiga Bay; elephants were killed at Kahumiro and Chondo; chimpanzees were fired at Chondo/Chisitu while baboons were killed at Machiba. In the last month of May 2010, one guard was killed, two were seriously injured, 12 armed contacts took place between guards and the military, two ambushes on the road, two of three park boats on Lake Edward were shot up by heavy machine guns, while two staff were abducted and tortured. This most recent and appalling report only confirms the plight of large mammals and park staff in the park. In view of the extremely negative consequences of the presence of armed groups in and around the park, the central government should urgently take measures to disarm and evacuate the armed groups and to reduce significantly the number of military positions inside the VNP, a world heritage site in danger since 1994. Sadly enough, a guard was killed during recent attack of Nyaleke patrol post (**Annex 12**) perpertrated by *Mai Mai* fighers on 25-26 May 2010 (Mushenzi, pers. comm.). This is a serious worrying trend.

One of the essential functions of the WHC is to monitor the state of conservation of properties on the World Heritage List (WHL) and decide whether a property may be removed from the WHL and examine request for international assistance from the world heritage fund. Based on the frequency at which the World Heritage Committee (WHC, 2008) has deliberated over this property over the past 15 years. (0 = minimum reports, 100 = maximum) reports, the graph in **Figure 4. 7. 2. 2** below shows that the threats pattern is consistently on increase as described above with the subsequent decline of wildlife and widespread carcasses and poachers' camps in the park. Given the threat levels, and following the 17th General Assembly (2009), the WHC has taken the Decision **33COM 7A.4** on the VNP encouraging the State Party's park management authority and other agencies to continue and strengthen their work to provide alternative energy sources as a way to alleviate; deforestation pressures and calls on the international community to support these activities. The decision also reiterates its request to the State Party to develop in consultation with the WHC and Advisory Bodies a draft statement of Outstanding Universal Value as well as a proposal for the desired state of conservation for the removal of the property from the list of World Heritage in Danger for examination by the WHC at its 34th session in 2010. Finally, the decision expresses regrets that the State Party has not yet undertaken the necessary measures to relocate, beyond the boundaries of the property, the training and reunification camp of the army based at Nyaleke (**Annex 12**) in the northern sector of the park. The 34th session in 2010 in Brasila (25 July-3 August 2010) has just confirmed through its decision **34 COM 8c.2** the VNP on WHL in Danger (WHC, 2010).

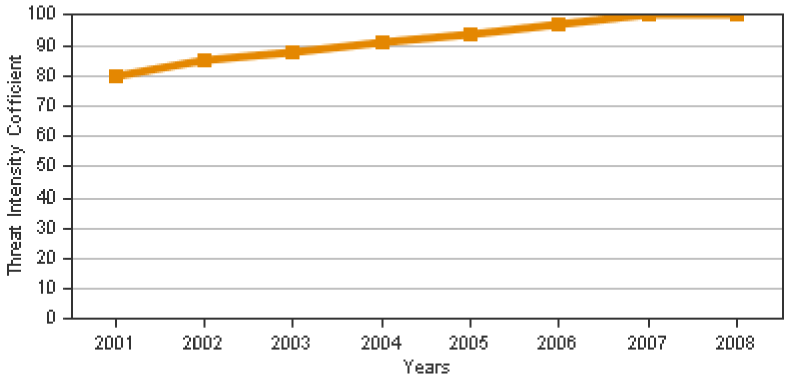


Figure 4. 7. 2. 2 *Threats reporting trend in Virunga National Park. Source: WHC report, (2008).*

In other PAs war proved to have beneficial effects on the environment. During the Zimbabwe civil war, the population of elephants in the Hwange National Park increased beyond local carrying capacity because the situation had become too dangerous for poachers (Hallagan, 1981). By the same token, Plumptre *et al*. (1997) noticed that the African buffalo (*Syncerus caffer*) did well in part of the Rwanda Volcano National Park during the war because the presence of the army made the area too dangerous for poachers. In contrast, several authors found that war only appears to be profitable for the environment if it keeps people out of large areas. Usually that is not the case, so war can hardly be considered beneficial to biodiversity as the negative effects of war on wildlife are much more commonly observed. Candotti (2000) described the problems faced by conservation NGOs as a result of the eastern DRC wars where control over large parts of KBNP and VNP, because of the presence of armed gangs killing wildlife, digging coltan and herding cattle (Draulans, 2002).

4. 7. 3 Charcoal: the Oil wells for corrupt gangs of charcoal-makers, mafia merchants and heretic park staff

Figures 4. 7. 3. 1 & **4. 7. 3. 2** indicate that charcoal exploitation is widespread along the park boundary with highest occurrence in the southern sector of the park suggesting that higher anthropogenetic pressures due to high human population on park boundary as shown by **Figure**

4. 8. 2. 2. The paths well explored by these merchants/charcoal makers were Bugomba, Bushenge, Buvunga, Nyamagana, Karambi, Kakomero and Rubare (**Figure 4. 7. 3. 2**).

With the exception of charcoal kiln pattern, firewood collection frequently occurred as well in the three fishing villages (Vitshumbi, Kyavinyonge and Nyakakoma), thus explaining that fish smoking activity induced firewood collection around fishing villages (**Figure 4. 7. 3. 1**). This finding prompts the need of estimating the quantity of fuelwood used annually in these fishing villages and using the result in the prospect of articulating a coherent strategy for the park including optimizing the control and management of the fisheries (d'Huart *et al*., 2009a).

According to recent study supported by WWF Environmental Program, the town of Goma which had 550,000 inhabitants in 2007 consumes 47,425 tons of charcoal (known as *makala* in Kiswahili) per year, which represents more than 250,000 tons of wood. An average household uses 24 sacks (of 35 kg each) of charcoal per year. This is the equivalent of 840 kg of charcoal or the equivalent of 5,040 kg of wood (on the background that six kilos of wood produce one kilo of charcoal). This translates into an average consumption of 2 kg per person per day, or 6,570 kg of wood per household per year. Consumers other than households use around 28,300 sacks per year (about 1,500 tons).

The region around the Virunga volcanoes is densely populated and no forest is left outside the national park. Making charcoal from the mountain forest trees in the Mikeno sector remains a multi-million-dollar business and a severe threat to the park despite ongoing destruction of the ovens by park staff. It is obvious, however, that the majority of people making charcoal in the Mikeno massif sector were coming from the neighbor Rwanda where charcoal kilns are prohibited and measures effectively enforced in this regad

Wood is primary necessity for Goma people, especially those living in a rural environment. They are significantly exploiting forest resources, namely because: (i) fuelwood is usually available to those in rural areas willing to gather it; (ii) the very low initial capital investment needed to use energy wood; (iii) the very low level electrification (barely 10% of homes) coupled with frequent power cuts and the lack of alternative energy sources; (iv) Goma's proximity to the Nyiragongo volcano provides a strong demand for construction timber; (v) a high flux of people caused by various rebellions and (vi) a preference for foods cooked over wood fires.

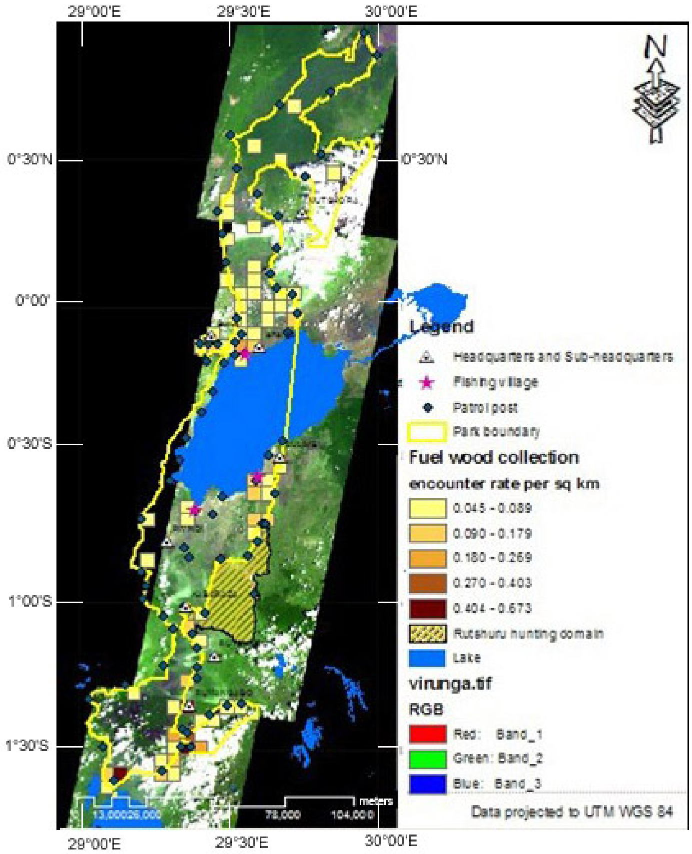


Figure 4. 7. 3. 1 *Fuelwood collection encounter rates in Virunga National Park.*

The quantity of construction wood (rafters and planks) used in Goma town is equivalent to 60,000 eucalyptus trees (*Eucalyptus globulus* Labill and *Eucalyptus maculata* Hook) per year. The combined data show that Goma's total consumption was 1,335,000 sacks of charcoal per year; this figure represents the equivalent of 47,425 tons per year and corresponding to around 285,500 tons of wood and/or 476,000 cubic metres (Languy *et al.*, 2009d).

Wooded ecosystems provide a range of goods and services to humankind in general, and to local rural communities in particular. The extraction of biological products such as timber, edible mushrooms (*Pleurotus sp*), fruits, fuelwood, honey and medicines raises concerns in relation to the ecological impacts on biological on biodiversity and ecosystem processes, commonly within the deforestation paradigm. Still, there is limited understanding of the ecological structure and function of wood communities and their response to these human pressures. This prompts the search for quantification of sustainable harvesting limits and the appropriate institutional arrangements under which sustainable harvesting can be implemented (Shackleton, 2001) in the near future.

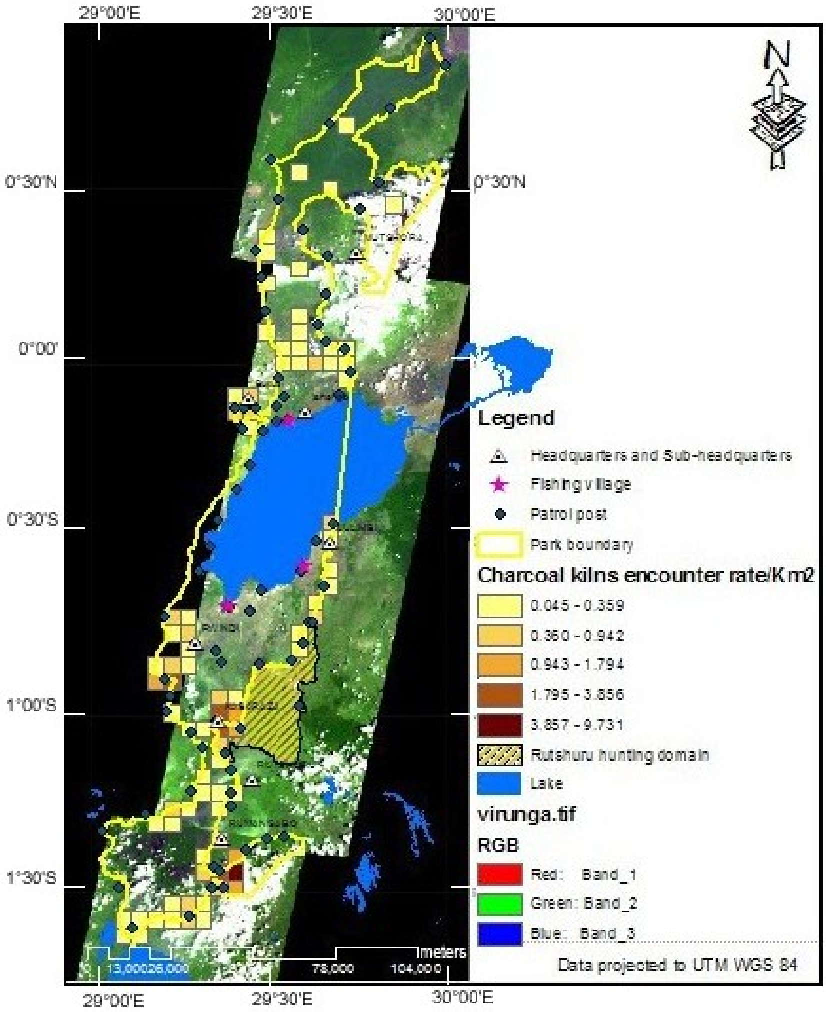


Figure 4. 7. 3. 2 *Charcoal kilns encounter rates in Virunga National Park*

This high demand of firewood and charcoal along with lumber for construction remains one of the most acute threats facing the park. This threat coupled with increasing urbanization of local population has boosted the charcoal demand. This phenomenon is evidenced by the 130 tons of *makala* are delivered to Goma each day (**Table 4. 7. 3. 2**). Indeed, the electricity and alternative sources of energy are extremely limited to supply Goma town. The electricity company (SNEL) only supplies Goma town with 9 megawatts (Balole, 2008). Only three percent of households had access to semi-reliable electricity and only occasionally needed to supply themselves with wood. A staggering 97 percent used *makala* almost exclusively as their source of energy, thus the tremendous need for energy creates enormous economic opportunities for *makala* traders in the region. It is estimated that more than 90 percent of this wood and *makala* come from the VNP with Rugari, Burungu, Rubare, Tongo, Rumangabo, Nyabanira, Kirolirwe (**Annex 12**) being among the suppliers points (Balole, 2008). In addition, Balole (2008) estimated that North Kivu province would need as much as a projected figure of between 6,825,500,000 and 7,227,000,000 kg of charcoal with 95% of degree of confidence. From these appalling figures, it can be easily stated that the *makala* industry is the main direct dynamic behind the large scale deforestation within the boundary of the VNP,especially in the Mikeno (250 km^2) sector as well as the Nyamulagira sector. The chimpanzee population at Tongo and those of the western shore of Lake Edward (namely Taliha, Lunyasenge and Kamandi) are very probably decreasing and may even be threatened with disappearance, because of charcoal production and illegal extension of field. This situation was similar with chimpanzee population in Kitiriba in Lulimbi sector where large-scale charcoal exploitation was noticed in Bulengera-Kasoso-Kamohororo and Kisitu (**Annex 12**). Leaky states that a corrupt mafia of charcoal merchants has recently begun harvesting Virunga forest, referring to Virunga’s trees as ‘their oil well’ and cutting these trees would fuel a US$ 30 million a year industry, according to Newseek (2007).

The plight of charcoal exploitation in VNP is appalling to the extent that National Geographic (2007) stressed that the mountain gorilla killings are fueled by charcoal trade. It further mentioned that like orangutans are dying for a cookie, gorillas in the DRC are dying because people in Rwanda need charcoal to cook and heat. "The gorillas have become a hindrance for the charcoal trade.” There's a very strong incentive for these people to kill the gorillas."The forests of VNP, near Rwanda, are being depleted by the illegal charcoal trade; Rwanda banned production of charcoal so it is now being smuggled in. “The last 15 years of DRC's history have been defined by the illegal exploitation of natural resources. The charcoal trade definitely fits into that reality." (de Merode, Director, pers. comm.).

Charcoal industry is not a new phenomenon in the park, but things started to get out of hand when in 2001 a meeting took place between the military, park staff, local traditional chief of Rugari (**Annex 12**) groupement, the representative of the local government based at Kabaya and UNARCO (Union des Associations pour le Reboisement Communautaire). The outcome of this meeting during which they struck the bargain was that local community was allowed to illegally produce *makala* in exchange of $US 10 then increased to $US 15per month for 3 sacks of charcoal produced in the park (**Table 4. 7. 3. 1**). A well structured organization was set up to deal with the charcoal mafia. Patrols were then organized to catch ‘offenders’ (since then meaning people who did not pay the $US 10-15 as the ‘authorization’ per month - when caught, defaulters were fined and the money paid does not go to the park cashier). The sharing cost of the collected fund was set as follows: 60% for the military (commander and collaborators); 20% for the park (chief park warden and collaborators); 17% for both the local traditional chief of Rugari groupement and the representative of the local government based at Kabaya (southern sector of the VNP) and 3% for UNARCO (PNVI-Rumangabo, 2006). The mafia was so rooted that the terms *Kutukura* (meaning a bunch in local language) or *Ishengera* were coined to refer to the economic benefits from this new shameful practice, and some park staff who dared go against the grain were severely punished (with bonus cut) and threatened by soldiers as the latter were the ones who frequently called the shots in this dirt and ridiculous operation.

Table 4. 7. 3. 1. *Consumption of makala by households in Goma town*

Category of consumption	Average consumption per house per year (35-kg sacks of makala per year)	Number of households sampled	Percentage of the total of households interviewed	Extra population of the number of households for the whole town of Goma	Total consumption per year (35-kg sacks of charcoal per year)
Purchase per sack of 35 kg	21	2,218	55	33,300	699.300
Purchase from retail	24	1,700	42	25,540	612,960
Electricity		149	3	2,260	0
Total		**4,067**	**100**	**61,100**	**1,312,260**

Source: Languy et al., 2009d.

Table 4. 7. 3. 2 *Consumption of wood and charcoal by different types of consumers in Goma*

Type of consumer	Cubic meters of wood per month	Sacks of charcoal per month sampled	Number of units	Consumption per year in sack (1 stere = 2 sacks)
Brickworks	25	-	5	3,000
Forges	-	2	15	360
Poultry houses	18	4	17	8,160
Orphanages	20	12	5	3,120
Medical buildings	-	1	4	48
Restaurants and cafés	-	7	13	1,092
Hotels	-	36	25	10,800
Bakeries	84	-	8	16,128
Total	-	-	**92**	**42,708**

Source: Languy et al., 2009d.

Professional charcoal-makers using large kilns typically achieved a yield of 20-25 percent or more, which is an energy-efficiency of 40-50 percent. Small kilns by farmers or occasional makers may have yields as low as 10 percent by weight, which energy efficient of about 20 percent, but such small manufactures usually; only supply a small proportion of overall consumption in countries where charcoal is a major domestic fuel. When the relative efficiency of wood to charcoal conversion and the burning efficiency of wood and charcoal fires are compared, the practice has much to commend it. Calculation shows that carbonizing large diameter wood and burning the charcoal is about twice as efficient thermal as burning the wood direct in an open cooking fire without axes, saws and wedges, large diameter wood is unused and may rot before it can be burned (FAO, 1983).

Taking the whole system from tree to domestic cooking pot, it can be seen that the overall efficiency of charcoal use may be as high as that of fuelwood, if not higher because the number of charcoal consumption should be multiplied by a factor of five or six to obtain the amount of wood used in its manufacture. In the traditional charcoal kiln, trees are cut, arranged in a pile, covered with earth and subjected to more or less controlled burning with a limited supply if air. The heat drives off the volatile components of the wood leaving the charcoal as residue.

Table 4. 7. 3. 3 *Charcoal specific hotspot in the park*

Park Management Unit	Illegal activity	Year	Poaching Hot spot (sq km)
	Charcoal production		
Northern		2004-2006	18.7
		2007	2.63
		2008	49.03
Central		2004-2006	4.19
		2007	82.33
		2008	92.69
Southern		2004-2006	62.68
		2007	170.8
		2008	130.8
Lulimbi		2004-2006	14.04
		2007	12.52
		2008	1
DCRKZ		2007	11.4
		2008	26.95
Average			**48.55**
STDEV			53.03

Table 4. 7. 3. 3 indicates that charcoal specific hotspot covered on average 48.55% of the park with the southern sector of the park having the highest distribution coverage

respectively in 2007 and 2008. The fact that the park had both the highest effective patrol man-days/km^2 and effective investigation days/km^2 along with the highest patrol day expenditure per km^2 in this period of time could particularly explain the charcoal detection over larger area in 2008. However, it's unfortunate that since then the advance force performance went down following lack of clear management procedures and staff misbehaviour within this special unit.

Well organized gangs from the urban areas (Beni, Butembo, Oicha, and Goma) pictured in **Figure 4. 1. 1. 1** and **Annex 12** often have chainsaws while rural dwellers operating on a smaller scale usually relied on traditional cutting and splitting tools. Gangs of charcoals-makers living in the countryside usually make charcoal by moving from area to area in accordance with the availability of suitable charcoal-making trees (*Olea europea, Cynometra alexandri, Bersama abyssinica, Macaranga sp, Maesa lanceolata, etc*). Charcoal kilns are almost invariably of the clay-mound type made to the local traditional design. The size of kiln and the level of skill of the charcoal makers vary, as does the efficiency of conversion of wood to charcoal. Commercial arrangements with sometimes some charcoal-makers acting as employees of urban dealers located in Beni (81,286 inhabitants in 2004)-Butembo (165,333 inhabitants in 2004), these are densely populated areas surrounding the park with respectively 1,777.91 and 868, 62 inhabitants/km^2 (Mediaspaul, 2007) - Lubero and Goma (**Figure 4. 1. 1. 1**) and other acting independently and selling their production at the best price they can obtain.

The new administration of the park has taken drastic steps to mitigate the charcoal mafia through well organized sweeps which have so far proved time tested. The advance forces were deployed in the southern sector of the park and as a result the charcoal kilns were reduced to 80% in Nyiragongo sector (ACF, 2008), and stocks of *makala* were seized as well depicted in the **Table 4. 7. 3. 4** below. The number of arrests kept reducing all the more so since the organized sweep carried on with the task to the point that when park guards arrived at oven making charcoal places they could find that offenders have already pulled up stakes.

Table 4. 7. 3. 4 *Charcoal seized by advance force following sweep operations in the park*

Unit	Period	Quantity of charcoal seized (sack)	Quantity of charcoal destroyed	Arrest
Advance force	January 2008	413	37	0
Advance force	February 2008	296	53	0
Advance force	March 2008	385	7	0
Advance force	April 2008	975	129	5
Advance force	May 2008	476	53	6
Total		**2,545**	**279**	**11**

All these sack of *makala* were given to the UNHCR (United Nations High Commissioner for Refugees) for distribution to the internally displaced people. In the meantime, the ACF (UK) is now exploring ways on how best to deal with the alternative solutions to the current charcoal crisis in the park. These include biomass bricks and cooker using plant oil. This initiative is worth trying.

4. 7. 3. 1 Efforts and Potential Perspectives to Avert the Fuelwood and Charcoal crisis

The extensive harvesting of wild trees for charcoal production in VNP and clearing of fallowing lands for agriculture in KBNP were the most significant factors contributing to tree loss. Charcoal burners harvest a lot of wood, especially of small-sized trees (Tabuti *et al*., 2009). Although many plant species are prone to unsustainable harvesting, woody plants are especially vulnerable because of their longevity, large size, poor dispersal capacities and low reproductive rates (Diaz *et al*., 2006); these characteristics render them susceptible to to local extinction. This loss of important traditional tree resources influenced by cultural, economic and political factors (Ticktin, 2004) may threaten livelihoods and increase poverty among local communities. It is therefore important that such species are managed sustainably.

A major weakness of the great majority of programs to improve the efficiency of charcoal-making is that, driven by the perceived need to save the forests, they have focused almost exclusively on energy efficiency, reasoning that higher efficiencies will lead to lower wood consumption and lower rates of deforestation. Energy efficiency as such, however, is of little significance to traditional charcoal-makers immersed in the financial practicabilities of the trade.

A wide variety of improved stove programs was launched in response to such perceptions of their potential role in saving forests. They included the promotion of homemade mud stoves in the rural areas and metal or ceramic types, which were sold commercially, in the urban areas. Some early commentators, however, questioned the rationale of stove design, asking whether energy efficiency was really such a priority for stove users. A particularly perceptive observation was the following: *One frequently hears questions like 'If you had a stove that used only half the fuel you currently use, would you cook on it? This is not the real question. The question might more accurately be if you had a stove that used less fuel would you be willing to cut your wood into some inch lengths control the damper and clean the fuel?* (Hoskins, 1979).

In the rural areas where people do not pay for fuelwood they use, it was evident that stoves would have a zero cost. Various types of home-constructed stoves were developed such as the one formed from a mixture of clay and sand. These required a considerable amount of labor on the part of the householder and imposed significant restrictions on the types and size of fuel, which could be sued. It soon became evident that they offered little, if any, improvement over what people were able to manage for themselves using the traditional three-stone fire. Therefore the adoption rate of these stoves was low and in household, which constructed one, they rapidly deteriorated and were not rebuilt. Results with rural stove programs elsewhere were similar and rural promotion was largely abandoned.

The urban areas where people pay for fuelwood, however, were a different story. Here people pay for their fuelwood and a more efficient stove enables them to save money on their fuel bills. A variety of firewood that is more energy-efficient and charcoal stoves was developed with substantial input of the WWF-Virunga Environmental Program. They were usually adapted from designs already in use and provided improved heat-transfer to the cooking pot and additional insulation to reduce heat losses. Substantial numbers of these new energy-saving stoves were already in use a variety of countries and the numbers being sold continue to rise, most of which are entirely in the hands of private sector producers and sellers. The Kenya program is well known for the successful promotion of the improved *Jiko*, or charcoal stove, in Nairobi. This improved stove allowed people to save about 25 percent of the fuel used in a traditional stove.

The *butanisation* program was actually based on the erroneous assumption that butane had ten times the calorific value of charcoal; in fact it has about 1.5 times the value. It's worth trying. The present afforestation programs are utterly inadequate by comparison with the size of foreseeable needs. The situation calls for 150,000 hectares of new plantations annually. Action must be prompt given the firewood crisis level in such a densely populated landscape. Time is of the essence. It should not be wasted on 'analyzing the situation' as there is a risk that in the meantime, the situation will have been so deteriorated that it can no longer be remedied.

What emerges particularly from this analysis is the magnitude of the task that has to be carried out in order to resolve the energy problem of the populations dependent on fuelwood, whose supplies will henceforth have to be ensured by deliberate action and no longer left to the people to gather as and where they can. The efforts to avert the fuelwood crisis can be divided into four broad approaches: economic on fuelwood consumption by promoting more energy-efficient cooking stoves and improved charcoal making; encouraging the use of substitutes for fuelwood; increased production of fuelwood in forest plantations and the promotion of tree-growing by individual farmers and communities; and the development of legal and fiscal measures to control fuelwood harvesting. For a sustainable economic development, the Albertine Rift countries need to strengthen the energy security, by generating more energy in a clean and sustainable way. To that end, the use of solar energy, wind, hydropower as well as a careful exploitation of the methane gas (CH4) in Lake Kivu should be a goal worthstriving.

Determining whether wood harvesting is sustainable at current rates, or at some point in the future, is simple if one knows the rates of supply and demand for wood. However, each of these two variables is highly complex, being determined by a range of interacting factors that vary through time. Demand will be depending on social factors such as the population size of a village, the income of the villagers, the cost of electricity, and even the structure of the population (which affects the number of people with the time and strength to go out and cut wood).

4. 7. 4 Legal and Illegal fishing villages in the Virunga National Park

First of all, it is worth emphasizing here that all of the DRC waters of Lake Edward are part of VNP and that, because of this, any fishery established on the park territory falls *de facto* under the law governing illegal fishing described under articles 58 and 60 of the Decree of 21 April 1937 (**Annex 2**) as well as alinea 6; 7 of article 5 and articles 8 & 10 of the wildlife Law 69-041 (**Annex 1**). In contrast, the Ugandan part of the lake is not part of QENP. The legal status of the fishing villages is unchanged as per 2010. Two fishing villages, Vitshumbi and Kyavinyonge (**Figures 4. 7. 4. 1 & 4. 7. 4. 4**) are officially recognized inside the park and a third one, Nyakakoma (**Figure 4. 7. 4. 6**), is tolerated. Given the population growth that the region has experienced and the weakening of the various authorities regulating fishing activities, the three known above mentioned fisheries have not stopped growing, both in terms of spatial extent and number of inhabitants. The fishing villages on the shores of Lake Edward, has seen a rapid expansion recently, as uncontrolled fishing activities lead to depletion of fish stocks. Overfishing is a common feature of most the VNP fishing villages that they threaten the integrity of the park.

When the park was created, there were 92 fishermen based in Vitshumbi (Harroy, 1987). By 1989 the number of people was estimated to be 10,000 (Verschuren, 1993). The 1948 maps show only a handful of huts in in Vitshumbi area while the aerial photos in 1959 indicate about a hundred habitations spread over 19 ha. In 1988, no less than 700 habitations were documented, and by 1994 the fishing village occupied an area of 38.7 ha. The total area of

Vitshumbi was 70.2 ha in November 2005 (**Figures 4. 7. 4. 2**), thus showing that the fishing village has more than tripled since 1959.

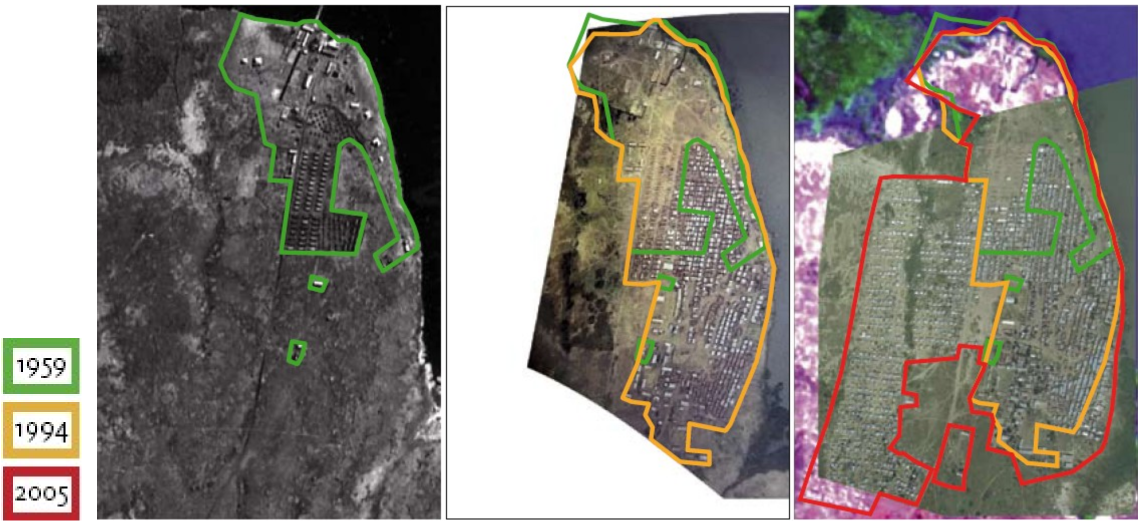


Figure 4. 7. 4. 1 *Status of the Vitshumbi fishing village between 1959 and 2005 (Source: Languy & Kujirakwinja, 2009c).*

A detailed analysis of recent aerial photographs shows that Vitshumbi fishing village had 747 habitations in July 1994 and 1,324 habitations by November 2005. Many new houses still under construction with new corrugated roofs are unambiguous evidence of Vitshumbi's spatial and human population growth (Languy & Kujirakwinja, 2009c). Following Vakily report (1989) setting the total number of dugouts at 400 in Vitshumbi fishing enclave, the number of people operating at Vitshumbi should reach 2,800 – with 7 people per dugout. The latter total people figure represents a fifth of the actual number of people living in this fishing enclave.

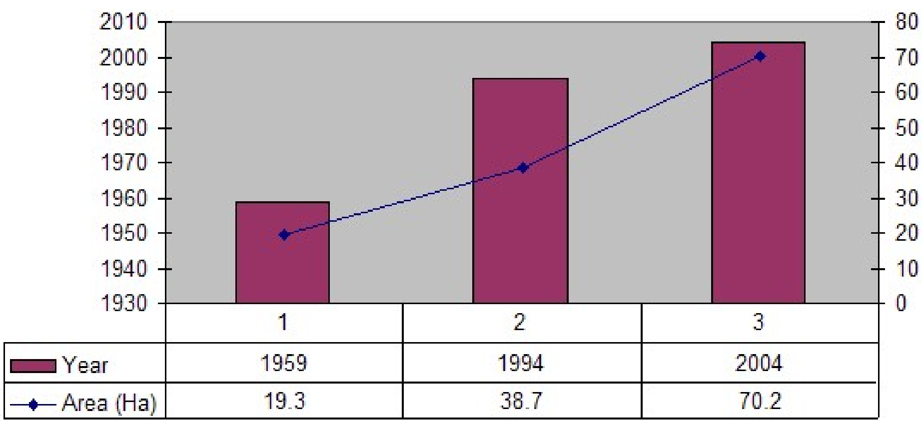


Figure 4. 7. 4. 2 *Graph showing the growth trend of spatial occupation at Vitshumbi fishing village. Data source: Languy & Kujirakwinja, 2009c.*

The Kyavinyonge fishing enclave was established in 1949. No form of habitation existed in this area before this period. Aerial photographs in 1959 show that there were 65 buildings on the site. Further aerial photograph taken by Aveling (1990) allowed estimating the figure of 1,735 while Verschuren (1993) estimated that there were between 5,000 in 1989 and 6,000 (Mushenzi, pers. comm.) inhabitants.

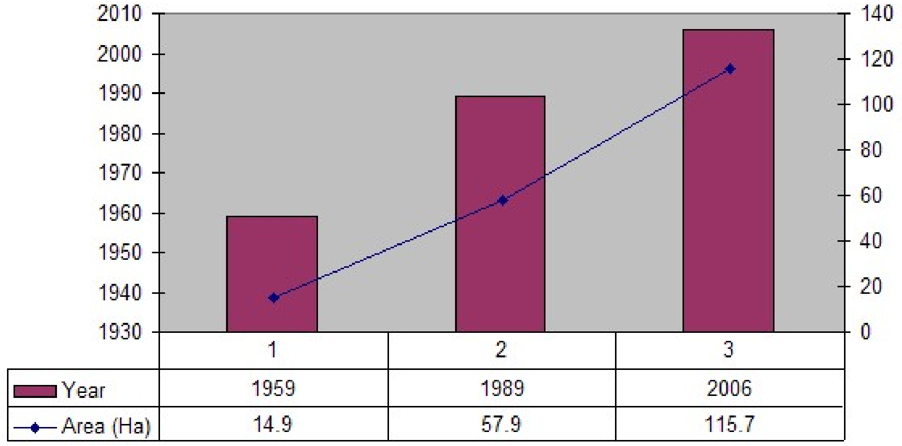


Figure 4. 7. 4. 3 *Graph showing the growth trend of spatial occupation at Kyavinyonge fishing village between 1959 and 2005. Data source: Languy & Kujirakwinja, 2009c* .

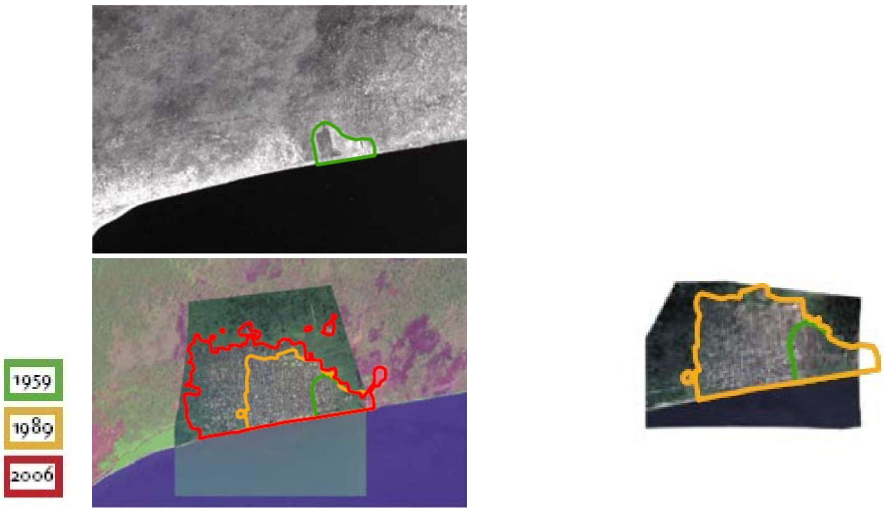
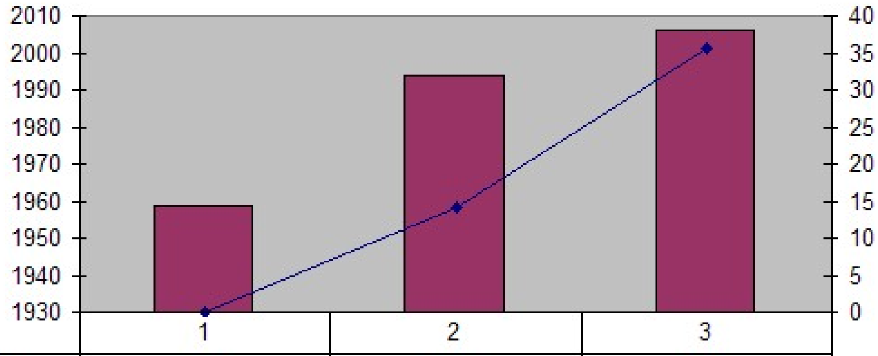


Figure 4. 7. 4. 4 *Status of the Kyavinyonge fishing village between 1959 and 2006 (Source: Languy & Kujirakwinja, 2009c).*

The censuses carried out by the Cooperative de Pêcheurs de Vitshumbi (COPEVI) in 2003 and 2005 show that there were 22,000 and 18,000 inhabitants respectively. However, the spatial growth of Kyavinyonge went from 15 ha in 1959 to 58 ha in 1989 and doubling 17 years later to 116 ha in 2006, making seven times its size since 1959.

Nyakakoma (**Figures 4. 7. 4. 5 & 4. 7. 4. 6**) was created in 1967 as a small fishing village used as an embarkation and landing place for dugouts from where the catch used to be taken to Ishasha village (**Annex 12**) for sale. Like the other two previous mentioned fishing villages, Nyakakoma has undergone a significant expansion that is proportionally greater than either Vitshumbi or Kyavinyonge. Aerial photos from July 1994 and March 2006 clearly show that the habitations went from 122 to 329 with a corresponding 1,830 and 4,935 inhabitants. These figures mean that Nyakakoma trippled in size within the space of 12 years.



	1	2	3
Year	1959	1994	2006
Area (Ha)	0	14.2	35.5

Figure 4. 7. 4. 5 *Graph showing the growth trend of spatial occupation at Nyakakoma fishing village (Data Source: Languy & Kujirakwinja, 2009c)*

Figure 4. 7. 4 .6 *Status of the Nyakakoma fishing village between 1994 and 2006 (Source: Languy & Kujirakwinja, 2009c).*

Between the above mentioned periods of the time, Nyakakoma increased from 14 ha to 35.5 ha as shown in the **Figure 4. 7. 4. 5).**

In sum, these figures thus show that there is evident population boom of the three legal fishing villages. In 1959, a total of 165 habitations were counted, then followed by 2,600 counted in 1994 and recently in 2006 the figure reached 3,661 implying that in less than 50 years the number of habitations in the three fishing villages has multiplied by 20 (Languy & Kujirakwinja, 2009c).

In parallel with the burgeoning fishing villages in the park, the number of fishing dugouts operating on the Lake Edward has also increased. It is noteworthy to mention that the illegal fishing goes back to the beginning of 1990s and that it began at the patrol posts set up on the lake shore. Indeed, the economic crisis, coupled with the ICCN's decreasing ability to intervene and the staff starvation wages rendered law enforcement by the guards very difficult, hence creating an incentive to allow fishing for direct or indirect revenues. As a consequence, the number of dugouts operating from patrol posts increased as well. In addition, the appearance of cultivated gardens around the fishing villages is a new and major development in terms of human encroachment, thus setting greater challenges for conservation. From this evidence, it is clear that in the total absence of law enforcement mechanism for the last decade, one step leading to another, the local populations living in the fishing villages have been able to develop agricultural activities.

Along the western shore of the Lake Edward, the proliferation of illegal fishing villages has resulted in 2,785 illegal habitations accommodating 27,850 people (**Table 4. 7. 4. 1**). These illegal fisheries established at the height of the civil strife at a period when the ICCN as an national institution was unable to carry out its own mandate, and accordingly to have then dismantled according to both the decree of 21 April 1937 (**Annex 2**) and the 69-041 wildlife Act (**Annex 1**). Poaching is still taking a toll on wildlife, but it is clear that the efforts of ICCN and its partners are finally struggling towards a reduction in the level of poaching amidst the most turbulent conditions.

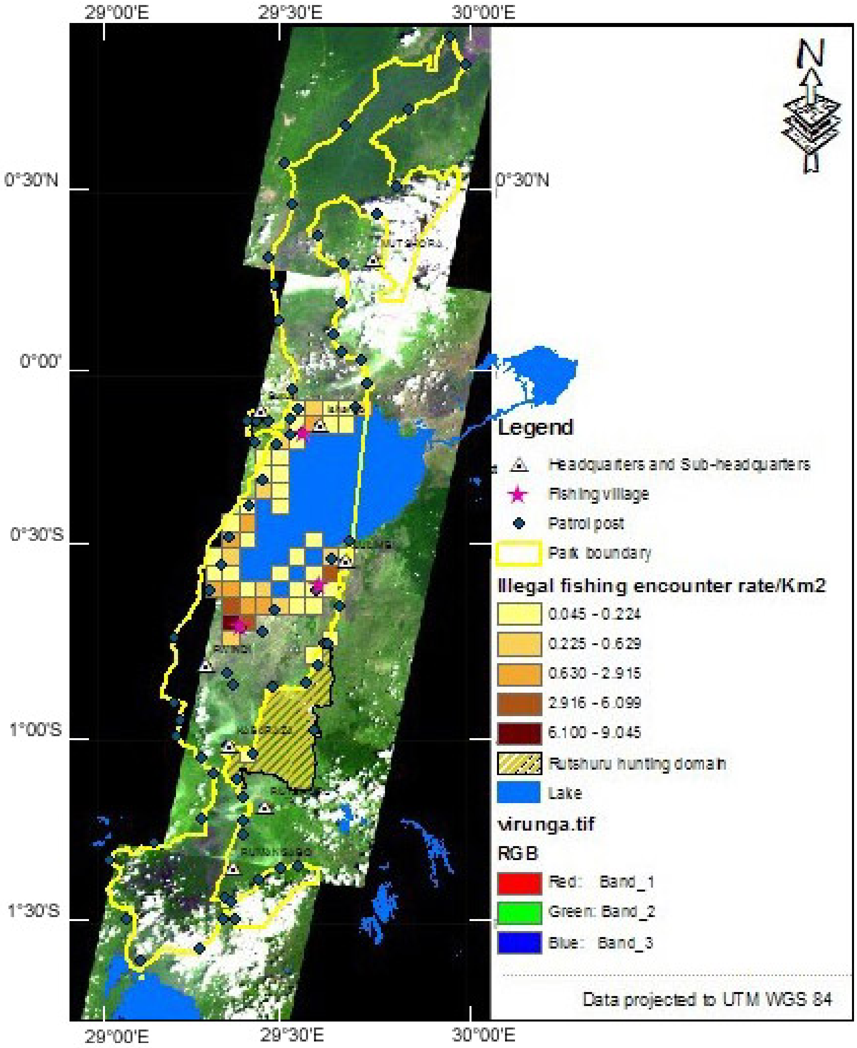


Figure 4. 7. 4. 7 Illegal fishing *encounter rates in Virunga National Park.*

Analysis of the satellite images shows that in 2005 over 11,685 hectares of the park were under cultivation along the western shore of Lake Edward (Languy & Kujirakwinja, 2009c). It is feared that, with the tens of thousands of people now living inside the park, on the edge of Lake Edward, the demand and trade in both bushmeat and Fuelwood collection to smoke fish will accordingly experience net increase. Given the current context, action should be taken by the central government body with support from the local administrative authorities to prevent all human encroachment, thus putting into practice the orders from the Ministry of Environment as stated in the circular letter No. 1283/CAB/Min/ECN-EF/2005 and press release dated on June 20, 2005 requesting that all agricultural activity be halted within the park. Control of the types of fishing net used should be undertaken and spawning grounds should be physically demarcated using buoys and ropes.

It is clear from the above that current situation on the Lake is as pictured in **Figure 4. 7. 4. 7 & Table 4. 7. 4. 1** remains a cause of alarm and concern as far as the management of fish stock is concerned. Four elements can be taken into consideration in concluding on the impact of human pressures on the productivity of Lake Edward: (i) on going fishing in spawning grounds leading to the reduction of the survival of the fry; (ii) the fishing with net mesh that is too small and leading to the reduction in fish reproduction with the tilapia (*Oreochromis niloticus*), *Bagrus docmak, Barbus altianalis edouardianus, Protopterus aethiopicus* and *Clarias gariepinus* being the most common heavily exploited species; (iii) over fishing and (iv) the decimation of the Common hippo population with the consequence of important loss of input in the trophic chain of the lake, particularly in regard to the process of fertilizing the lake with the dung for the good healthy fish reproduction. It's noteworthy to state that the increasing number of people inhabiting the illegal and legal fishing villages, especially along the western shore of the Lake Edward is rendering the control work of park guards practically difficult. The high figure of illegal fishing events (**Figure 4. 7. 4. 7**) gives insight how challenging is the task of stemming the tide of illegal fishing activity.

Table 4. 7. 4. 1 *illegal fishing village along Lake Edward*

Fishing village	Sector	Habitations	Inhabitants
Kasindi port	Northern	327	3,270
Mahiha	Northern	700	700
Muramba	Central	202	2,020
Kisaka	Central	429	4.290
Mosenda	Central	139	1,390
Lunyasenge	Central	546	5,460
Talya	Central	406	4,060
Baie de Kamande	Central	60	600
Kamande	Central	408	4,080
Total		**2,785**	**27,850**

Source: Languy & Kujirakwinja, 2009c.

From the above, it is crucial to complete as soon as possible the dismantling of the illegal fishing villages along the western shore of the Lake so that good fishing management can start to be practiced for the benefit of the local community while preserving the primary objective of protecting the VNP. Getting fishermen abiding by the conservation Act and park staff reinforce control of the types of fishing nets used and to reinforce the regulation of the spawning grounds will be the major stumbling block. To counter the belief that the Lake is a bottomless pit of fishes and encourage maximum sustainable yield concept defined here as the largest annual catch that may be taken from a stock continuously without affecting the catch of future years, fisheries need to be managed through regional coordination because boats regularly cross the international border illegally to fish. Boats were basically made out of *Cordia africana* sp trees locally known as *Mulingati* (Mushenzi, pers. comm.). Western shore of Lake Edward (between Muramba and Kamandi) was the area where *Cordia africana* sp was commonly exploited.

The emerging crisis created by declining fish stocks poses a challenge to resource users and managers. The problem is particularly acute in VNP, where fishing is an important subsistence activity, but high fishing intensity and use of destructive gear have resulted in declining catches. As expected, the proportion of fishers that would exit the fishery increased with magnitude of decline in catch. In this context, developing effective management strategies requires an understanding of how fishers may respond to declines in catch**.** Our finding that fishers from poorer households would be less likely to exit a severely declining fishery is consistent with the literature on poverty traps, which suggests the poor are unable to mobilize the necessary resources to overcome either shocks or chronic low-income situations and consequently may remain in poverty. Fishers were aware of fluctuations in catch and may not be able to distinguish short-term variation from long-term trends in stock abundance due to overexploitation (van Densen, 2001). Therefore they have developed a range of strategies and responses to deal with fluctuations in catch (Allison & Ellis 2001). The general response options to fishers faced with a decline in yield are to suffer losses in catch; temporarily switch to alternative occupations in hopes that catches will improve later; leave the fishery; or attempt to mask declining stocks with increases in effort, changing to alternate and usually more efficient or destructive gear (Pauly 1990; McClanahan *et al*., 2005), or changing fishing grounds to the point of permanentaly violating Uganda water body on Lake Edward.

4. 8 Human Demography Induced Park 'Islandization'

4. 8. 1 Park Encroachment and Habitat Loss

The high pressure for agricultural land represents possibly the greatest potential threat to the gorilla habitat. The human population density (**Figures 4. 8. 2. 1 & 4. 8. 2. 3**) around parts of the Great Virunga Landscape reaches 700 people per km^2, 95% of whom are subsistence farmers (van de Giessen, 2008). Population annual growth rate (2005-2015) was set at 3.2% (IGCP, 1996; UNDP, 2008). More than 90% of the people conduct a subsistence agricultural lifestyle and many depend on resources from the VNP to supplement their livelihoods. The majority of the population has been classified as living in extreme poverty, with more than 50% lacking sufficient land to meet their basic needs (Lanjouw *et al*., 2001). Forty five percent of the central sector is now being used for coffee (*Coffea* sp), tea (*Camelia sinensis*) cultivation, fuelwood, logging and concern for the park, especially the recurring encroachments, increases in population along the borders. Furthermore, some 95% of its limits are now in densely cultivated land and in many places no longer clearly marked (UNEP-WCMC, 2008). The increasing human pressure and land scarcity has exacerbated ethnic discord and disrupted animal migration patterns to the extent that local population which covets its potential agricultural land was strongly opposed to ICCN. This situation has fueled resentmen and hostility that has led to vandalism, such as frequent wild fire setting and the frequent violation of park boundaries and regulations.

Table 4. 8. 1. 1 *Poacher's habitat preferences through human encroachment occurrence in different vegetation types in wet and dry seasons*

Vegetation type	*Area (km^2)*	*No. of occurrences (%)*	*Preference indices (E)*				
			r	*p*	*r-p*	*r+p*	*r-p/r+p*
Afro-alpine zone	1.4	0	0	0	0	0	0
Afro-subalpine dominated *heathers*	2.8	0	0	0	0	0	0
Montane forest dominated by *Podocarpus* and *Neoboutonia*	11.2	174	12.33	1.74	10.59	14.07	0.752665245
Drought-resistant scerophyllous bush	12.3	40	2.84	0.4	2.44	3.24	0.75308642
Hagenia forest	0.4	0	0	0	0	0	0
Lowland humid forest	11.8	0	0	0	0	0	0
Gallery forest	1.4	0	0	0	0	0	0
Grassland and bush savanna	35.7	1197	84.83	11.97	72.86	96.8	0.075268595
Recent lava flows	2.3	0	0	0	0	0	0
Lake and River	18.3	0	0	0	0	0	0

Key *r = the ratio of habitat type where snares occurred*
p = the proportion of occurrence of snares

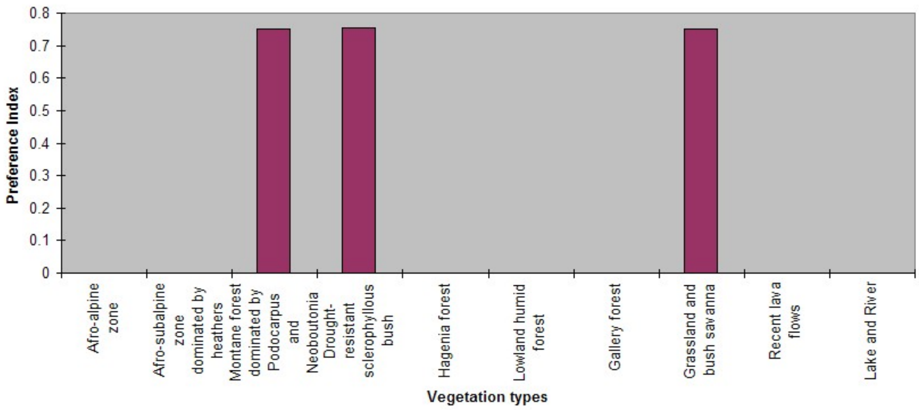


Figure 4. 8. 1. 1 *Offenders' habitat selection through human encroachment in both dry and wet seasons.*

Table 4. 8. 1. 2 shows that on average, human encroachment specific hotspot covered 36. 53% of the park with the central sector having the highest human encroachment distribution area in 2004-2006 period followed by the northern sector in 2008. However, **Figure 4. 8. 1. 1 & Table 4. 8. 1. 1** on offender's habitat selection through human encroachment show that there was no habitat preference in both the dry and wet seasons, thus explaining the reason why 95% of the park boundaries are now in densely cultivated land and in many places no longer clearly marked. The same explanation holds true for the increasing pressure of population and scarcity of land that has exacerbated ethnic discord and disrupted animal migration patterns.

Table 4. 8. 1. 2 *Human encroachment specific hotspot in Virunga National Park*

Park Management Unit	Year	Illegal activity	Poaching Hot spot (sq km)
		Human encroachment	KHR (50%)
Northern	2004-2006		59.3
	2007		19.66
	2008		76.2
Central	2004-2006		89.57
	2007		60
	2008		65.79
Southern	2004-2006		0
	2007		0
	2008		68.76
Lulimbi	2004-2006		0
	2007		0
	2008		0
DCRKZ	2007		22.91
	2008		49.2
Average			**36.53**
STDEV			33.57

The disintegration of the VNP problem can be seen at several levels, including (i) lack of policy in land use planning and rural development, (ii) non-payment and/or poor salary of civil servants, mainly soldiers, and (iii) poor interagency cooperation as multiple agencies charged with enforcement rarely communicate nor are they mandated (by policy or law) to do so. On this subject, Mugangu (2001) distinguish between systematic violations organized by powerful networks whose objective is to take over agricultural space in the park and occasional violation carried out by the resident to survive. Mugangu & Katembo (2000) pinpoint the persistent insular management that prevailed for a long time in VNP, which did not favor development of the areas around the park. Indeed, this management strategy was effective as long as the state was strong enough to watch over the park and deal severely with offences under the "*fortress conservation*" including police repression, tough fines, etc.). But the weaknesses of the state in the past decade have exposed the inefficiency of this management strategy, notably with the violation of boundaries and several cases of invasions as shown in **Table 4. 8. 1. 3**.

Table 4. 8. 1. 3. *Levels of invasion of the Virunga National Park*

Locality	**Invasion in 2000-2005**		**Situation on 15 November 2006**	
	Area (ha)	**Persons**	**Area (ha)**	**Persons**
Kilolirwe	10,200	60,000	10,200	60,000
Tongo	60	0	0	0
Kibirizi	19,000	0	0	0
Kongo	9,000	18,000	0	0
Ishasha	500	15	0	0
Kanyabayonga	2,100	0	1,200	0
Tshiaberimu	3,500	1,800	0	0
Lubylia	4,200	22,000	7	100
Mavivi	1,900	25,000	0	0
Karuruma	2,000	445	0	0
Kyavinyonge	5,000	0	0	0
Kanyatsi	3,000	7,000	0	0
Lume	2,300	4,600	0	0
West coast	11,700	28,000	11,700	28,000
Total	**91,560**	**166,860**	**23,107**	**88,100**

Source: Languy *et al*., 2009e.

As seen from the **Table 4. 8. 1. 3**, tremendous effort was done by ICCN and its partners to tackle the human encroachment problem in the park. However, although some of the illegal fisheries, such as the one at Birwa along the eastern shore of lake have been evacuated now, many other still persist. Between 2003 and 2006, 256 km of boundary have been marked and 464 signs placed through mixed commissions involving representatives of all interested parties (Languy *et al.*, 2009e). The most striking result was that the surface violated has been reduced to 25.2% while the number of people decreased to 52.8% with the departure of 88,100 people from the park. Over the last decades, three traditional chiefs provided significant support for the recovery of areas encroached in the park and were granted the Abraham Award. They acted over in the face of indifference, and even outright hostility of their subject. Mwami Kapupa Masali Mukindi II, chief of the Collectivité secteur Beni/Mbau was instrumental in restoring 15 km of park limit between Djuma amd Malulu and in the evacuation of 2,500 illegal squatters and in the Mayangose area. Chief Muhindo Muungu of the *groupement* Malambo/Rwenzoti led as well the evacuation of 6,500 squatters and recovery of over 10,500 ha of illegally occupied lands. Mwami Kalemire Selemani from the Collectivité of bashu assisted in evacuating 4,500 squatters from the most populated areas of the northern sector of the VNP. Overall, results show that most deforestation in any case, is a result of clearing land for agriculture rather than fuelwood harvesting.

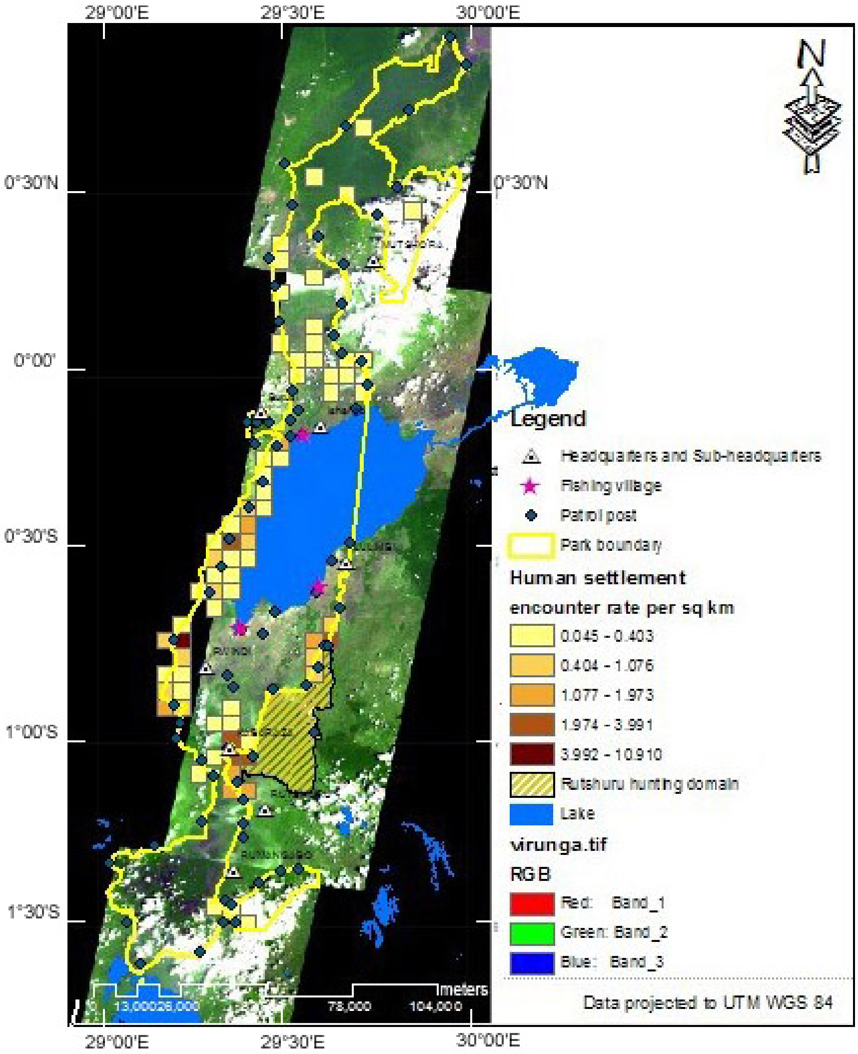


***Figure 4. 8 .2. 1** Human encroachment encounter rates in Virunga National Park.*

Putting two and two together, signs of human activities were unevenly distributed, but most concentrated in the sectors to the south of Karisimbi and Mikeno, and the eastern part of the volcano massif around Mount Muhavura (**Figure 4. 8. 2. 1 & 4. 8. 2. 2**) where populations are highly dependent on traditional agriculture with 0.5 ha on average area cultivated per household (Mubalama, pers. comm.). In the northern sector of the VNP, illegally set gardens in the park had sizes varying between 0.25 ha in Kasindi-Lubiliya areas (Mavono, Kiyingi-Vishishe villages) and 2.5 ha in Mutwanga area (Kiboto-Mulimande-Nyakivingu-Livina-Kasaka villages), thus fueling the conflict over natural resources use between the park management and local population (Mugangu, 2001; Kayungura *et al.*, 2007). When looking at different specific types of disturbance, most show a similar pattern, with some variation in detail. Antelope snares, human paths and tracks and wood-cutting were found over much of the area, but with greater concentrations towards either end of the Mikeno massif. Bamboo cutting, honey gathering and wood cutting however, were more restricted to specific sectors, although again mostly towards the extreme ends of the massif.

4. 8. 2 Land Use Changes and Park Boundary Demarcation Issues

As most of the boundaries of the VNP were established 75 years ago following the Decree of 12 November 1935 (**Annex 3**) which is the first proper reference point for defining the park, the way they were defined and the landmarks to which they referred to are no longer completely relevant to the present day context. As a consequence, uncertainties have often led to conflict over the true position of the park boundaries deliberately, e.g., Mugangu report (2001) evidenced that during the park physical demarcation people in Nyamilima referred to the river Tshabaganda as River Nyamigende and the River Kakoma as Kataraga in order to cloud the park boundary issues), and some times unknowingly, over the few past years numerous people (**Table 4. 8. 2. 3**) have violated the boundaries of the park (**Figure 4. 8. 2. 2**).

Various types of man-made infrastructure are used as points of reference in the definition of boundaries, such as villages, hamlets, motorbike tracks and caravan routes. However, many of them have now disappeared or being modified. The situation is more difficult because it is trickier to determine the exact location in 1935 or 1950. The case in point is the Goma-Rutshuru road which has hardly changed its trajectory and represents a truly shape boundary. In this case, the recommendation is to follow the present-day layout. However, caravan routes (**Annex 3**) present a more complicated case because, for the most part, these tracks are no longer visible. Hence, historical research is needed in order to relocate the routes (**Annex 3**), together with former intersection and hamlets. In this regard, various maps from the 1930s and 1940s and to a lesser extent, the 1959 aerial photos prove a very useful tool.

Most of the park boundary definitions refer to natural entities such as mountains, ravines, river network, and hill crest line and so on. Although some of these natural elements (notably hills and mountains) are immobile and have not changed over the course of time, the same does not hold true for other natural features, such as rivers in particular. The most vivid example is the Ishasha River which forms the border between the VNP (DRC) and QENP (Uganda). Since the border of VNP corresponds with the the lower course of the Ishasha River as far as its mouth at Lake Edward, this boundary is 'mobile'. Other cases are more sensitive and include the point of contact between the May-Na-Nkwenda River and the Kabaraza River as one of the park boundary's point of reference. Indeed, present day-SPOT images (2005) true color composite, as well as aerial photographs taken in 1959, show that the Kabaraza River- which is not a permanent river- no longer flows into the May-Na-Nkwenda but has changed course and now flows into the Rutshuru River. This case of physical disappearance of a point of reference is obviously a problem when it comes to fixing the park boundaries though the only solutions to find where the two rivers did meet in 1935. Other similar cases include the meeting point between the Rutshuru and the Rugera Rivers, which still exist, but seems to have shifted slightly.

As one can see, there is a no general rule to follow in these particular cases, except to keep as closely as possible to the original intention of the legislator and again where possible, to preserve the original natural borders when they have been chosen as limits in the original boundary description. As a result, most park management units are artificial biotic areas inextricably linked to natural and human activities outside their boundaries. Regardless of the degree, however, threats originating from incompatible activities on adjacent lands (**Figure 4. 8. 2. 2**) were among the most serious problems facing park managers today (Curry-Lindahl, 1972). Whether current level of protection of the park boundaries can continue in the face of the sociopolitical and economic pressures now confronting the region remains to be seen. However, the size of the task remains daunting despite tremendous work.

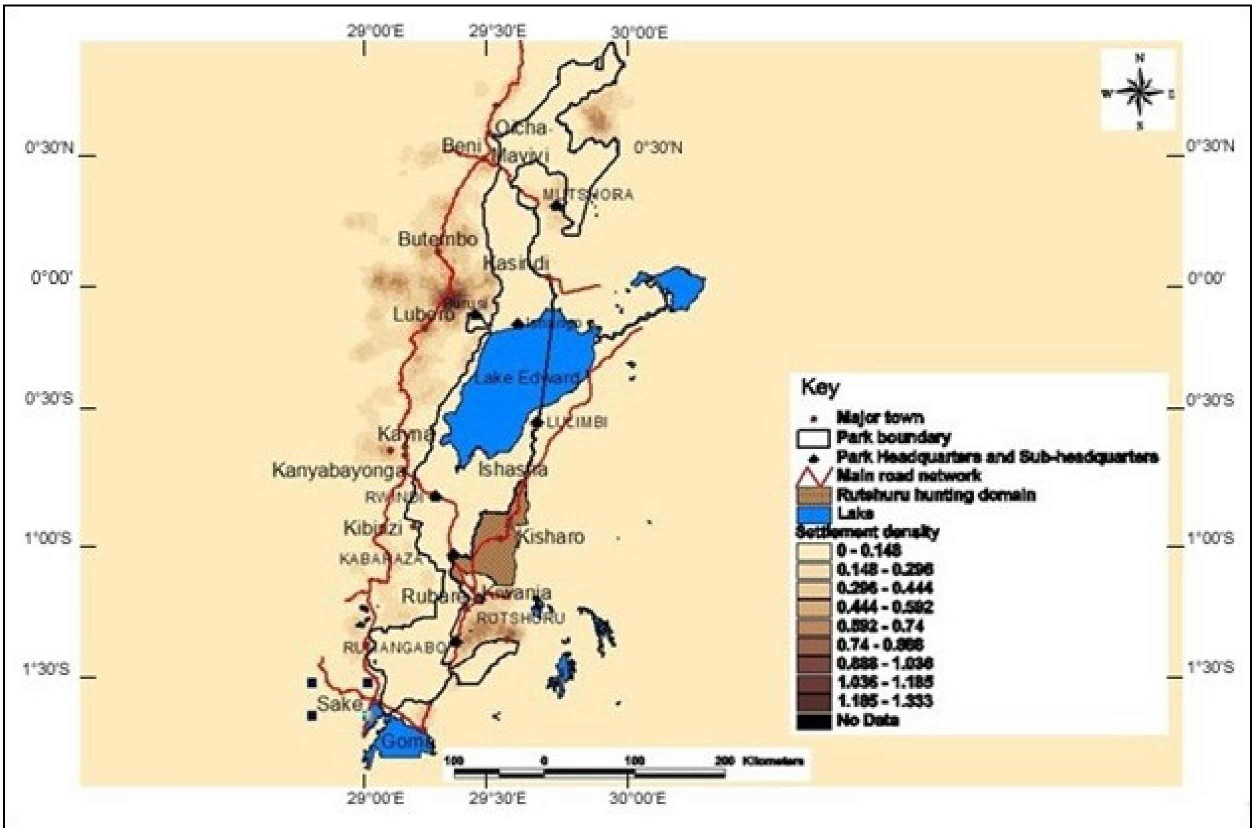


Figure 4. 8. 2. 1 *Human settlement density in the Virunga National Park.*

The present lack of clear boundary demarcation is the root cause of many management problems and of friction between the park and its neighbors. By late 2006, 15% of the park's boundaries had been overrun as a result of anthropogenic activity (Languy & *et al.*, 2009e). Despite their legal definitions, the beacons that are supposed to mark the boundaries on the ground were either never placed or have since disappeared. These boundaries therefore need to be resurveyed according to the existing legal definitions, and remarked in a permanent fashion. Each year cassava (*Manihot esculenta* Crantz), Irish potatoe (*Solanum tuberosum*) and maize (*Zeya mays* L) and beans (*Phaselous vulgaris* I) fields extend further and further into the park, but little can be done with a farmer who can claim he did not know he was cultivating inside the park because its boundary is not marked. A very limited number of gardens growing coffee (*Coffea* sp), tea (*Camelia sinensis*) and banana plants (*Musa paradisiaca*) have been documented.

Over recent years, the VNP has been experiencing an unprecedented number of incursions. Only between 2000 and 2004, over 160,000 people illegally entered the park to pursue agricultural activities and, to a lesser extent, to put their livestock out to pasture (Languy *et al.*, 2009b). It is difficult to determine the park's precise limits given that most of the few boundary markers placed during the 1920s and 1930s have disappeared.

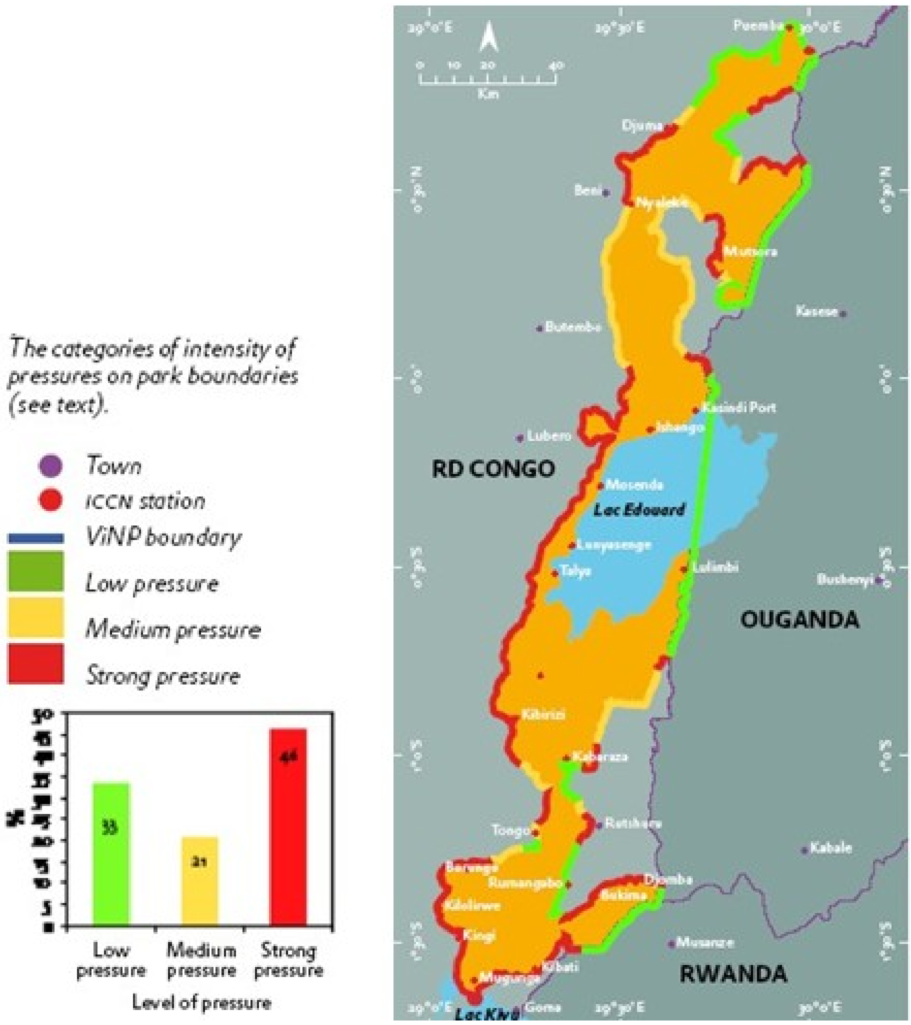


Figure 4. 8. 2. 2 *Categories of intensity of anthropogenic pressures on park boundaries. Source: Languy & et al., 2009b.*

The two legal and one tolerated fisheries (Vitshumbi, Kyavinyonge and Nyakakoma) of the VNP (**Figures 4. 7. 4. 1; 4. 7. 4. 4 & 4. 7. 4. 6**) have not stopped growing, in area as well as in number of inhabitants. Along the western shore of the Lake Edward, the illegal fisheries have resulted in 2,785 illegal habitations as shown in the **Table 4. 7. 4. 1.** All efforts to demarcate the spatial extend of the fisheries in the perspective of suggested biosphere reserve designation would have as only goal the restriction of the human habitations. On no account should the proposed 5km-buffer zone be considered as a separate demarcation of the boundaries of the park.

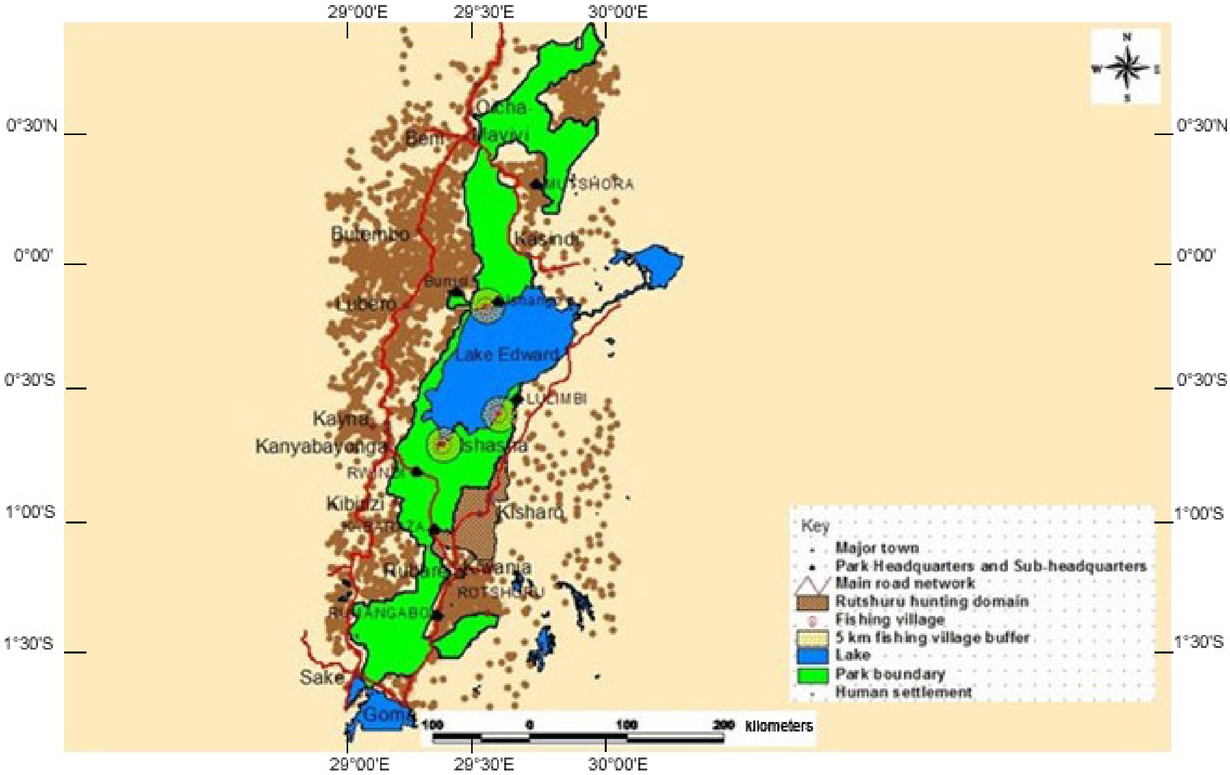


__Figure 4. 8. 2. 3__ A 5 x 5km fishing village buffer and settlement density inside and around the park.

The map showing the intensity of human pressures (**Figures 4. 8. 2. 1; 4. 8. 2. 2 & 4. 8. 2. 3)** on park boundaries clearly correlates to some extent with the map of hotspot poaching **& Figures 4. 5. 5. 3; 4. 5. 5. 4. & 4. 5. 5. 5**), thus suggesting that human beings are arguably stewards of nature, whether we like it or not. Buffers in these regions contain high population growth rates to the extent that if the VNP is expected to serve as refuge for the 'last of the wild' (Sanderson *et al*., 2002), the patterns documented here are cause for concern. Demarcation of village boundaries and park limits using modern techniques is au urgent priority, for without this there will always be room for argument as to where certain regulations start or end. Following the results of the participatory demarcation work, the ICCN and its partners now have at their disposal a substantial set of data on the exact and legal location of the park's boundaries.

SPOT image from 2005 indicates an invasion of more than 6,000 ha inside the park in the area between Mavivi and Nyaleke (7 km East of Beni town) where the forest was cut down over 3,000 ha and even the rates of deforestation here reached 8.5 percent per year (Leyens *et al*., 2009). This invasion ended in December 2005 when the area was entirely vacated, however the scars remain and it will take many decades for a natural habitat to recolonize the invaded area. In the area between the bridge at Vieux-Beni and Mwenda, cultivated lands have reached the park limits along an 8 km stretch immediately to the nord-west of Mwenda amplifying the already severe strain under which natural resources exist

An interesting point related to the park invasion occurred when migrants to Karuruma in the northern sector of the park including Hima cattle herders from Uganda crossed the border with their herds in order to settle in the so called free access land. Forty six Ugandan households along with 3, 000 cattle were documented in 2005 (SYGIAP, 2006b) in Karuruma area. It should be noted that even relatively small numbers of cattle can cause massive environmental degradation and lead to widespread and permanent changes to ecosystems through grazing of native species, soil compaction, excess nutrient loading, and introduction of invasive plant species. Karuruma along with Mayangos and Mavivi (**Figure 4. 4. 3. 4**) crisis which have been the prime subject of conversation were peacefully resolved with the removal of local people in Mayangos and Mavivi in December 2005 and the departure of Hima cattle herders in April 2006 following a series of negociations with ICCN (Muir & de Merode, 2009).

Seven hundred hectares of forest on Mount Tshiaberimu inside the park were cleared for agricultural purposes in 2000s to the point that the corridor (known as *Mulango wa Nyama* in Kiswahili, meaning the gate for the wildlife) linking the mountain to the shore of Lake Edward is still occupied by farmers. The area between Kibirizi and Tongo (**Annex 12**) in the central sector of the park is so far the area where the change as a result of population pressures is the most striking. Thousands of hectares of the plain bordering Mount Kasali have been cultivated by people who have cleared all the land. There was continuous overlapping between human encroachments in this region with other major threats; this may explain the pattern of hotspot poaching observed in **Figure 4. 5. 5. 4** within the central sector of the park. At least 60,000 displaced people have taken over more than 10,000 ha of the forest in the area between Butambira and Sake where large-scale charcoal production supervised by military personnel is taking place (Dziedzic, 2005).

4. 8. 2. 1 Land Use Changes in the Rutshuru Hunting Domain

The Rutshuru Hunting Domain (RHD) created in 1946 then modified by the provisions of the decree No. 00024 dated on February 1974 is the most important illustration of the impact of population explosion on land use around the hinterland of the park. From the 163,000 ha encompassing the RHD and adjacent areas, land that was subjected to agricultural activity went from less than 14,000 ha in 1959 to 81,000 ha in 1987 and then 92,000 ha in 2004. The expansion of Rutshuru and Kiwanja towns is spectacular as the population in Rutshuru went from 5,000-6,000 inhabitants in 1937 (Verschuren, 1993) to 50,000 inhabitants in 1991 (Harroy, 1987; Verschuren, 1993) bringing together the inhabitants of both cities. Kiwanja was created around the middle of the 1950s, when Ishasha road was opened. In 2008, the population of Rutshuru and Kiwanja are estimated to be 15,000 and 40,000 inhabitants respectively (Languy *et al*., 2009b). All these populations living on the edge of the park limit constitute a potential threat to the future existence of the park.

The RHD is 90 percent occupied by human settlements and field dominated by staple crops, including cassava (*Manihot esculenta* Crantz), Irish potatoes (*Solanum tuberosum*), maize (*Zeya mays* L) and beans (*Phaselous vulgaris*). Some fields are now growing coffee (*Coffea* sp), tea (*Camelia sinensis*) and banana plants (*Musa paradisiaca*) as a mean of perpetrating perennial crops within the reserve. Increasing human populations (**Figure 4. 8. 2. 1**) and expansion of agriculture are viewed as major contributing factor of park violation. Alongside of this rapid population increase there has been an equally dramatic increase in demand for major park resources. Large, impoverished rural populations, including landless, displaced peasants, used the park's resources for basic subsistence: food, firewood, and building materials. The above situation can only be explained by simple mathematics suggesting that the greater the number of people, the more resources that will be required from the land, as mediated by their consumption rate (Malthus, 1798; Wackernagel & Rees, 1996).

The park is still seen as readily available land and as a rich supply of bushmeat and other natural products that have been overexploited elsewhere, and many of those involved in illegal exploitation and land grabs find that the park provide easy takings. While areas in the vicinity of the park represent zones of risk and restriction, they are also potential zones of opportunity for current and potential migrant populations (Mugangu, 2001). This dual character of park landscapes will likely generate and/or intensify distinctive patterns of land use around the park, which will in turn have important consequences for the park itself. To address the tradeoffs and dilemmas surrounding the conflict between people and park, research should seek to document the livelihoods of people in the landscapes around the park and investigate the impacts that park and biodiversity outside the park have on their livelihoods and activities in turn.

In light of the recent hot debates over the potential of participatory approaches, it is particularly important to consider whether the inclusion of local populations in decision-making processes does lead to improvements in park conditions. Among the constant objectives consigned to the VNP over more than eighty years, there has never been any precaution to ensure that the overall policy on conservation ecosystem and biodiversity is in harmony with socio-economic development of the populations living next to the PA (Leyens *et al*., 2009). From that prospect, there is a crucial need to consider and evaluate the opportunity of designating the VNP as a Biosphere Reserve, as well as a region of interest in the UNESCO Man and the Biosphere Program with the implicit goal of integrating sustainable human activities within the objectives of the Park system. The suggested designation implicitly should endorse the principle UNESCO Man and Biosphere suggesting that any biosphere reserve should promote and demonstrate a balanced relationship between human and the biosphere. The VNP currently meets all criteria by: (i) providing an opportunity to explore and demonstrate approaches to sustainable resource utilization by its enclave fishing villages; (ii) encompassing a mosaic of Albertine's major bio-geographic types, and (iii) having significant biological diversity though still under human pressure.

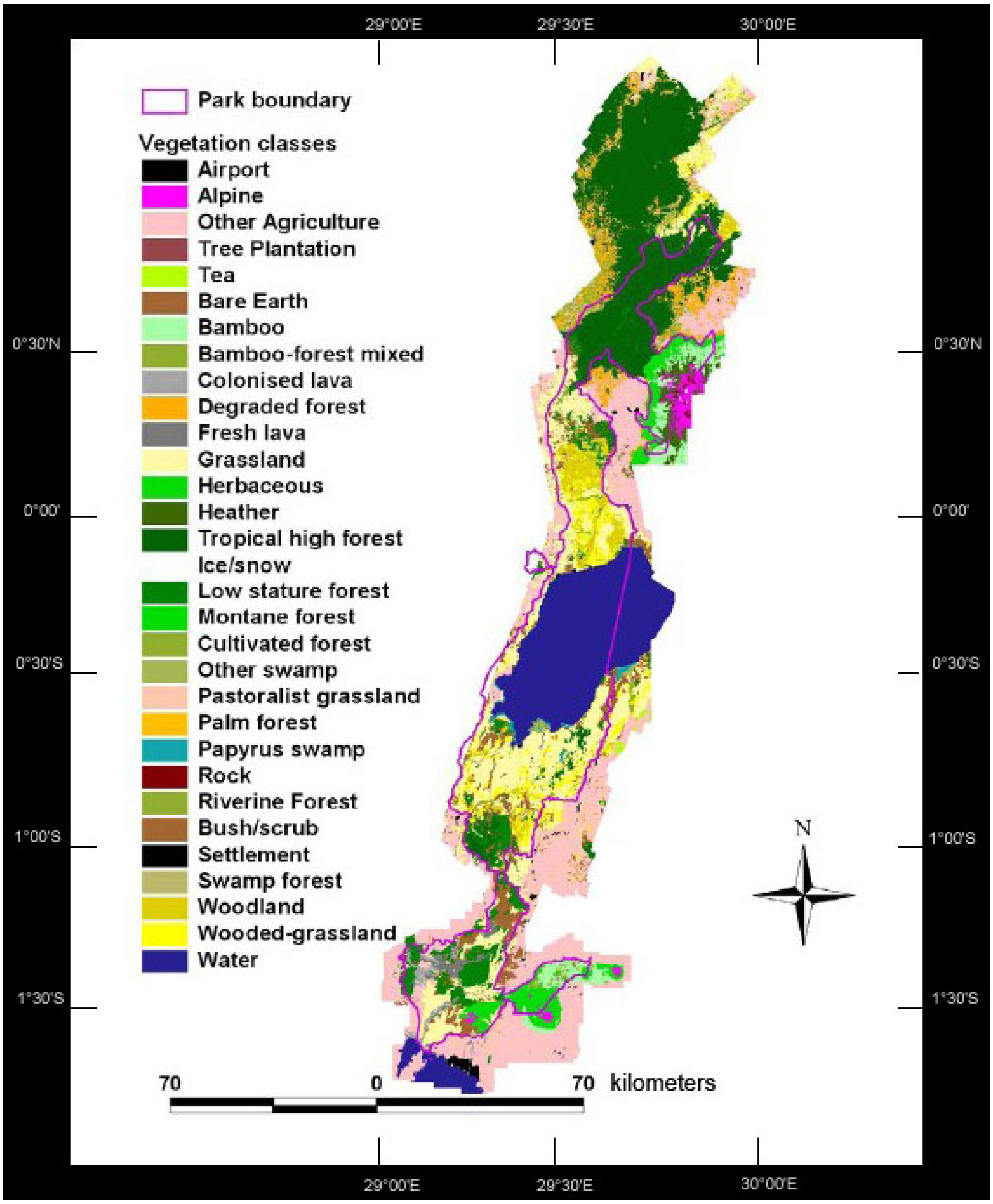


Figure 4. 8. 3. 1 *Map showing land use pattern in the park from aerial photo mosaics. Source:Plumptre et al., 2008.*

Throughout the developing world parks are surrounded by landscapes that, while still containing considerable biodiversity, also have rapidly growing human populations (Child, 2004). The North and South Kivu provinces PAs are not an exception to this rule. The domesticated portions of these landscapes are zones of dynamics change in demography; land use and land cover (**Figure 4. 8. 3. 1**). In a majority of these areas, agriculture is already or is rapidly becoming the main land use (McNelly & Scherr, 2001) and thus, the greatest threat to the PA. As a result, there exist a substantial empirical overlap between parks and human land uses (**Figure 4. 8. 3. 1**) around the world (Pimbert & Pretty, 2000). The park landscape remains largely characterized by biological and socio-political dilemmas not found elsewhere.

4. 9 The Use of Wild bush fire in the Park

Fire is a major threat to many national parks worldwide (Hough, 1993). Most of the park woodlands are burnt frequently, often annually. Some of these bushfires occur naturally, as a result of lightning, but the majority was set deliberately by hunters in order to flush game from cover or to drive it towards the waiting hunter or to increase the supply of ceratin forest products.

Bush fire was widely distributed in the central sector and Ishango sub headquarters with high level of occurrence in the Rutshuru-Ishasha plain (**Figure 4. 9. 1**).

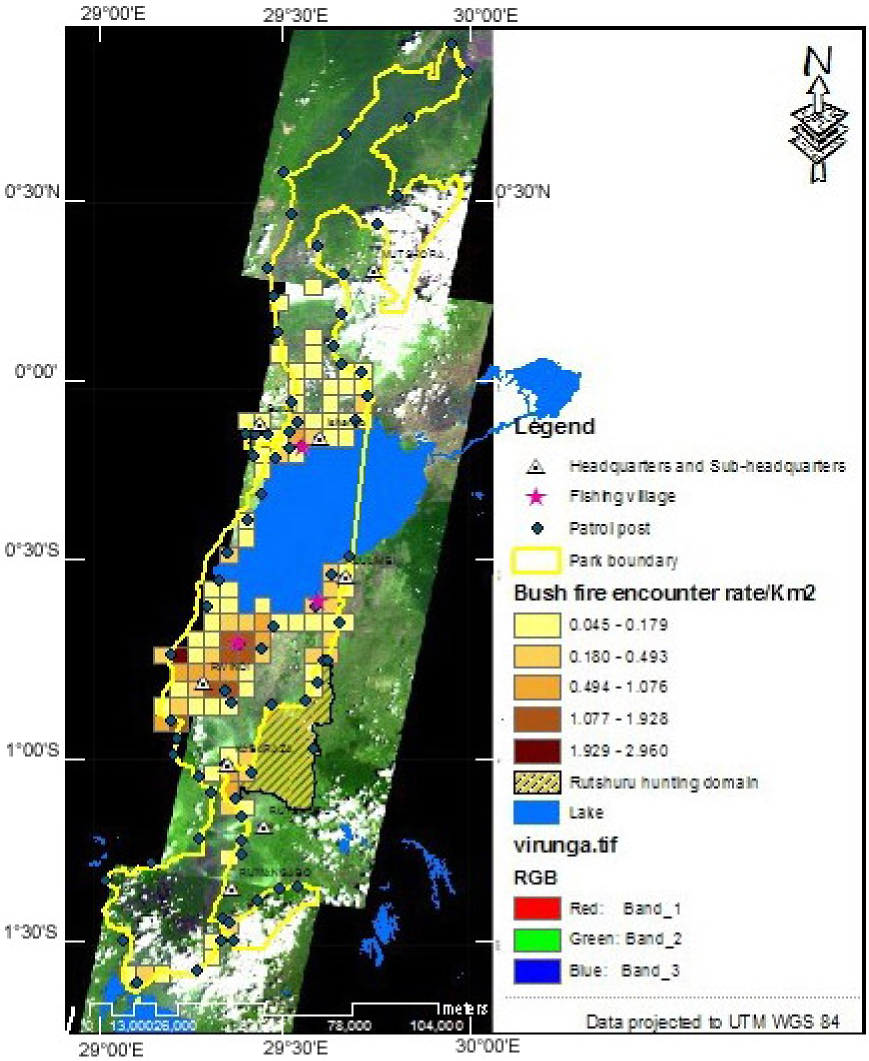


***Figure 4. 9. 1** Bush fire encounter rates in Virunga National Park.*

Fire frequency in park is difficult to assess, as the vast majority of fires are caused by human activity, however lightning strikes are as common a cause as human ignited fires and often as arson to take revenge on the natural reserve. There is ample reason for its use; it quickly and easily clears the land for cultivation, adding to its fertility in the process; it stimulates production of grasses for grazing, it drives game from cover, allowing them to be hunted more easily; and finally it is said to reduce tick and other parasite numbers. The effects of fire can appear extremely severe but woodlands tend to recover quite rapidly.

The following is the overall description of the effects of fire in the African savanna:

> *Just after the annual dry season fire, the savanna looks devastated. The trees and shrubs are leafless and have charcoal blackened barks. All that remains of the herb stratum are a few charred remains of unburned grass and a layer of ash on the soil surface… Within a week or ten days of burning, fresh green leaves will have emerged from the grass tufts and within a fornight or so most of the trees will have burst their buds and produced their new stems and leaves. Also, most of the small trees that were scaled back to ground level will have produced new suckers (*Fairhead & Leach, 1996*).*

The anthropogenic use of bush fire in and around VNP has increased drastically in recent decades. Fire has long been used as a management tool in the savanna and woodland ecosystems of VNP and the surrounding region. Burning on an annual or sub-annual rotation has helped to maintain the open landscape, as well as providing substratum for new vegetative growth on which to graze cattle and other livestock in the surrounding park boundary. In recent decade, however, increased population pressures (**Figure 4. 8. 2. 1**) and frequent burning have begun to test the land's ability to recover from each successive fire. Additionally, wild fires that escape into the neighboring VNP have threatened to permanently damage the delicately balanced ecosystems within the park. Park managers have adopted the practice of strategic, preventative burning in VNP-setting fires in certain areas on a regular schedule to regulate fuel-loading and make it less like the park will burn on a large scale.

Key factors affecting bush fire are (i) Fuel: Anything that burns is fuel for the fire: litter on the ground (leaves, twigs, rubbish), undergrowth (shrubs, grass, seedlings), trees and other vegetation, structures (such as houses) and any other miscellaneous objects in the vicinity; gas bottles, piles of firewood, tires, etc. That's why it is forbidden to make damping and leave objects in the park, (ii) Weather: Weather is a major contributor to bush fires. The hotter and dryer, the more likely it is for a bushfire to start and spread uncontrollably. High winds will reduce humidity, and cause an ongoing bushfire to spread more rapidly. Most bush fires start in the afternoon, when it is driest and hottest, (iii) Topography/slope: The topography of the terrain is a major factor in bushfire behavior. Bush fires are an annual occurrence (**Figure 4. 9. 1**) in the herbaceous component of the wooded savanna on the clay-silt soils north of Kibirizi, southern extension of the Rwindi-Lula plain, between the Kasali and the Mitumba Mountains supports a mixture of *Brachiaria*, *Themeda triandra*, and *Panicum maximum*, shaded by *Acacia sieberiana*.

Complete elimination of fire is neither desirable nor feasible. It is a natural element in the ecology of these ecosystems and an essential tool in the land management strategies used by local people. Living in thatched dwellings and depending for their livelihoods on their local surroundings, they have a strong vested interest in keeping the destructive powers of the fire as much control as possible. The evidence is that they are usually able to do so when given the chance.

With an appreciation of the villagers'perceptions we can predict that the protection of national parks will increase the incidence of human-caused bush-fires. To counter this, parks need to promote changes in long-standing traditions, encourage more intensive land-use practises, assist in protecting crops and livestock against wild animals, and improve relationships with the surrounding villagers. Yet the long-term effects of this relatively new, intensified fire regime on the land, vegetation, fauna, and human populations of the Virunga landscape have yet to be determined.

4. 10 *Bringing Human Detection Sensors to the Wild to Technologically Enhance Anti-poaching Efforts*

Evidence has shown that persistent effort to thwart these illegal hunters proved very limited. Indeed, it has been an unequal contest. Poachers target wildlife under the cover of dense rainforest to avoid being detected from aircraft, and patrols like park staff have to trek through the forest on foot. At the height of civil war in 2000, killings could go undetected for months or even years, and during one sweep, park staff patrol might find as much as 5 wildlife carcasses in various stages of decomposition in different park management sectors mired with rebellion and blooshed for much of the last decade. To counter this poaching strategy, there's a real need to transform wildlife observation techniques into real-time warning systems. To help achieve that Steve Gulick, an electrical engineer who calls himself a "biologist wannabe," has designed a metal detector specifically to pick up the presence of poachers' weapons and send an electronic signal, via satellite, to law enforcement authorities. One of its products, a small seismic detector called TrailGuard, can be buried along forest pathways to pick up the footfalls of people as they pass. It's based on military technology used to detect enemy troop movements. To distinguish hunters from harmless passers-by, the devices also contain magnetometers that can detect iron in guns several meters away.

Steve Gulick has spent about 6 months in the northern part of the VNP, basically in Ishango and the Mount Tshiaberimu where he tested the TrailGuard device. At the time, the principal means of detecting the passage of a poacher was a concealed magnetometer (or metal detector). He has since added miniature concealed cameras to the system which take a picture of whatever event triggered the camera and then the image is analyzed by a small, attached microcomputer, and if it is identified as a human, rather than some other animal, the image is transmitted either by a satellite modem using the Thuraya system, or where GSM (Global System for Mobile communications) coverage is available it is sent via the cell modem.

Following the VNP test, Steve found that the system can increase ranger safety, particularly in a place like the Virunga since even before rangers are sent out, you would know from the transmitted images the kind of risks the patrol would be facing (e.g., subsistence poachers or heavily armed militia). TrailGuard could also provide increased security for ranger stations in the VNP by providing early warning in the event of a rebel attack as has happened in Virunga in the past. The device picks up the presence of weapons such as machetes, assault rifles or shotguns. Armed law enforcement workers can be equipped with transponders that send a specific signal of their own so they will not be mistaken for poachers. However, one of the needs of the device is the need to operate on extremely low average power so that the system potentially could operate unattended for years.

Once triggered, the TrailGuard transmits a radio signal to an antenna at the top of the forest canopy, which relays it to a hub to be sent to forest rangers over a satellite phone link. "You can tell the number of people in the party and the direction they are walking, so you can come prepared, before the killing starts," Gulick claims. Given the big size of the park, the only time the y can go across fresh poaching incident is if they go out based on reliable information supplied by informants. Most of the time patrols arrive to find results of poaching piles of rotting animal corpses and or rule-breakers have pulled up stakes. At this particular point in time, I would suggest continue the experiment in a limited area where there is a highly effective management presence to take advantage of the new technology. Then if can be proved to work well in these circumstances it would naturally be more widely adopted. Lush vegetation in KBNP makes it difficult to avoid trails; therefore most TrailGuard devices can easily be set up in these two sites. The knowledge that the ‘park has invisible eyes’ and that anyone entering risks being detected – and recorded- should help serve the primary goal of deterring illegal entry into the park (Galick, 2008). In other words, in such situations, people knowing that there are hidden cameras potentially recording what they are doing might be enough to remove the temptation to go poaching.

To sum up, building upon such a device, wildlife manager can tell how many poachers there are in a particular management area and therefore come prepared before wildlife killing starts. In this regard, the remote metal detector could be a valuable tool for park rangers charged with patrolling vast areas of wildlife habitat. Steve Gulick describes the detectors as a cost-effective way to increase the effectiveness of human resources (SUN, 2007). Full details related to the functioning of the device are provided in **Box 4. 10. 1**. Making offenders believe that the probabilities of being caught are greater than they really are may lead to unexpected reduction of wildlife crimes not directly targeted by preventive action. This phenomenon well described by Wilson & Kelling (1982) and known as“broken windows”or “halo effect” theory holds that the control of incivilities and nuisance behviour may prevent the emergence of more serious crime patterns. Under this theory, deliberate action is taken to nip trouble in the bud. These processes are labeled, respectively; deterrence and discouragement keep offenders in perpetual uncertainty about the actual risks and may lead them to overestimate these just in order to be safe.

Box.4.10.1

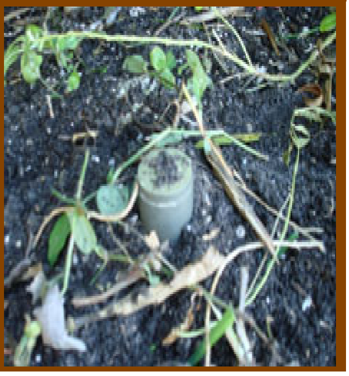
TECHNOLOGY TO THE RESCUE

"Like the resource it seeks to protect, wildlife conservation must be dynamic, changing as conditions change, seeking always to become more effective"
Rachel Carson

TRAILGUARDS:
Wildland Security has designed and is currently employing electronic surveillance technology for monitoring of protected parklands. The use of remote electronic surveillance technology increases the effectiveness of protection efforts both in terms of the cost effectiveness of monitoring as well as by increasing apprehension before poaching occurs. Electronic intrusion detectors have the advantage of remaining vigilant at all hours of day for years with little if any maintenance or costs incurred after the system is initially installed. Through utilization of this technology, park rangers no longer depend upon intelligence information such as from informants that may be unreliable or outdated. The real-time information obtained from the sensors allows timely dispatches of patrols into areas under invasion.

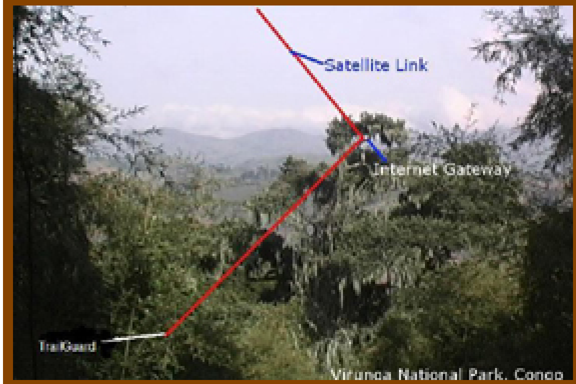
This system, called TrailGuards, is a network of miniaturized, weatherproofed, concealable, sensors similar to those used in airports to detect metal. The alarm sensors in this devise can be triggered by any number of events including metal, movement, sound, or fire. Metal detection sensors are the most typically used since poacher and rangers are often the only metal bearing animals in protected parks. The sensors are specially programd to ignore passer-bys who are coded as “rangers”.

The Trailguards are placed along forest trails and other natural "choke points" where humans entering a protected area are likely to pass. The devices are readily concealed and will require little maintenance once installed.



By placing the sensors near entry points to PAs, it becomes an early warning system, sending alarms possibly hours before the intruders reach their hunting grounds and in time to be apprehended before they can start killing. Using the Trailguard, metal (weapon) carrying individuals can be detected immediately, long before poaching occurs. A rifle or machete will trigger the magnetic sensor (metal detector).

Once metal is detected, the device sends a signal to a pager alarm via satellite, which notifies personnel immediately that a metal carrying person has entered the range of the detector.



More specifically, the TrailGuard system is comprised of unattended magnetic sensors that are networked via an internet gateway and which, when triggered by a metal object such as a firearm, cable snare, or machete, send intruder detection alarms to park authorities on handheld satellite pagers. When the sensor detects an intruder, the event is radio-transmitted to the Internet via a satellite gateway (typically located at the top of the forest canopy, and well camouflaged). An alarm is sent via satellite data transmission to a web server where the event is logged, an incident report is automatically generated, and text messages are immediately sent via standard pagers or as emails to park officials and any other pre-specified parties. After a detection event, the TrailGuard system continually prompts protection authorities that an intruder is present.

The intruder message is sent to both park personnel on the ground in the park as well as other agencies outside of the park that have a need to know what is happening in the park from a management and oversight perspective. So within a matter a few minutes of the intrusion detection, a permanent record, accessible by many, is made and any number of people received notification.

SUSTAINABILITY

Once the system is installed, the TrailGuard system requires a very minimal fixed infrastructure to function continuously for up to ten years without maintenance to the sensor or gateway components. However, the system is also highly "scalable" which means that more sensors can be added incrementally to increase coverage without requiring any redesign of the system. Training of park staff in web server access and functionality will ensure that the performance-monitoring component of the system is incorporated into a long-term adaptive management strategy.

The obvious intention is to save lives, not to just punish poachers. This technology has the potential for decreasing poaching activity independent of apprehension. In several parks utilizing effective anti-poaching surveillance, poaching has decreased significantly simply in response to individuals learning that their activities are being monitored.

Source: SUN, 2007.

4. 11 Factors Driving Wildlife Slaughter, Short and Long-term Strategies to Curbing Poaching

Poaching gangs in VNP have become better armed, with automatic weapons such as the AK47 and semi-automatic weapons largely replacing muzzle loading rifles made of wood and old tyres, with bike spokes for darts. Some documented weapons have been traced to high ranking officials, indicating significant capital investment in poaching gangs by rogue elements in the Congolese military and militia command or their collaborators. In order to improve law enforcement performance, the current advance forces set up after Ishango training should be revived as an up and running strike force whose efficacy will depend on good communication and mobility. This force should mount armed patrols throughout the park on an unpredictable basis, and provide a rapid response unit to reports and calls for assistance forwarded by the various park headquarters. This unit should be properly armed and supplied with adequate ammunition to ensure that it is at least on an equal footing or better with well armed poachers gangs. There has been tangible proof of the direct involvement in poaching by soldiers belonging to both the rebel and the regular army. While efforts taken to stop illegal hunting remain noteworthy, these efforts seem futile as guards who pursue the poachers were frequently outmanned and outgunned. As things stand right now on the ground, it is crucial to tackle this problem and ensure that the sites is cleared of all military factions and armed bandits before major conservation progress is made. Finally, national and local governments must also seek to increase their direct support for the VNP as they don't seem to put any stock in the recovery of some degarded sites from their current endangered conservation status.

The poverty of the rural population, the present lack of knowledge of large mammals' dynamics and behavior, the ineffectiveness of the national wildlife service, and corruption with poorly paid park staff being susceptible to bribery (Barnes *et al*., 1995; Crawford & Bernstein, 2008; Olupot *et al*., 2009) could all potentially facilitate poaching upsurge. Corruption can be attributed to the dramatic disparity between official monthly salaries and the returns from a single illegal hunting; guards park earn just CF 22,628 per month (approximately $US 41), while a single hippo carcass could fetch $US100-150. Budget for wildlife protection has plummeted and morale among park staff had become severely eroded to the point that, in some documented cases, park guards depended on kickbacks from illegal activities in order to survive (Hart & Hall, 1996). While such behavior may be understandable it remains totally unacceptable (Mubalama, 2000).There is thus a crucial need to improve the motivation of the poorly paid wildlife staff to boost their morale and put teeth into wildlife law enforcement in the framework of the ICCN institutional review now at the early stage of its implementation.

The park's total law enforcement budget for the study period was about 1,615,961 $ US, which represents about the estimated annually $US needed to secure adequate protection for the VNP wildlife and habitat (Inogwabini *et al*. in press). Operational budget for the park was $US 89.3 per km^2 $year^{-1}$. This under-funding jeopardizes the ability of the VNP to safeguard biodiversity and the benefits that intact nature provides to society (Bruner *et al*., 2001). Taking into account the costs of supporting staff, transport, subsistence, incidental expenses and funds for management and poaching hotspots, our analysis holds that effective *in situ* large mammals conservation and habitat protection requires a funding commitment of close to \$US 240/ km^2 (James *et al*., 2001) a financial burden the park management has not been able to shoulder. The magnitude of the threats to biodiversity, coupled with the limited financial, technical, and physical resources available for biodiversity conservation requires careful prioritization of the protection efforts within high poaching risk areas. Building on this, the short and medium terms goals in VNP's anti-poaching action plan calls for seeping changes in conevtional flagship species conservation using Trackguard devices coupled more intelligence based patrols. Such approach will allow wildlife authorities to direct law enforcement to WCHs, potentially curb trade before the wildlife is actually slaughtered, and thwart trade before it enters into an increasingly complex web of international wildlife criminal activity.

.Formal recognition of the transboundary effects of biodiversity conservation (DRC-Rwanda and Uganda) only happened recently, with the conceptualization of the ecosystems/landscape approach to PA management in the region (Lanjouw *et al.*, 2009b). The Memorandum of Understanding signed between the three PA authorities elucidates, among other objectives behind this collaboration as follows: (i) advocate for integrated bioregional land-use planning and management to reduce threats to PAs, (ii) strengthen cooperation in research, monitoring and information management programs, and (iii) ensure that conservation of biodiversity in the region contributes to the reduction of poverty. However, the salary discrepancy between park staff working in the same landscape is not of the nature of involving them in what is going on and to foster their commitment and identification within the transboundary implementation process. Indeed, the salary of a first rank park guard in VNP is set at \$US 41 while his colleagues in Volcano NP (Rwanda) and Mgahinga NP owns respectively 70,000 Rwanda Francs (125 \$US) and 600,000 Uganda Shillings (100 \$US).

The knock-on effects that this situation may have to the work plans of different people involved meant that there is need for further considerations (at least from ICCN side) in order to avoid potential setback in line with the implementation of further planned conservation activities in the framework of the implementation of the ten year transboundary strategic plan supported by IGCP and funded by USAID. This point raised here on staff motivation and commitment might impinge in a big way on the staff professional life as a whole.

It is obvious that the overall decline in law enforcement effort and especially the deterioration of guard efficiency, which is pronounced in between 2006 and 2008, was due to two factors acting in concert. First, most of the park guards ill-equiped (some patrol posts were still inadequately armed with old service rifles (muzzle loading guns), usually with no more than two rounds of ammunition each, no match against groups of heavily armed poachers' gangs. But the reality on the ground is that, despite the scarcity of equipment, many non-functioning weapons continue to be carried by game staff in an attempt to sustain the desired image (Mubalama, 2000). The stabilization of wildlife numbers observed between 2003 and 2006, amounting even to a slight increase for some species, offers a glimmer of real hope in a context of emerging, if cautious, optimism (Languy, 2009). Second, as a result of the dismissal of the carriers following general breaking of law and order, the guards had to haul their own patrol gear in the field, restricting their movements and speed and reducing manpower during encounters (Jachmann, 1998). Notwithstanding, most poachers in some areas were aware of the reality and not surprisingly showed scant respect for the rangers (Mubalama, 2000).

Cropland expansion has been a primary method by which Africa's agriculture production has increased and has been a major contributing factor in the loss of biodiversity (Pagiola *et al*., 1998). Land remains people's primary asset and social security around the VNP where population growth (2-3% per year) and land use pressures remain major concern for conservation. In addition, tropical forests traditionally have been a source of food and other resources for local peoples (Redford, 1992). Thus, it is likely that people will continue to settle and convert new areas to cropland and pasture as one of their primary responses to population growth, leading to a huge demand for farmland and consequently pressures on VNP (Mubalama, 1995). Ignoring human factors in the sustainable management of bushmeat is a clear recipe for failure. Striking a balance between the long-term objectives of the VNP and the immediate needs of the local communities living in and around it is the most pressing challenge facing the park managers (Balole & Boendi, 2009b). The solution lies within an economic reinvigoration of rural economies.

4. 12 Management Implications for Conservation Strategies

Lack of understanding of the costs of biodiversity conservation has contributed to the impression that global conservation strategies re unrealistically expensive, when in fact they are not. A small shift in government expenditures toward environmental sustainability could preserve a substantial proportion of global biodiversity for current and future generations. Effective conservation lies well within local communities' means.

Based on the study findings, I suggest two strategies to mitigate the threats facing the VNP. The first is to manage direct threats (habitat destruction and poaching) across all the VNP poaching hotspots to halt direct persecution of wildlife. In view of the extremely negative consequences of the presence of armed groups in and around the park, and given the fact that poaching threats has reached epidemic proportions, the central government should urgently take measures to disarm and evacuate the armed groups and to reduce significantly the number of military positions inside the VNP, a World Heritage Site in danger since 1994.

The effort to conserve nature during a period of extreme insecurity and instability and the effort to do so as a united international and national front, together carve graspable contours to a future conservation ethic. In most DRC protected areas, strong conservation leadership is not provided by a government organization. Conservation cannot be a top priority in a bankrupt nation. Therefore the progress made to even uphold the conservation laws on the books depends on outside donors. The weaknesses of outside donors have been their short-term perspective and their autonomous modes of operation. In this regard, what conservation under conditions of armed anarchy requires is strong unity of all its proponents, long-term goals, and a fundamental investment in the development of a diverse and competent local leadership.

The second strategy (which can be pursued concurrently) is to address the long-term threats (human incursions, charcoal kilns and bush fire) through approach such as direct payments economic incentives or lease programs negotiated with land owners, community conservation initiatives, integrated land use planning and integrating conservation of biodiversity in regional development (Newmark & Hough, 2000). The living standards of people living in and around the VNP are generally low and, in the absence of alternative livelihoods options, there is a temptation to turn to unsustainable extraction of resources from within the VNP (e.g., game meat, charcoal, thatching grass-spear grass-*imperata*). Poverty is inescapable fact of life following a protracted economic decline experienced by the country since a decade. It was knowledged that biodiversity could not be protected without considering the needs of the people living in or around these PAs (Chapin, 2004). From that prospect, the view is quite widely held that without a reasonable level of local people cooperation, wildlife conservation efforts would be doomed. Community support taken as the new ‘school of though’ is especially critical, as here, where resources available to park managers are limited and political instability endemic. In the long-run, there is a need to bear in mind the idea of supporting rural development using the benefits derived from wildlife.

As agricultural sector develops more and more on the boundary of the two PAs, adverse environmental impacts will need to be closely monitored to ensure that short-term economic gains do not result in longer term loss of biodiversity. While governmental efforts to increase agricultural production will focus to a large extent on developing more efficient agricultural practices (improved varieties and seeds, various agro-forestry techniques, micro-irrigation techniques etc) the issues of land tenure ultimately have to be addressed for farmers, and peri-urban fuelwood producers, to have real incentives for intensification of production and sustained management of natural resources. Development and proper implementation of land-use plans are therefore critical to reconcile sustainable growth in the agricultural sector with conservation of the two PAs unique biological diversity. In this regard, the importance of developing a national-level GIS spatial investment in revitalizing the agriculture sector would benefit the most people, generate the most wealth, and pose the least risk to the DRC's vital biological resources.

Given the unprecedented number of intrusions experienced by the VNP and in order to counteract the rising level of intrusion, it is very important that the park boundaries are physically marked using boundary markers. Recognition by those on the ground of the 1,150 km of park boundary is essential in facilitating the identification of illegal agricultural encroachment. In the meantime, measures should be put in place to assist the 'displaced farmers' who have to regroup outside the park. The objective here is not to modify the legal boundaries but to mark documented legal boundaries using the *Feuillet Technique n° 1*- the consolidated document containing all boundaries – three types of information that are at hand to help determine exactly where these boundaries are on the ground (Languy, 2005; Languy *et al*, 2009e). In light of the participatory demarcation of the park boundaries, all efforts to demarcate the spatial extent of the three official fisheries would have as only goal the restriction of the human habitations. On no account should it be considered as a demarcation of the boundaries of the park, all the more so since only a presidential decree can modify the limits of a national park in the DRC (**Annex 1**).

Concerns about the degradation and depletion of fish stocks in the Lake Edward are not new; it is a recurrent phenomenon which happens every year. Fishing in the inland waters of Lake Edward remains an important source of protein for many local people and urban populations around the two parks. While no recent data on productivity and offtake are available in line with the updating of Vakily report (1989), it is likely that over fishing and depletion of fish stocks is occurring at unprecedented rates. Only a detailed local investigation will reveal exactly what is happening. Priorities for policymakers will, therefore be to enforce a solid regulatory framework to ensure sustainable fishing and the generation of long-term nutritional and economic benefits for the local community, bearing in mind that these fisheries are not enclaves but are rather integral part of the park.

Once the political stability has returned, tourism will undoubtedly be one of the first economic activities to resume in the region given the presence of great apes population as potential source revenue. In 2003, the International Gorilla Conservation Programmme (IGCP) commissioned a study on the tourism market in the Virunga and at Bwindi (Uganda), providing useful information on the present and potential economic value of gorilla tourism. It also provided the basis for a marketing strategy at government and international levels. The study also enabled an evaluation of the distribution of benefits between local, national and international communities. With an occupancy rate of 30-40 percent and a price per visit fixed at $US250 or more, only visits to the gorillas in the DRC could induce benefits of more than $US 20 millions per year (Lanjouw *et al*., 2009a). Since ICCN Community-based conservation (CBC) strategy (2008) has set up the revenue-sharing rate (40%) of total generated revenue, a portion of the funds generated should be managed by committee composed of park staff and representatives of the local people, and they may be used to fund projects in the surrounding communities. The park management has established a unit of 40 "Community Scouts" who will help with the de-snaring operations in the gorilla sector. Instead of a patrol being made up of 4 guards, a patrol logged by GPS will now be made up of 1 or 2 guards accompanied by 2 or 3 unarmed community scouts known to be supportive to help the park in the past (de Merode, 2010).

The impact humanity has on biodiversity is largely determined by the social and economic activities of societies. For example, the documented transformation of forest or savanna into agricultural land, which is the direct driver of the loss of many species, was caused by a variety of indirect socioeconomic drivers. Market pressures, land tenure arrangements, poverty, and various regulatory frameworks all played a role (Chomitz, 2007). Similarly, the dynamics of fishery exploitation depended on law governing water resource exploitation (**Annexes 1&2**), and negotiation at a large scale, and community management practices, financial resources, and the availability of markets played a significant role at a smaller scale. As can be seen from these examples, an understanding of the connections between socioeconomic factors and environmental outcomes is crucial if effective strategies for managing the environment are to be developed.

Given that illegal resource use is, and will continue to be, a major threat to conservation, different types of illegal activity may require different methods. Different scenarios require different techniques, but several methodological concerns apply to any study of illegal resource use. First, monitoring is critical. Regular monitoring will detect trends in illegal activities, which an adaptive management approach can adjust to in real time. Nevertheless, given the widespread lack of comprehensive baseline data for conservation in some inaccessible areas due to insecurity, modelling can play a vital role. Modelling can incorporate sampling error and data uncertainties to provide a range of estimates regarding quantities, locations, and trends in illegal resource use bearing in mind that no model is better than the data upon which it is based. With other methods, such as indirect observations and enforcement records, corrections can be made to limit the impact of bias. Finally, triangulation, by comparing outcomes of multiple methods used simultaneously, can obtain the most accurate results (Gribble & Robertson 1998; Pitcher *et al*., 2002; Gavin *et al*., 2009).

Investigations of illegal resource use face different challenges depending on the financial and human resources available. A proper comparison of methods would ideally examine how well different methods estimate resource use across a wide array of illegal activities and would incorporate concerns about cost and time efficiency. Future methods comparisons should also examine the statistical power of different techniques to detect changes in illegal resource use over time (Jones *et al*., 2009). From that prospect, research on space-time accessibility concerned with determining and assessing the opportunities for poachers' activity participation calculating cost of network in both parks is a goal worth striving in the near future.

In consideration of the KBNP and VNP case studies, it is note worthy that although wildlife crime pattern theory and routine activity are mutually supportive in many respects; they can give rise to different explanations of poaching at specific locations. Following a set of high-crime locations (poaching hottest spot), a wildlife crime pattern theorist would focus on how offenders discover and gain access to the place while a routine activity theorist would focus instead on the behaviors of the targets and the possible absence of park staff whose presence could have prevented the offenses from taking place. While a few offenders may aggressively seek out uncharted areas, most will conduct their search within areas they become familiar with, especially where sophisticated poaching syndicates and networks with international links are swelling and imposing a serious threat to park helpless-wild-animals with gangs of poachers routinely taking pot shot using high-powered-rifles. Clearly, both explanations can be valid in different contexts and situations; they offer offer insights and emphasize the concept of place in crime pattern theory (Eeck *et al*., 2005). Combination of the two theories is needed to underpin management and conservation practices.

CHAPTER 5

VALIDATION OF LAW ENFORCEMENT MONITORING MODEL USING SOCIO ECONOMIC DATA

Developing statistical methods for validation is the most difficult task in the modelling process, as there is no gold standard against which predictions can be gauged

— **Fielding, A. H. 2002** —

5. 1 Validation Results related to Illegal Wildlife Use from the KBNP Prospect

Illegal use of natural resources is a major threat to biodiversity globally (Gavin *et al*., 2009). Trade in bushmeat has been presented as the primary threat to wild mammal populations in Central Africa (Mittermeier, 1987; Fa *et al.,* 1998). Robinson & Redford's (1991) simple model for measuring sustainability from harvesting rates provided the basis for a number of studies examining the relationship between the marketing of bushmeat and animal populations. For example, Juste *et al.* (1994) undertook long-term monitoring of markets in Equatorial Guinea and analysed the effects of wildlife harvesting on local mammal populations. A similar study was undertaken in the Arabuko-Sokoke Forest in Kenya by Fitzgibbon *et al*. (1995). The objectives of these studies were to assess the sustainability of wildlife harvesting, and to identify those species that were subject to over-harvesting bearing in mind that cost-effective data collection of bushmeat consumption will provide a viable alternative to assess levels of poaching involvement of villages that border PAs (Knapp *et al*., 2010).

Bushmeat has become a real scourge of KBNP's rich natural heritage. For many rural and urban people in African moist forests, meat from wild animals is highly valued product. Bushmeat provides an important source of protein in household diets because domestic meats are often not available (Koppert *et al*., 1993). Tropical forests are low-productivity ecosystems in comparison to tropical savannas, and are hence more vulnerable to uncontrolled exploitation (Fa & Peres, 2001; Fa *et al*., 2002). The consumption and value of bushmeat is rapidly changing in many regions due to the increasing demand from urban areas and the dwindling supplies of wild animals in rapidly degrading environments (Fa *et al*., 1995). In the face of such decline, Fa *et al*. (1995) used the Equatorial Guinean market data to recommend greater regulation through "*the* *maintenance of already decreed protected areas ... where control of hunting is vital for conserving the endemic fauna*". Both the KBNP and VNP are not an exception to such trends.

Market surveys were carried out from July – October 2007 and during the same period in 2008 to monitor wildlife trade in Hombo and Bulambika (**Figure 3. 22. 1. 1**) settlements in the vicinity of the KBNP where the markets were visited between 06:30 and 12:00 hours in both years (no meat arrived at other times). All meat was sold on the day it was taken to market, thus reducing the risk of counting an item twice. Biomass entering the market for both periods was calculated by multiplying the total number of carcasses counted by the average body mass of each species. Average body mass (to the nearest 1 kg) of a species was taken as the mean weight of juvenile and adult animals obtained from the literature (Fa & Purvis, 1997). A semi-structured enquiry (**Annex 6**) was undertaken over a prolonged period consisting of regular, informal interviews with a range of bushmeat sellers and purchasers who were present at the market in the village. Most of the results described below are drawn from these exchanges at the market place. The surveys produced valuable insights into people's harvesting and trading patterns, but were felt to be intrusive and demanding of interviewees' time. The interview exercises involved 137 people actively dealing with bushmeat trade over the years, and frequently accessing the targeted market places during the surveys. Margin sampling error was of ± 2.5 percentage of points.

The discussions were friendly, diverse and instructive. Exchanges typically consisted of discussions about why people had come to the market, what they had come to buy or sell and exploring some of the problems relating to the marketing and purchasing of food products. Bushmeat was not explicitly introduced into the conversation, but the theme was developed when mentioned by the interviewee. Stall keepers were questioned about the geographical origin of the meat (**Annex 6**). Purchasing meat provided a catalyst for generating discussion around the use, and the benefits derived from the use of wildlife. The key themes from these conversations were then recorded immediately after the market, usually the same evening, and structured, several months later, to form a coherent picture of local wildlife utilisation (de Merode, 1998).

Following Juste *et al*. (1995), I measured two main attributes of markets dynamics, quantity and daily availability of goods, during the study time periods. These measures were expressed quantitatively as (i) daily abundance (hereafter, abundance) of a species as the monthly average number of carcasses per species per day for all days sampled and (ii) availability as the percentage of market days sampled in which the species appeared. A number of significant differences emerge from these socioeconomic analyses as shown below.

During each market visit, one or two trained covert observers working together walked the meat section of the market, counting and identifying animals or animal part displayed. Quantities too large or piled too deeply on tables to be counted easily were estimated by counting a sub-sample and extrapolating across the pile. At each market stall selling multiple animal parts (rather than whole animals), the number of individual animals was estimated by calculating number of hind feet of that species divided by two, number of fore feet divided by two, and number of heads, and then taking the greatest number of the three. Carcasses were counted by the author or by trained local field assistants familiar with all markets entry points and species. Smoked meat identifiable species, and some live animals were recorded as they arrived at the market. It should be noted that bushmeat in the study area was eaten as fresh or smoked meat in soups and stews, occasionally roasted or fried.

Meat was usually processed before being taken to the market. This involved cutting it into smaller pieces and possibly smoking the meat, to preserve it and to reduce the weight during transport. As a result, it was not always possible to recognize the mammal species from the processed meat. However, the form and texture of the meat meant that the larger, protected species were easily identifiable, and therefore it was possible to use the category of protected / unprotected to describe the meat. Due to a number of factors that prevented species level identifications for some individuals (e.g., under cover nature of the monitoring, charred or singed conditions of some individuals), most animals were classified into general categories (**Table 5. 1. 1**). Each of the market was visited at least two or three times in a month. Survey duration ranged from 0.32 to 4.12 hours (mean = 1.33h; median = 1.11 h).

As such, identification and counts of animals were a sample of goods for sale during the market survey. For this reason, I standardized the volume of wildlife counted in markets by hour and used encounter frequency as my metric to compare patterns of wildlife trade; this is the index of wildlife trade activity I used throughout the study period. The settings in different markets were similar, and I assumed that the observers' pace of walking through markets did not differ systematically with market, hence enabling direct comparisons of encounter rates among markets. Wildlife encounter frequencies in individual markets visited multiple times in one month were averaged across several visits in the sites depicted in **Figure 3. 22. 1. 1**.

Table 5. 1. 1 *Summary of total and mean (± SD) number of carcasses and biomass entering the market each month in 2007 and 2008 in Hombo and Bulambika*

Year and species	Total number Of carcasses	Mean per month	Total biomass (kg)	Mean per Month
2007				
Monkey sp*	494	59.9 ± 33.4	2470	234.2 ± 113.4
Atherurus africanus	358	36.3 ± 12.6	1790	187.6 ± 97.5
Cricetomys emini	256	30.4 ± 23.8	1280	134.3 ± 143.1
Tryonomus sp	231	29.9 ± 12.7	1155	127.4 ± 101.7
Cephalophus monticola	229	29.4 ± 23.7	1145	119.6 ± 196.5
Duikers (other than C. monticola)	223	28.4 ± 20.4	1115	113.3 ± 5.9
Potamochoerus porcus	189	23.7 ± 2.8	945	97.2 ± 10.5
Manis gigantea	159	15.3 ± 11.4	795	80.1 ± 2.9
Kinixys erosa	77	8.5 ± 6.9	385	4.6 ± 3.7
All species	2216	203.3 ± 139.1	1080	1098.3± 675.2
* *Cercopithecus*				
2008				
Monkey sp*	994	149.3 ± 33.4	4970	234.2 ± 113.4
Atherurus africanus	538	66.5 ± 12.6	2690	187.6 ± 97.5
Cricetomys emini	476	53.6 ± 23.8	2380	143.1 ± 134.3
Tryonomus sp	345	44.8 ± 12.7	1725	127.4 ± 101.7
Cephalophus monticola	342	39.4 ± 23.7	1710	196.5 ± 119.6
Duikers (other than C. monticola)	337	28.4 ± 20.4	1685	113.3 ± 5.9
Potamochoerus porcus	298	52.7 ± 2.8	1490	97.2 ± 10.5
Dendrohyrax dorsalis	235	35.3 ± 11.4	1175	80.1 ± 2.9
Kinixys erosa	93	17.5 ± 6.9	465	4.6 ± 3.7
All species	3658	487.5 ± 147.7	18,290	1184.0± 589.5

* *Cercopithecus*

Ten species with duikers and monkey subdivided in more species (at least 7) were noted in the market in both years under consideration. In both years, the *Cercopithecus* sp was the most abundant species with 22.3% of all carcasses in 2007 and 27.2% in 2008, followed by *Atherurus africanus* (16.1% in 2007 and 14.7% in 2008) and the Emin's pouched rat (*Cricetomys emini*) with 11.5% in 2007 and 13% in 2008. Biomass contributed by each species was positively correlated with the number of carcasses of that species appearing in market (2007: $y = 4.39x + 1$, $r^2 = 0.45$, $P < 0.001$; 2008: $y = 6.86x + 1$; $r^2 = 0.34$, $P < 0.01$). There was a significant difference between years in the monthly number of carcasses ($\chi^2 = 7112$; df = 3, $P < 0.001$).

Encounter frequencies from markets surveys were analyzed in three ways. Differences in index of trade activity between sites (Hombo vs Bulambika) and years were examined using two-factor repeated measures ANOVA with region and year as fixed factors and markets as the replicate. This ANOVA was performed for all taxa combined and for protected species only. Second, within-year temporal variation in wildlife sales was examined using two-way ANOVA with year and month as fixed factors and market as the replicate. Standard ANOVA rather than repeated measures was used, because the index of trade activity between adjacent months was not significantly correlated ($R = 0.118$; $P = 0.267$), indicating independence. Finally, I tested whether the index of wildlife trade activity declined during the study by (i) comparing trade index between years using the ANOVAs described above; (ii) testing for significant declining trends over time using linear correlation; and (iii) performing paired sample *t*-test of months between years after averaging across all markets in a given month.

5. 1. 2 Bushmeat Markets and Economics as Indicators of Wildlife Utilization

Juste *et al.* (1995) suggest that most hunted ungulates and primates end up in the markets, but that some species, such as rodents or other small mammals are more likely to be consumed by the hunter's family without the meat reaching the market. The fact that village hunters eat meat directly after hunting introduces some bias into the results because a measure of the meat in the village markets underestimates the amount consumed by village residents. The results of the socio-economic survey which examines people's harvesting patterns show that, excluding meat obtained from snares, over 53% of bushmeat obtained by village hunters is subsequently sold at the local market. Thus, the meat represented in village markets is likely to represent half of the total amount of meat consumed in the village. By contrast, the meat recorded in the urban markets represents most of the meat consumed by urban dwellers. However, the supply side considered here as the bushmeat available at both Hombo and Bulambika markets is a reflection of the bushmeat exploitation (Fa *et al*., 2000).

What the figures revealed is stunning. Significantly more carcasses were counted in 2008 (n = 1,829) than in 2007 (n = 1,095) (χ^2 = 604.4; df = 1; P < 0.001). Similarly, biomass varied significantly between years (7,017.4 kg of dressed meat in 2007 and 11,716 kg in 2008 (χ^2 = 103.4; df = 1; P < 0.001). This represents an extra 733.5 carcass, or 4,698.6 kg in 2008, an increase of 40.1%. On average, an estimated number of 1,462.2 individual wildlife carcasses totaling 9,366.8 kg were recorded during surveys of three markets. This latter figure compares well with other findings in the Lopé Reserve in Gabon (White, 1994), and the Virunga in DRC (Plumptre, 1991), where the above mentioned authors estimated that mammalian biomass ranged between 1,000 and 6,000 kg/km^2.

The largest proportion of these was primate, which accounted for 25.3% of all encounters, followed by porcupine (15.2%), *Cricetomys emini* (12.5%), *Tryonomus* sp (9.8%) and *Cephalophus monticola* (9.7%). Overall, the index of trade in mammalian wildlife sold in the three sampled markets shows considerable variation across markets and over time, from a consistent encounter frequency of < 6 individual animal h^{-1} at Bulambika to >15 individuals h^{-1} at Hombo. In repeated measures ANOVA with sites and year as fixed factors, sites (Bulambika vs Hombo) had a significant effect on the trade activity index of all wild mammals in markets ($F_{1,\ 2}$ = 1.231, P = 0.001) with an average across years of 23.2 individuals h^{-1} in Bulambika and 117.2 in Hombo . Two-way ANOVA to test for monthly seasonality (July 2007 with July 2008) in wild meat trade shows no seasonal pattern for all wild mammals combined ($F_{1,\ 2}$ = 0.127, P = 0.665), but strong seasonality of trade in keystone species when the analysis was repeated using z-scores (rather than count) with a significance ($F_{1,\ 2}$ = 1.213, P = 0.01). Though only 52 % of the variation could explain the frequency of encounter of wildlife between Hombo and Bulambika, there was a very significant correlation between the frequency of encountering of widlife in Hombo and Bulambika bushmeat markets in 2007 and 2008 as shown by the regression equation (Y = 5409 + 983x; R^2 = 0. 516; P < 0, 0001) in **Figure 5. 1. 1** depicting the relationship between the frequencies of encountering of bushmeat products in Hombo and Bulambika markets 2007 versus 2008.

To sum up, it’s clear that the bushmeat trade remains one of the major threats to rainforest wildlife (Robinson *et al*., 1999; Barnes, 2002; Davies, 2002). It was virtually impossible to assess whether a given bushmeat market is based on sustainable offtake from the study area. However, it was evident that when hunting pressure increased, hunters tended to switch to prey species that were easier to obtain, which is reflected in the supplied at the market market. In general, high-reproduction species tended to replace large low reproduction species.

ANOVA Table

Frequency of encountering of wildlife in bushmeat market 2007 vs. Frequency of encountering of wildlife in bushmeat market 2008

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	4622.912	4622.912	24.526	<.0001
Residual	23	4335.248	188.489		
Total	24	8958.160			

Regression Coefficients

Frequency of encountering of wildlife in bushmeat market 2007 vs. Frequency of encountering of wildlife in bushmeat market 2008

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	5.409	3.412	5.409	1.585	.1266
Frequency of encountering of wildlife in ...	.983	.199	.718	4.952	<.0001

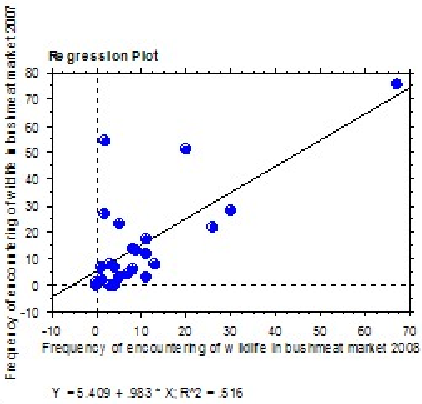


Figure 5. 1. 1 *Relationship between the frequencies of encountering of bushmeat products in Hombo and Bulambika markets 2007 versus 2008.*

Most of the interviewees that the field teams managed to contact in the course of the survey provided information on the frequency, type, and approximate numbers of snares used, access to hunting camps, seasonality of snare use, animals caught, and habitat exploited (e.g., hunting sector). They reported as well that poachers usually operate on the ground using a hunting territory approach. This finding is consistent with Kasereka *et al*. (2006) results emphasizing that poachers had partitioned the Highland Park management unit into 9 poaching sectors following their “hunting agreement”. Some of them who provided meat for sale had experienced multiple jail-release episode following they involvement in wildlife killing.

Some well known avoided by hunters building upon local believes and cultural values coinced with poaching coldspot areas. These were Byamba, Cibinda, Cirhunvangoma, Kashalala, Magalule, Kamano, Magwerhe, Muhehwa, and Nyamarhale. In fact, according to Pygmies who lived long time ago in the park, these areas inspire trouble and fear. If Byamba means traduces itself by the occurrence of animal that changes into fearful spirit, Nyamarhale is an area which becomes dark every time when there is human presence, Magalule refers to an area where people become foolish once they pop in, and Kamano evokes an area when it suddenly rains cats and dogs as people step in (Shalukoma, 2002). Not surprisingly, there was less threats frequency in these areas. A plausible explanation is that many guards come from the region; therefore they do, to some extent, share the same belief accordingly, thus possibly avoiding themselves these areas.

Such attitude exhited by both offenders and some park staff could be explored in the framework of beneficial links between cultural values and biodiversity protection.

I used χ^2 contingency test to analyze the relationship between expected location, wildlife species occurrence as quoted by interviewees, and observed results from LEM data. Before pooling data from strata, heterogeneity χ^2 test using a 95%; 0.05 confidence limit was performed and data were confirmed to be homogeneous ($\chi^2 = 46$, $P < 0.05$). There were significantly more small-bodied wildlife species than expected in quoted strata ($\chi^2 = 12.45$, $P < 0.05$).

I then estimated the number of mammals killed in one year by the rural population. In 2007, there were an estimated 9,491 hunters (opportunistic and permanent) over a total population living in the vicinity of the park estimated at 437,993 people (**Annex 10**). This figure provides one hunter over c.0.022 people. I multiplied the number of hunters by the per capita per annum meat consumption values of 159 g/person/day for foragers (Wilkie *et al*., 1998). The resulting figure, 1,509 individual mammals killed each year, suggests the staggering extent of subsistence hunting.

Kills provide local people with income and exchange value. Hunters usually sell meat and trophies to local and outsiders. They exchange game meat and skins for cash needed to purchase consumer goods and to pay school fees. In addition to economic benefits, some hunters gain social status from providing their next of kin and fellow villagers with meat and economic goods. With the spiraling war in the region, weapons and ammunitions spread over in wrong hands, thus explaining the rapidly decline in large-bodied species with increased armed hunters presence. A limited number of local people preferred to hunt with firearms because they furnish a surer method of killing larger game, which in turn, provided greater returns to hunting efforts. Commercially produced weapons were also preferred to locally fashioned firearms, traps, or snares. Villagers often constructed their own muzzle loader (the steering column of a Land rover was for a time the most popular object from which to form a gun’s barrel), mixed their own gunpowder, and used various found objects for ammunitions (e.g., nails, bolts, old screws, or stone). They derived substantial consumption value from wild foods in the lean season when agricultural products are scarce, and relied heavily on wild foods for their cash income throughout the year and therefore the importance of biodiversity to food security in the region cannot be overstated (Snel, 2004).

An important implication of these results, for both conservation and development policy, is that while commercial hunting is unusual, perceived as a greater conservation threat than subsistence hunting, it is the market sale and not consumption of wild foods that can be most important to households living in extreme poverty. Nevertheless, it is also important to recognize that in this community the value of these commercialized wild foods still remains insufficient to increase the income of any household above the threshold of extreme poverty with income below US$1 per capita day (UNDP, 2001, de Merode *et al*., 2004). In light of this it is important for wildlife managers to recognize how food security may affect and be affected by conservation initiatives.

One of the shortfalls of this survey is that the information is an underestimate of the situation because one cannot account for the numbers of animals brought on the way to market, and – most important – animals that escape with injuries, decompose in traps, or become food for scavengers (Fa *et al*., 2000). In this study I documented 25-32.5% wastage in duiker and primate species caught in snares, this compares well with Noss (1995) reporting up to 40% wastage in some species caught in snares in Bayanga, Central African Republic. The slight difference may be explained by the removal of unreported carcasses used by staff in patrol, all the more so since ICCN policy allows patrols to eat dead animal remains for rations. Another bias may result from corruption by enforcement agencies, which can result in deliberate underreporting and ineffective enforcement. Finally, enforcement records can be biased toward readily apparent violations, including illegal activities closer to enforcement headquarters and activities violators cannot conceal (Gavin *et al*., 2009) though park guards are at the frontaline of law enforcement.

5. 1. 3 Enforcement Economics Case study: Kahuzi-Biega National Park

Following the decision **33COM 7A.5** – on Kahuzi-Biega National Park, adopted at its 33rd session (2009), the World Heritage Committee (WHC, 2009), and recalling Decision **32 COM 7A.5**, adopted at its 32nd session (Quebec, 2008), has recognized that Illegal harvesting is serious threat to the persistence of many plant and animal taxa in the KBNP. The WHC expressed regrets in line with the lack of significant progress in the resolution of the cases of illegal occupation of the corridor and the granting of mining concessions in the property. Over and above, the WHC decided to continue to apply the reinforcement monitoring mechanism for one more year and to retain KBNP on the List of World Heritage in Danger.

The current case study analysis focused on cases of human encroachment that had occurred in Kasirusiru patrol post (**Figure 3.6.1**) area between 1997 and 2008 and involving park violation by renegade farmers group under the aegis of Magistrate Muhimuzi Muzibu Ernest. The latter occupied a patch of land in the Lushanja block (land located in perimeter delineated by the beacons 102 and 129) under SR 339 registered certificate FB. 105 folio 19 dated on June 29, 1997 and Volume FK 1 folio 107 dated on December 2004 though Ordnance-Law No. 69-041 forbids under its article 3 any form of land use incompatible with the conservation of nature. This provision is as well supported by provisions of land law No. 73-021 dated July July 20, 1973 under provided articles 55 and 104. Following different judgements rendered by the courts, namely R.C.A 3319 dated on September 2002; R. C. 1531 dated on March 05, 2004; R. C. A. 3607 signed on February 25, 2008 and executed on August 2008, the ICCN rights over the violated patch of land grabed by Magistrate Muhimuzi Muzibu Ernest were duly recognized, hence suggesting that the park administration vowed to leave no stone unturned and insisted on standing on its rights before the courts.

During the course of all these altercations between the park administration and Magistrate Muhimuzi Muzibu Ernest, people loyal to Magistrate Muhimuzi Muzibu Ernest even changed known geographic beacon location, chopped down trees for charcoal kilns in a bid to cloud the land issues to the detriment of the park, and thus showing Magistrate Muhimuzi Muzibu Ernest dissatisfaction. It is unfortunate that some unchecked elements of the FARDC were used by Magistrate Muhimuzi Muzibu Ernest in destroying the park resources (PNKB, 2009). The attack launched against the Mugaba patrol post in July 2005 by a FARC dissident Colonel 106 is another unfortunate event supppotng the evidence of the involvement of national military in park destruction (PNKB, 2006). The enforcement process analyzed in this case was a judicial process; therefore I tracked the cases through the hands of both public prosecutions and into courts.

Due process can be extremely challenging in the current context. Bukavu and Kavumu courts had little or no resources in dealing with the KBNP versus Magistrate case. Magistrates were unable to function properly when salaries have not been paid for several months, making them extremely susceptible to corruption. Similarly, the *Officers of judiciary police* had no resources to collect evidence or to make arrests. This has to be provided externally often by the plaintiff, thereby introducing an immediate bias to the case. Furthermore, even where prosecutions were brought, courts tended to be lenient in their sentencing policy.

According to my estimate, the profits to illegal invasion of bunch of land in the sector from harvesting as little as one tree are $US95. Using the enforcement economics methodology, I found the value of the disincentive generated by the enforcement system in this region was only $US5 (**Table 5. 1. 2**). Fines for the illegal theft of resources from park did appear to be low relative to the social cost though the civil jurisprudence under Articles 8 and 10 of the wildlife

Act (**Annex 1**) has a rule of thumb that fines should be proportionate to the crime. Yet, the current reality is that fines were typically too low to deter illegal activity, whatever the probability of being caught, even taking into account the costs associated with the illegal activity such as the purchase of a gun for hunting or the time and distance cost offinding the resource (Abbot & Mace, 1999).

Table 5. 1. 2. *Economic Disincentive: Case Study of the Kahuzi-Biega National Park*

Probability		Value	Cumulative Probability
Of Detection given illegal human encroachment	P_d	1	
Of citation given detection	$P_{a/d}$	1	
Of prosecution given citation	$P_{p/a}$	0.48	0.48
Of conviction given prosecution	$P_{c/p}$	0.12	0.064
Average value of penalty		$50	
Average time elapsed (days)	t	15	
Enforcement disincentive	ED	$5	
Profits to illegal human encroachment		$75	

Calculating the ED (**Table 5. 1. 2**) for the park, I had to make two generous assumptions. Data limitations precluded the calculation of precise quantitative values for probability of detection and probability of citation upon detection. For this analysis, therefore I assumed both those probabilities to be 100 percent. However, detailed qualitative analysis conducted in the region using LEM data clearly demonstrated that the probabilities are not that high in the case in point. The probability of detection was quite low near Kasirusiru owing to a number of factors including lack of public willingness to report park incursion, jurisdictional confusion, and frequent incursions of militias due to insecurity. The adverse effects have generated resentment and hostility that has led to vandalism, such as setting fires, and, in extreme cases, local population violation of park boundaries and regulations by hunting animals, cutting down trees, and grazing their stock inside the park. Likewise, probability of citation upon detection was low.

Although corruption was identified as a contributing factor, no specific analysis of corruption was conducted. Likewise, probability of citation upon detection was low because detection agents often give warnings rather than writing up citations and, in some instances, may be bribed (Hart & Hall, 1996) into overlooking a detected illegal act. If calculated using the true probabilities of detection and citation upon detection, the ED would undoubtedly be much lower than the already paltry $US5 calculated through this work (**Table 5. 1. 2**). The data show that the cumulative probability of an illegal act being penalized was only 0.064. However, the cumulative probability was also artificially high because I assumed the probabilities of detection and citation upon detection were both 1. In reality, the ultimate probability of an offence being penalized is far less than 0.064. In this case, even with (assumed) 100 percent detection, the enforcement system is ineffectual at countering the incentives to apportion a bunch of land. In the case of KBNP, only one over ten of all detected offenses was prosecuted and even lower percentage of offenders were convicted. Penalties are relatively low (less than $US10) and the slow functioning of the system ensures that violators, even if sanctioned both at Kavumu and Bukavu courts, do not "pay" for their offenses until well after two weeks has passed-during which time they are set free and accordingly can continue to violate the law. In such circumstance, having outstanding detection would make very little difference.

Current study results go beyond those of Leader-Williams & Milner-Gulland (1993) suggesting that, in Africa, concentrating on increasing detection rates is a better strategy than increasing the length of prison sentences. The case study further validates the assertion that detection alone is not enforcement and those investments across the enforcement chain are necessary to make the system more effective. While any government enforcement strengthening money on acquiring more equipments and hiring more people for detection efforts are undoubtedly important, our analysis suggests that the KBNP effectiveness would improve more through investments in other elements of the enforcement chain, including training prosecutors and judges, for instance all the more so since in DRC the courts are completely separate from the wildlife authority and do not always set the same priority on protecting wildlife. Unless the wildlife department is again attached to the office of the Head of state as it was in the 1970s, it remains less likely that the wildlife will be treated seriously, especially in the aftermath of political instability period when both military and militias continue to poach.

Although speculative, the 2008 socio-economic findings could be interpreted as a reflection of buyers demanding the smaller, more commercial species. An alternative explanation springs directly from the fact that in the face of a deteriorating national economy, the increase in supply of cheaper game might have been liberately brought about by hunters to bolster their profit margins. But if higher prices are likely to be paid for the rarer meat (average prices have indeed increased by about 25% in the last five years), this might encourage hunters to pursue these species even more, thus driving them further to extinction. Although data on the current condition of prey populations are required, what may be happening in the market is a spiraling relationship between diminishing supply and increasing demand for bushmeat. Hence, as the larger more expensive (and, for hunters, more profitable) prey dwindles, prices for these may rise so that progressively fewer people can afford to buy them, but there will always be some who can pay a high price. This in turn could force hunters to move on to the supply of smaller prey, Gambian rat (*Cricetomys emini*) and porcupines. These are likely to be brought by more people because they are cheaper and preferred, thus maintaining the hunters' profits for at least a while until this quarry is exhausted, hence suggesting that even threefold increase in patrol frequency would have been insufficient to cope with wartime poaching and human encroachment levels.

The shift to smaller game may create a respite for the scarcer large prey. Whether such a forced moratorium benefits these species will depend on the level at which these prey populations are left and if hunters are not forced to look for rare meat species to supply some buyers that may be prepared to pay more.

Previous analysis has shown that bushmeat hunting in the park increased during the conflict, but then declined, in conjunction with changes in the sociopolitical structures that hold control over the land and local bushmeat trade. Allthough there was incentive from the wildlife management to curb poaching to acceptable level and put out the blaze of human encroachment, results from protection effort run counter to Arcese *et al*. (1995) as well as Jachmann & Billiouw (1997) whose previous studies on park protection have demonstrated that poaching declines in response to patrol effort. Furthermore, it controverts Merode *et al*. (2007) unexpected findings in Garamba National Park in DRC where poaching declined under weak protection.

Finally, the research results overall strongly support the position there is little immediate spatial displacement of wildlife crime as a result of hotspots policing approaches, however can allow identifying other displacement outcomes that may occur in focused policing efforts (Weisburd *et al*., 2004). Offenders interviewed in the study described factors that inhibit spatial displacement, including the importance of familiar territory to offenders, and the social organization of illicit activities which often precluded easy movement to other areas that offer wildlife crime opportunities (Kasereka *et al*., 2006). Shi (52.4%), Mbuti (38.1%) and Tembo (9.5%) offenders from poaching sector in KBNP, for example, were found to work near their homes, and described being uncomfortable moving to other areas where different types of people worked and different types of clients were found. Some of them described the importance of the familiarity of a hunting place, and some emphasized the dangers of encroaching on the territory of offenders in other hotspots. Overall, offenders will often try other modes of adaptation to guard interventions, the most common being a change in the methods of committing illegal acts.

5. 1. 4 Managers' Perceptions of Threats to the Kahuzi-Biega National Park: Assessment of Threats Vulnerability for Effective Management

The success of conservation activity largely depends on public consent; influencing and monitoring of public attitudes are essential components of conservation actions. An important source of information on public attitudes is the activity pattern of the local communities.

Table 5. 1. 4. 1 Assessment of relative severity of 10 threat factors through collected data in each PA management unit, ranked from high to low relative severity

Threat factors	Threat activities	Causes of identified threats
Wire and rope Snare	Snaring of wildlife	Poor rural population that is dependent on natural resources (bushmeat)
Agricultural expansion & other land use changes	Expansion of agricultural activities in wildlife rangelands	Increased human population & associated food needs
Human encroachment	Increasing human settlement & associated infrastructure in the vicinity of the park, illegal grazing of livestock	Increasing human population and diminishing land resources
Loss of ecological corridor	Diminishing and degradation of wildlife dispersal areas	Increased human population & confinement of livestock in pastoral communities, land use chnges incompatible with wildlife conservation
Fuelwood cutting	Illegal exploitation of firewood, wood carving, medicinal plants thatching, construction material	Increased human population & diminishing land resources, poor rural populace that is dependent on natural resources
Mining	Extraction, prospecting of minerals & quarrying	Increased human population & associated food needs, additional sources of income
Insecurity	Expansion of agricultural activities in wildlife rangelands	Increased human population & associated food needs
Illegal bamboo cutting	Illegal extraction of bamboo	Increased human population & diminishing land resource, and alternative source of income
Livestock in the park	Expansion of agricultural and pastoralist activities in wildlife home range	Increased human population & diminishing land resources
Bush fire	Wild fire set indiscriminately to attract animal	Poor enforcement of park rules

The KBNP faces 10 major threats with a range of relative severity of 0.77- 0.23 (**Tables 5. 1. 4. 1 & 5. 1. 4. 2**). The threats with the highest relative severity, from higher to lower, were wire and rope snare, agricultural expansion, human encroachment, loss of ecological corridor and fuelwood collection. There was a positive and significant correlation between the relative vulnerability of PA and human encroachment (r = 0.54, P < 0.001), human encroachment (r = 0.44, P < 0.001), and snaring (r = 0.68, P < 0.001). Relative vulnerability of the park was best predicted by human encroachment accounting for 57.3% of vulnerability, followed by snaring (14.1%) and loss of ecological corridor (5.2%).

Table 5. 1. 4. 2 *The mean score and relative severity of 10 threat factors, as assessed by collected data in each PA management unit, ranked from high to low relative severity*

Threat	Mean Score ± SE	Relative Severity
Wire and rope snare	3.87 ± 0.13	0.77
Agricultural expansion	3.54 ± 0.22	0.69
Human encroachment	3.43 ± 0.19	0.67
Loss of ecological corridor	2.82 ± 0.26	0.56
Fuel wood cutting	2.67 ± 0.18	0.52
Mining	1.83 ± 0.16	0.37
Insecurity	1.77 ± 0.21	0.33
Illegal bamboo harvesting	1.60± 0.20	0.31
Livestock in the park	1.43± 0.16	0.27
Bush fire	1.33± 0.19	0.23

5. 2 Validation Results related to Illegal Wildlife Use from the VNP Prospect

Recalling Decision **32 COM 7A.4**, adopted at its 32nd session (Quebec City, 2008), and having examinined the extent of encroachment and deforestation in the region, the degree of poaching, as well as progress accomplished in the implementation of the corrective measures, for examination by the World Heritage Committee at its 34th session in 2010; the WHC regrets the breakdown in security that continues to hamper the implementation of conservation activities and threatens the Outstanding Universal Value of the property and decides to continue to apply the reinforced monitoring mechanism for one more year. To top it all, the WHC decided to retain Virunga National Park on the List of World Heritage in Danger following the Decision **33COM 7A.4**.

Hunting by local communities is among the most widespread threats to VNP wildlife, yet, the understanding of its nature, extent, and impacts on wildlife has been poor. Our surveys were conducted during 2006-2007 in Kyavinyonge, Kiwanja and Kibumba settlements using the socio economic data questionnaire (**Annex 6**). The populations of villages taken together are estimated to c.33, 000 individuals.

There are however, many large villages that could be considered as big cities, but they were deserted by people following the civil strife and political instability in the areas surrounding PAs. For the purpose of the study, households to be interviewed were selected by counting houses on randomly selected villages and selecting tenth one. A total of 55 households inside and outside the park were selected in order to get data aimed at validating the results of the poaching hotspot cluster mapping in the Virunga. Besides their other socio professional category, all people interviewed were involved in hunting and/or fishing either directly (with no other socio professional category, e.g., the 7 fishermen referred to here) or indirectly by providing weapons, ammunitions, snares, and fishing nets).

The research team consisted of one researcher (author) and two independent technical staff with experience in village interviews. Previous to the survey, the technicians were carefully briefed on the methods and goals of the survey. The contacts, local knowledge and unique insight of the researcher's team have made it possible to provide information on clandestine activities that would simply not be available to foreign researchers. The extraordinary valuable data was, nevertheless, collected in conditions of considerable difficulty and in a short period of time; it represents a remarkable achievement. Despite being local to the areas studied, all the team found the research very arduous because of the often illegal nature of the activities being investigated and because of the logistical difficulties in doing research in a region of political instability, such as transportation and communication problems, rising prices and therefore research costs, and the endless delays that beset any endeavor in the current political and economic situation.

Officially the economy of DRC was in a state of disaster: export could not keep up with imports, production lagged, industry barely functioned, scarcities were rife, the infrastructure has deteriorated drastically, wages were at starvation level and nothing worked as it should. The spiraling decline of the official economy was often offset by flourishing activities unreported in the national accounts. The phenomenon was so widespread, so large in scale, and so well integrated into the functioning of almost all economies that it is the subject of considerable concern to tax authorities, government policy planners, and development agencies. The populace broke state laws and regulations which they rejected as unacceptable. The essence of the underground economy lies in the relationship between the government and economic activity. It was the people's spontaneous and creative response to the state's incapacity to satisfy the basic needs of the impoverished masses (UNDP, 2001, de Merode *et al.*, 2004).

The interviewees were given 3 sets of questions. The first set of questions pertained to the large fauna of the area. Besides gathering information on the presence-absence of various large mammals, we also probed the perceptions of respondents regarding changes in the wildlife populations over the last decade. The second set of questions basically surveyed hunting practices, and motivations for hunting. In addition, information was also gathered on the ethnicity, economic profile of the interviewees (including landownership, income, etc). The questionnaire contained open-ended questions. The questionnaire gathered information on the marital status, sex, major occupation (occupation here being the activity generating the higher income) of the respondents, and their consumption of meat with emphasis on bushmeat. The third section sought information on the preference of respondents for hunting areas (**Annex 6**).

Respondents' openness of our in discussing poaching was facilitated by the informal settings and congenital atmosphere of the interview and focus group discussions, and the good relationship developed with the researcher. Emphasis was placed on obtaining information related to the intensity of hunting and describing patterns of hunting vis-à-vis hunter prey-choice, hunting techniques used, and the influence of socio-cultural factors in driving the activity. Since hunting of protected wildlife is forbidden under law, the field team was essentially probing an illicit activity that people were generally averse to discuss. Therefore the field team used under cover method. The teams used prior contacts in the area to identify local villagers who could provide valuable information. Using this method, field teams were able to hold detailed personal interviews with several neutral informants. Field team also randomly cross-checked statements from testimonies of hunters with their hunting companions and discarded dubious data.

Despite local cooperation, it was by no means possible to make first-hand estimates of hunting frequency and offtake, or even, interview all hunters in any village. I therefore estimated these parameters based on assessments made by individual hunters of (i) the approximate number of active hunters operating in their village. I then used the product of these 2 estimates as a measure of the extent of hunting in each of the village concerned (in man-days per month). We as well asked hunters to estimate the hunting effort (number of foray) they had to make before a large vertebrate could be bagged. The quantity was used as a measure of hunting success for large vertebrates. To asses the putative impacts of hunting on large mammal species, I correlated the hunting rate on species (% interviewees hunting it) with perceived rarity (% interviewees perceiving a decline in its numbers over the past 10 years).

It was hypothesized that people's religion, occupation and locality could influence what they eat and how often. Locality could influence people's choice mostly from the point of view of availability of bushmeat while occupation which is directly linked to the income, could influence what a person eats by the means at his/her disposal. The influence of locality and occupation on the frequency of bushmeat consumption was tested using Student t-test. The preference ranking of each wild animal species was calculated by summing up the number of respondents who mentioned it amongst the three most preferred species (**Table 5. 2. 1**). The per kilogram price of each species was calculated from the market price, or by dividing weight determined from the literature (Depierre & Vivien, 1992) and personal data by whole price. Regression test was carried out to determine the effect of prices on respondents' preferences for different species.

To calculate the monthly and annual consumption of bushmeat, respondents were asked questions on how often they consumed meat of both wild and domestic origin. The following assumptions were made in the final calculations: the percentage of respondents in each consumption group is representative of the whole region; an average household in the region is made of six people; and on average, a meal that includes meat is taken to contain 0.25 kg of meat per household. Therefore the numbers of respondents who eat meat were multiplied by the number of times they eat it per month to arrive at a monthly consumption figure. The yearly regional figures were extrapolated from this.

While religion had a smaller influence ($P < 0.001$) while locality of respondents had no significant influence on the overall frequency of meat consumption ($P = 0.19$), the Catch per unit effort (CPUE) may also be influenced by the different distribution of plant food resources among habitats (e.g., clustered fruiting vs. diffuse browse; Parry *et al*., 2007), which may influence prey movements and rates of prey encounter. The varying distribution of food resources among habitats could affect hunting methods and therefore bias CPUE estimates (Rist *et al*., 2008). To this end, and due to the importance of CPUE and the assumption that CPUE is proportional to abundance, it is important that any other factors that may influence CPUE are removed from the index through standardizing the CPUE and simulation analyses.

Table 5. 2. 1 *Frequency of consumption of meat from wild and domestic origin amongst respondents of different occupations, localities and religions*

Level	n	*Mean number of times meat is consumed per week±95% CI*
Occupation		
Civil servants	5	4.7 ± 2.2
Farmers	8	5.0 ± 3.5
NGO workers	6	6.5 ± 4.2
Mechanics	3	3.7 ± 1.4
Tailors	2	4.8 ± 1.3
Drivers	3	4.7 ± 1.4
Hunters	7	5.1 ± 2.8
Traders	9	5.0 ± 3.7
Fishermen	7	4.5 ± 3.5
Others	5	5.1 ± 2.5
Locality		
Cities	21	6.1 ± 2.9
Villages	34	4.8 ± 4.1
Religion		
Christians	23	4.7 ± 3.9
Muslims	11	4.8 ± 3.5
Sects	21	4.0 ± 2.6
Overall mean	55	4.8 ± 3.2

Fifty one percent of respondents preferred bushmeat, 42% domestic livestock, and 7% either had no preference or did not know what they preferred. There was no significant overall difference in the consumption of bushmeat between city and village people ($\chi^2 = 0.173$, df = 1, $P < 0.5$). However, for those who ate bushmeat one or more times a week (Table), villagers appeared to eat bushmeat relatively more often than people in towns ($\chi^2 = 6.443$, df = 1, $P < 0.01$). Among those who did not eat bushmeat, or who ate once a week or less frequently (**Table 5. 2. 2**), respondents of traditional religion did not differ from Christians in the frequency of meat consumption ($\chi^2 = 0.143$ and 0.121, df = 1, $P > 0.5$) but they did differ significantly from Muslim ($\chi^2 = 0.532$, df = 2, $P < 0.01$).

Table 5. 2. 2 *Weekly bushmeat consumption amongst religious groups*

	Frequency of bushmeat consumption (number of times per week)				
Religion	0 or do not eat	0.25	1	2	3
Christian	7	9	3	3	1
Muslim	4	3	2	1	1
Sect	3	10	2	4	2
Total	14	22	7	8	4

Table 5. 2. 3 *Classification of wild animals in increasing order of decline within the last ten years according to respondents (n = 55)*

Species common name	Number Of respondents	Position on preference list	Decline index based on respondents (%)
Buffalo	3	9	0.9
Cane rat	2	11	0.6
Chimpanzee	3	-	0.9
Duiker	4	7	1.2
Hippopotamus	8	8	2.3
Elephant	8	14	2.3
Francolin	3	2	0.9
Guinea fowl	4	1	1.2
Gorilla	5	-	1.4
Monkey	2	10	0.6
Porcupine	2	3	0.6
Squirrel	2	4	0.6
Pangolin	2	11	0.6
Uganda kob	4	5	1.2
Warthog	3	6	0.9

Most respondents (69.4%) said they had noticed a decline (**Table 5. 2. 3**) and even disappearance of some wild animals in their region over the last ten years and asserted that it was more difficult to get bushmeat, with price being much higher now than ten years ago before the beginning of the war. Another 16.5% said there was no difference from ten years ago and bushmeat available and price had not changed. There was a significant difference in the perception of decline in wild animals amongst localities (**Figure 5. 2. 1; Table 5. 2. 3**), with people in villages tending to perceive a decline and disappearance of wild animals species more than those in town ($\chi^2 = 3.73$, df = 1, $p < 0.01$). Both elephant and Common hippo equally topped the list amongst species cited as having declined in number over the last ten year (**Table 5. 2. 3**). It was closely followed by the Gorilla, thomas' kob and duiker. This finding is consistent with Kujirakwinja (2010) who found that Common hippopotamus and elephant were most frequently selected by poachers for the quantities of meat, the ivories and trophies which generated more money than other wildlife species.

ANOVA Table
Perceived rarity of species % vs. Hunting intensity %

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	314.234	314.234	247.278	<.0001
Residual	8	10.166	1.271		
Total	9	324.400			

Regression Coefficients
Perceived rarity of species % vs. Hunting intensity %

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	41.457	1.256	41.457	33.000	<.0001
Hunting intensity %	.413	.026	.984	15.725	<.0001

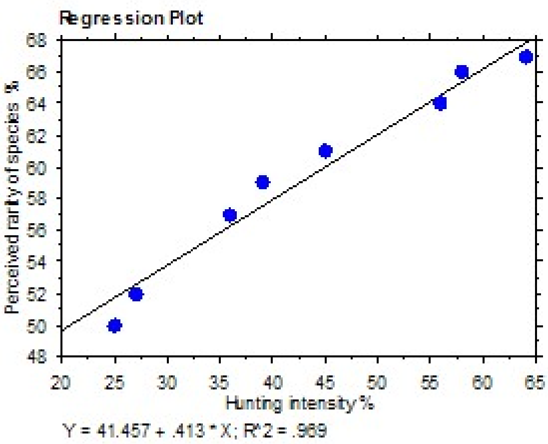


Figure 5. 2. 1 *Relationship between hunting intensity and the perceived rarity of species among interviewees in the neighborhood of the Virunga National Park (N=55).*

Surveys data clearly show that hunting was widespread in each of the villages and cities surveyed. On average, 38 hunters (± 3 hunters S.E) operated in each village, an individual offender hunting on 3.8 days (± 0.3 days S.E) per month. Taking this together, I estimated an average hunting effort of 119 hunter-days per month per village. The survey data also revealed differences in hunting intensity in the 3 villages. Hunting intensity in Kiwanja was estimated to be the highest at 156 hunter-days per month (± 24 hunter-days S.E), followed by Kyavinyonge, with 94 hunter-days per month (± 16 hunter-days S. E) and Kibati, where it was the least at 60 hunter-days per month (± 19 hunter-days S. E). Of all the interviewees 72% reported a general decline in the abundance of large mammals in the areas known to harbor main ungulates, namely in the plain south of Lake Edward. This perceived decline in wildlife population is evidenced by the single fact that the total weight of the main ungulates in the savannas south of Lake Edward (1,250 km^2) was 34,523 tons in 1959, compared with 25,567 tons in 1981 and 14,043 tons in 2006 (Languy & de Merode, 2009a). Overall, active hunters in the region themselves reported striking declines of large wildlife.

Table 5. 2. 4. *Mean weight for the most preferred wild animals expressed by respondents*

Common and scientific names	Mean weight	carcass yield
Guinea fowl (*Numidia meleagris*)	1.5	0.8
Francolin (*Francolinus* sp)	0.8	0.4
Uganda kob (*Kobus kob thomasi*)	80	41.8
Warthog (*Phacochoerus aethiopicus*)	85	44.4
Buffalo (Syncerus caffer)	700	366
Wild duck	2.0	1.0
Monkey	4	2.1
Tortoise	2.0	1.0
Pangolin (*Manis gigantea*)	40	20.9
Porcupine (*Hystrix cristata*)	15	7.8
African brush-tailed porcupine (*Atherurus africanus*)	2.5	1.3
Bush pig (*Potamochoerus larvatus*)	135	70.6
Giant forest hog (*Hylochoerus meinertzhageni*)	150	78.4
Bushbuck (*Tragelaphus scriptus*)	75	39.2
Elephant (*Loxodonta africana africana*)	5000	2615
Hippopotamus (*Hippopotamus amphibius*)	1500	784.5

Table 5. 2. 5 *Kilograms*[a] *of meat taken by local hunters in the Virunga National Park: 2004-2008*

Year	A	B	C	D	E	F	G
2004	1,322	109	2,865	2,887	[c]	209	2,112
2005	1,142	123	2, 492	1,501[b]	3,112	566	2,459
2006	303	145	1,400	1,663	4,587	267	3,776
2007	1,056	178	1, 574	3,356	4,007	434	3,456
2008	1,161	202	416	4,983	2,334	255	4,312

[a]Kilograms (kg) are calculated by using estimated carcass yields for species and sex (around 50-60 percent of live weight). For example, the carcass yield for a bull African buffalo is estimated at 366 kg, a female Uganda kob at 42 kg, and a male warthog at 53 kg.

[b]Results from partial year only

[c]No Data

The lower per kilogram prices of big games like elephant (US$0.4) and Common hippo (US$0.3), as compared to the small species like cane rat (*Thryonomys* sp) (US$0.4), could be explained by the fact that bushmeat was usually sold whole. Limited quantity of smoked bushmeat reached the market. A poss reason springs in that most of the meat was obtained illegally and the poachers had to sell it quickly to avoid arrest. Most of the big games were sold by professional hunters after collecting their trophies. If a kilogram of meat for big animals were to cost the same as for small ones, the whole price would be prohibitive. Therefore there was a market for small animals, with no equivalent market for chopped-up large animals. Yet, the Common hippo was also poached for its meat, which was sold in many villages bordering the park, as well as in some of the illegal fisheries. At the beginning of the 2000, poaching was so rife that the price of Common hippo meat did not exceed one US$ per kilo. In 2002 along the west coast of Lake Edward, a whole Common hippo would only fetch as much as $US 50.

In the second set of the questions, the survey team asked each interviewee to name species in whose abundance he perceived a decline over the last decade. I did find a significant positive relationship between the perceived rarity of a species and the rate at which it was hunted locally as shown by the equation Y = 41457 + 413x; $R^2 = 0.989$, $P < 0.001$) in **Figure 5. 2. 1**.

It is estimated that respondents ate a total of 152.3 kg of bushmeat per month compared to 302.6 kg of meat domestic livestock (**Table 5. 2. 5**). This figure is five fold high when one considers that the current bushmeat protein supply in DRC is 180 gr person^{-1} day^{-1} (Fa *et al*., 2003). Bushmeat, generally the flesh of forest mammals (Fa *et al*., 2003), but also the meat of some reptiles (snakes, crocodiles, and tortoises) and birds (hornbills, turacos), was a cheap and plentiful supply of protein in regions where often meat from domestic animals was both scant and more expensive. One key finding in this survey is that related to the massive volume of domestic livestock consumption as opposed to the bushmeat volume. There is one possible explanation. The reduced availability of domestic meat may have increased demand for bushmeat comparable to the increase in its supply during this period. Unfortunately, available data do not allow us to distinguish between the domestic and bushmeat over several periods.

Bushmeat was transported secretly and usually delivered to hunter's homes at night. Sales of live animals were also secretive- hunters and dealers sold to only the people they trusted using a password, for example "mushroom" in conversation. According to experienced hunters in the area, hunting occurred throughout the year with peaks occurring in the dry season, and during the rainy season. Peaks also occur around end of year celebrations.

Table 5. 2. 6 *Comparative monthly and annual bushmeat and domestic livestock consumption by respondents*

	Domestic livestocks			Bushmeat		
Number of times Meat consumed per week	Number of respondents	% of simple (n = 55)	Monthly (annual) Consumption by respondents (kg)	Number of respondents	% of (n = 55)	Monthly (annual) Consumption by respondents (kg)
0	12	21.8	0 (0)	14	25.5	0 (0)
0.25	20	36.4	50 (132.3)	22	40	35.3 (395.7)
1	9	16.4	20.2 (114.5)	7	12.7	21.7 (122)
2	9	16.4	22.2 (128.5)	8	14.5	33.5 (125)
≥3	5	9.0	210.2 (207.9)	4	7.3	61.8 (137.5)
Total	55	100	302.6 (299.3)	55	100	152.3 (338.8)

Hunting was common both by day (65% of hunters) and night (79%), and a variety of hunting techniques were documented from the region. Automatic weapons rather than locally crafted muzzle guns were the most popular means of hunting (91% of hunters), while 33% of hunters reported using snares to hunt ungulates. Although all hunters did not own guns, 87% of them had either borrowed or lent guns, hence contributing to sparkle poaching incidents.

Enforcement efforts hitherto did not seem at all effective in controlling hunting in the region: 34% of the hunters interviewed reported encounters with enforcement staff on hunts, 17% were apprehended, and none was ever prosecuted. Moreover, 57% of the fishermen reported deriving assistance from enforcement staff in their fishing activities. One fisherman explained, '*In my opinion, killing a few animals does not harm*'

Fishing and hunting takes a number of different forms. Hunting is a way of being with friends and gaining a reputation among fellows. It is indeed a point contact for men in the village, providing engrossing topics of conversation to fill long hours in the bar. As one interviewee pointed out: '*if it weren't for hunting we wouldn't know what to talk about'*. In addition, hunting cements wider social relationship through the distribution of meat to relatives, friends and patrons. A hunter belongs to a community of knowledge and practice; therefore he stacks up favors and boosts the strength of his social network through transactions with meat.

Illegal fishing was openly acknowledged by fishermen to be extremely widespread. Enforcement of regulation was reported to be typically so weak to the point that people readily admit to illegal fishing, even in the presence of park guards. A commercial fisherman readily admitted in a focus group, '*We all fish illegally, since we often use non-motorized dugouts in the spawning grounds using nets with prohibited mesh size*'. Another divulged that '*more money is* *made from fishing, thus illegal fishing never stops* '. Another reported that '*There are many poachers – they are endless*'.

Most experienced fishermen interviewed proclaimed they would go fishing even if no fish remained. This powerful identification with fishing extends to the lake itself, even among younger fishermen who said:' *our life is the lake*'. This idealization of fishing helps to justify the hard work it entails against the current slender contribution of fishing to household income and demonstrates that fishing is something which integrates people and nature. In addition to the ritualized connection to nature that both activities signify, there are important social dimensions. In fact, with very few exceptions, only men hunt and fish, and these activities represent valuable mean of transmitting masculine values between generations in the face of considerable social change and upheaval.

From the socioeconomic surveys, there was a general agreement, among respondents, that the ever growing human population in both the legal and illegal fishing enclave villages is the major factor responsible for the demise of the fishery (Crivelli *et al*., 1995) not to mention the related over-exploitation of wildlife population. The view was widely held that the main hunting areas uplands next to the lake where the most common quarry were Common hippo, African buffalo, along with game birds geese, pheasant (*Phasianus colchicus*) and wood pigeon.

Discovering the identity of the 'bad' poachers is a game of distorting mirrors, but all informants acknowledged that poachers were largely drawn from the ranks of local people (de Merode *et al*., 2007; Robinson *et al*., 2010), and most people claimed to know who they are, albeit secretly. Most commercial fishermen stressed that poachers were all amateur fishermen.

5. 2. 1 Enforcement Economics Case study: Illegal Fishing in Virunga National Park

- *Environmental violation analysis*: Illegal fishing with prohibited nets (with too small a mesh).
- *Scale of crime*: Illegal fishing by local community and fishermen in the Lake Edward
- *Administrative or Judicial*: Judicial
- *Components of the enforcement*: Detection, arrest, filing, prosecution, and penalty

The illegal expansion of fishing activity goes back to the beginning of the 1990s and it began at the patrol posts. The ICCN ability to administer the VNP was inadequate few months before the war, but was further weakened by the conflict. The economic crisis, coupled with the ICCN decreasing ability to intervene and the starvation wages received by park staff, rendered law enforcement very difficult, creating an evident incentives to allow fishing activity for direct or indirect revenues. This basically led to an increase in the number of dugouts operating from patrol posts as well as the burgeoning illegal fishing villages (**Figure 4.7.4.7 & Table 4.7.4.1**).

In principle, on the basis of a thorough scientific study commissioned by the government and funded by the European Commissions, fishing quota of 700 dugouts was fixed along the Congolese shore of Lake Edward and distributed as follows: Vitshumbi fishery 400 dugouts; Kyavinyonge 213 dugouts and Nyakakoma 87 dugouts (Kasonia & Mushenzi, 2009). Illegal fishing was openly acknowledged by fishermen to be extremely widespread. Enforcement of regulation was reported to be typically so weak to the point that people readily admit to illegal fishing, even in the presence of park guards. A commercial fisherman readily admitted in a focus group, '*We all fish illegally, since we often use non-motorized dugouts in the spawning grounds using nets with prohibited mesh size*'. Another divulged that '*more money is made from fishing, thus illegal fishing never stops* '. Another reported that '*There are many poachers – they are endless*'

Most experienced fishermen interviewed proclaimed they would go fishing even if no fish remained. This powerful identification with fishing extends to the lake itself, even among younger fishermen who said:' *our life is the lake*'. This idealization of fishing helps to justify the hard work it entails against the current slender contribution of fishing to household income and demonstrates that fishing is something which integrates people and nature. In addition, some guards were themselves widely known to be poachers. As one retired fisherman put it, '*When the wardens themselves go into the lake in broad daylight and catch fish illegally, what more is there to say*? This situation has prompted confusion amongst fishermen as to the whereabouts of paying the fishing tax on the Lake.

The fundamental questions for issues of law enforcement were posed by Becker (1968) who, recognizing that enforcement is costly, asked 'how many offences should be permitted and how many offenders should go unpunished'. Becker concluded that the greater the expected penalty, the greater the deterrent effect on crime. After due consideration, I found out that large fines can encourage socially wasteful avoidance activities that reduce the probability of an individual being caught and fined. Finally, when there is scope for bribes, higher official fines may simply result in greater scope for bribe taking (Mookherjee & Png, 1995). For a number of reasons, from that prospect, more recent theory predicts that the optimal level of enforcement is likely to require a relatively high probability of detection and a relatively low fine.

Table 5. 2. 1. 1 *Economic Disincentive: Case study of the Virunga National Park*

Probability		Value	Cumulative Probability
Of Detection given illegal fishing	P_d	0.03	
Of arrest given detection	$P_{a/d}$	0.001	0.0009
Of filing given arrest			0.0006
Of prosecution given filing	$P_{p/a}$	0.56	0.0002
Of conviction given prosecution	$P_{c/p}$	0.19	0.0001
Average value of penalty		$50	
Average time elapsed (days)	T	15	
Enforcement disincentive	ED	$5	
Profits to illegal fishing		$95	

The cumulative probability of fisherman being convicted of illegal fishing activity was very low 0.0002 (**Table 5. 2. 1. 1**). In the case of the Lake Edward, the fact that no assumption was made about the probability of detection makes this cumulative more realistic. The very low probability of arrest upon detection is giving cause of concern not only because it is low 0.0009 (**Table 5. 2. 1. 1**) but also because corruption system appears to be embedded in this low probability. The greatest problem of enforcement during wartime is the failure to prosecute offences; although park wardens are officially appointed as auxiliary police officers and have the same powers as the police, except that they are not usually authorized to make arrest for more than 48 hours, they experienced difficulty to carry out their own mandate. In additon public prosecutors were in most cases less interested to provide support, unless the offence was very serious and involved large valuable wildlife specimens and widely publicized. In fact, many detection records indicated on several times strong evidence of a team of violators had been caught at the lake and the products and equipment seized as dictated by the Wildlife Act 69-041 under article 10 but the violators were often released following military interaction and/or park official involvement. In addition to fines or imprisonment commonly used to deter illegal exploitation of wildlife in Africa (IUCN, 1986), the legislation provides for the confiscation of specimens which have been taken, held or traded illegally. Confiscation is also ordered in respect of the vehicles, dugouts, equipments and weapons used in the offence. Qualitative data show that the filing process was so rife with issues that filing generally did not happen within the time frame prescribed by law. The value of this example is that it suggests that in some instances, when enforcement is poor and there is little support for fixing it, it may be useful to explore the viability of alternative systems. The question then is whether the policy of stiffer sentences will work.

Toward this end, fines proved arguably a better form of penalty than prison sentences since they act as 'tax' on illegal activity and as a direct transfer payment from offender to victim, in this case the state, which has lost a valuable animal (Becker, 1968). However, very high fines are unlikely to be paid. A disadvantage of a very high penalty is that although it may lower the overall level of crime, the level of serious crime may increase (Stigler, 1970). Local poachers may move to serious crime if punishment is unselective. The implication of the failure to control poaching with the death penalty is that the stiffer possible penalty is not in itself an effective deterrent to poaching in PAs. I therefore suggest that wildlife authorities should not simply press for more severe penalties but instead put their primary emphasis on improving their detection rates to levels that deter poachers, with secondary emphasis on achieving more severe penalties for those involved in serious crimes. Severe penalties in law may be unhelpful if detection rates remain low and/or if the judiciary does not pass the mandatory sentence (Leader-Williams *et al*., 1990).

5. 2. 2 *Managers' Perceptions of Threats to the park: Assessment of Threats Vulnerability for Effective Management*

I assessed the relative severity of threats to the two PAs using the perceptions of PA officers. Twenty five officers from each park were interviewed in person, including the park wardens, senior rangers and research scientists in the KBNP. These officers had all served continuously for more than 5 years. Interviews were conducted over 3 months in 2007 and 2008, following a preliminary study (Okello & Kiringe, 2004). In the present case study, I requested the interviewees to score independently of each other, the relative severity of each threat, on a scale of 1-5 (1, no threat; 2, mild threat; 3, moderate threat; 4, high threat; 5, severe threat) to the PA they served. The interviewees only scored the level of severity of threat factors associated with their own PA. On the contrary, when dealing with the VNP; I used comprehensive results a workshop conducted in 2005. In early 2005, ICCN and its NGOs partners came together to develop a comprehensive monitoring plan for the park. The logical process involved, (i) identifying targets (species and ecological processes) to protect within VNP, (ii) identifying threats to these targets, and (iii) classifying threats based on the method proposed by Margoluis and Salafsky (2001) by defining five areas affected by the threat, the intensity of threat, and the urgency with which the threat needs to be addressed (Plumptre *et al*., 2009).

I then calculated three indicators of the level of threat and the vulnerability of PAs to these threats, including: mean score of each threat = sum of all the scores for a threat/the total number of respondents

Table 5. 2. 1 *The 16 main threats to the two PAs as perceived opinion of PA managers with the activity and causes associated with each threat in Virunga National Park*

Threat factors	Threat activities	Causes of identified threats
Human encroachment	Increasing human settlement & associated infrastructure in the vicinity of the park, illegal grazing of livestock	Increasing human population and diminishing land resources
Illegal construction	Increasing human settlements & associated infrastructures	Increased human population, diminishing land resources
Poaching of large mammals	Killing of wildlife, especially large mammals (Gorilla, Elephant, Hippopotamus, African buffalo, etc)	Insufficient resources for enhancing wildlife security, trade in wildlife trophies & products, poor monitoring & enforcement
Over-fishing	Illegal exploitation of the Lake Edward	Increased human population, reduction in fish reproduction, fishing in spawning grounds, fishing with net mesh
Charcoal production	Exploitation of large quantities and trade	Diminishing land resources & alternative source of income
Insecurity caused by the presence of militia	Inaccessibility of portion of the park	Poor monitoring & law enforcement
Fuelwood collection	Illegal exploitation of firewood, wood carving, medicinal plants thatching, construction material	Increased human population & diminishing land resources, poor rural populace that is dependent on natural resources
Bush fires caused by man	Wild fire set indiscriminately to attract animal	Poor enforcement of park rules
Disease introduced by men	Wildlife prone to human induced disease	Poor veterinary coverage (intervention limited to gorilla sectors)
Livestock in the park	Expansion of agricultural and pastoralist activities in wildlife home range	Increased human population & diminishing land resources
Poaching of infant gorillas	Killing of adult Gorilla	Insufficient resources for enhancing wildlife security, trade in wildlife trophies & products, poor monitoring & enforcement
Illegal logging	Illegal exploitation of the forest, timber, construction material	Insufficient resources for enhancing protection effort, trade in timber products, poor monitoring & enforcement
Military camps involved in illegal activities	Armed poaching	Poor enforcement of park rules by government, political instability
Illegal bamboo harvesting	Illegal extraction of bamboo	Increased human population & diminishing land resource, and alternative source of income
Poaching of wildlife outside the park	Killing of wildlife	Insufficient resources for enhancing wildlife security, ICCN mandate limited to *in situ* conservation
Illegal water collection from within the park	Illegal exploitation of park resource	Conservation model that excludes natural resource use

The impact of armed groups and military camps was combined into a single category while volcanic eruptions, climate change and pollution which were identified by participants were examined through a research exercise rather than a monitoring program.

The VNP faced 16 major threats with a range of relative severity of 0.81-0.14 (**Table 5. 2. 2**), The threats with the highest relative severity, from higher to lower with human encroachment (81%), illegal construction (67%), poaching (70%), illegal fishing (59%) and charcoal exploitation (58%) holding the highest relative severity. There was a positive and significant correlation between the relative vulnerability of PA and human encroachment (r = 0.46, $P < 0.011$), charcoal production (r = 0.65, $P < 0.001$), and snaring (r = 0. 45, $P < 0.001$). This results confirm that socioeconomic surveys is an important factor to consider when predicting rates of anthropogenic biodiversity loss within PAs network.

Table 5. 2. 2 *The mean score and relative severity threat factors, as assesses by collected data in the PA management unit, ranked from high to low relative severity*

Threat	Mean Score ± SE	Relative Severity
Human encroachment	4.21 ± 0.23	0.81
Illegal construction	3.07 ± 0.13	0.67
Poaching	3.53 ± 0.70	0.64
Illegal fishing	2.52 ± 0.96	0.59
Charcoal	2.27 ± 0.08	0.58
Military camps	1.87 ± 0.22	0.38
Fuel wood	1.73 ± 0.16	0.37
Bush fires	1.61± 0.19	0.33
Disease introduced by men	1.56± 0.17	0.30
Livestock in the park	1.44± 0.19	0.29
Poaching of infant gorilla	1.43± 0.15	0.27
Illegal logging	1.41± 0.21	0.25
Illegal bamboo harvesting	1.39± 0.18	0.19
Poaching wildlife outside park	1.35± 0.11	0.17
Illegal water collection	1.29± 0.13	0.14

In VNP, agriculture is often a marginally productive use of land, but state owernship of wildlife effectively precludes local people from opting for wildlife as a land use. The accumulation of the costs of living with wildlife and the capture of wildlife's economic benefits elsewhere create local disincentives to conserve wildlife (Emerton, 2001). Hence there is a pressing need for documenting the operational payments for ecosystem services as a strategy for developing economic incentives for biodiversity conservation.

CHAPTER 6

CONCLUDING DISCUSSION

In Genesis, God blesses human beings and bids us to take dominion over the fish in the sea, the birds in the air, and every other living thing. We are entreated to be fruitful and multiply, to fill the earth, and subdue it (Gen. 1:28). The bad news, and the good news, is that we have almost succeeded.

-Sanderson *et al***., 2002 -**

6. 1 Summary of Lessons Learnt and Key Findings

This study was undertaken to assess the impact of the escalating poaching and the increasing local human population on large mammals within the VNP and KBNP. Throughout the study, I have shown that law enforcement being one of the major branches of wildlife management can be effective in deterring wildlife offenders and in reducing both subsistence and commercial poaching, if conducted systematically. One of the key findings to effective law enforcement monitoring system described here as the RBM is that it allows wildlife managers to run law enforcement operations efficiently and cost-effectively, even in times of uncertainty, providing up-to-date information on which to make informed decisions for a conservation area. Law enforcement in VNP and KBNP shows that the abundance of large mammal species is unlikely to fluctuate in a synchronus pattern across all habitats and areas in which they occur (Brashares *et al*., 2001). These sites are in fairly fertile areas with relatively dense populations. Habitat destruction, overharvesting, and illegal use of resources are indicators of biodiversity loss while the root cause of biodiversity loss have to do with poverty, land tenure, population changes and national policy failures. Besides reliable data from anti-poaching units, cost-effective data collection of bushmeat consumption can provide a viable alternative to assess levels of poaching involvement of villages that border PAs.

This dissertation has analysed the biological, social, and economic outcomes of conservation management. Research questions are dealt with and interesting avenues for further future work is outlined to improve conservation management within both studied sites. Basically, this chapter summarises the main research findings to reflect on my contributions.

6. 1. 1 Methodological Approach

I employed a scientific methodology that used broad scale data sets, such as remotely sensed images, to site fine-scale data sets, such as extensive law enforcement field observations compiled over a five year period and socio-economic surveys. As such I leveraged more extensive but less costly information to more advantageously position finer-detailed but costlier information. It is interesting to note that predicting species occurrence using a modelling approach based on a state-of-the art GIS technology represents a new methodological tool which can be used to endorse conservation policies, on condition that models are validated for reliability as the case was in this thesis.

The study illustrated the potential of GIS and RS to provide useful information for wildlife management. Faced with the anthropogenic threats that both the VNP and KBNP are subjected to as a result of demographics and geopolitics, the remarkable opportunities offered by geomatics (GPS, GIS and RS) represent a real asset for improving monitoring of the park. As stressed by Leyens *et al*. (2009), not only do these technical tools provide necessary objectivity for development of a rational policy, but they also enable monitoring in sensitive remote areas where an approach on the ground involves high risk. The documented cases of the demarcation of park boundaries with GPS devices involving park staff and local population proved that geomatics tools provide a solid base on which to develop a participatory approach. It further reveals and confirms the crucial need to pay sufficient attention to issues of utilization of RS and GIS in actual national parks agency in addition to issues related to implementation given the fact that to be effective, however, management has to be science-based (Gordon *et al*., 2004).

As seen through previous chapter two, conducting wildlife crime hotspot analysis depends on several factors, varying from theory selection, to type of illegal activity being analyzed to the display of output results. The hotspot analysis must have a logical and systematic approach. Analysts should use statistical tools in conjunction with human understanding of an area to give the analysis a solid foundation for starting where threats hotspots actually are occurring. They must scientifically determine that a hotspot is indeed an actual cluster of events that are not occurring at random. Hotspot analysis typically answers the question, ‘where is the best illegal activity location?’ Spatial kriging-based interpolation is used to take known values and interpolate them into a surface, deriving new estimated spatially continuous phenomena. Places have unique characteristics that affect the distribution of illegal resource use over space (e.g., spatial processes) and temporal distributions. This leads to a premise that has long been championed in geography-place matters (Gesler & Albert, 2000).

An important feature of the monitoring system is the relationship between illegal activity encountered on patrol and law enforcement effort was expressed in terms of CPUE. The monitoring system and more specifically the resulting CPUE indices of the different types of illegal activity can be used as an adaptive management tool provided improvement of factors which may changes the CPUE relationship is. What really matters for management-oriented LEM is that methods used are very simple, cost-effective and possible to sustain with limited external support and that the time from data collection to management action can be shortened.

Why is it that wildlife researchers struggle to manage the environment and to preserve wildlife using GIS? The answer is twofold: to improve our livelihoods and to limit degradation of the environment, mainly for aesthetic and economic reasons (Murphree, 1991). Indeed, mapping and analysis of spatial patterns of criminal behavior is gaining acceptance in the law enforcement community due to the increasing availability of GIS software capable of quickly analyzing large amounts of data to derive patterns that can be used to guide enforcement activities (Block, 1993; Young *et al*., 2003). Its use to biologists has predominately been restricted to modelling a species' distribution and potential habitat suitability (Khaemba & Stein, 2000) and for selecting and designing PAs (Smith *et al*., 1997). However, the use of GIS can be used to identify areas most at risk from poaching and enable activities to be concentrated in these areas. From an ecological and livelihoods perspective, it might be best to protect a smaller area of forest more effectively than a larger area less effectively (Albers, 2010).

In the final analysis, LEM can provide insight in the relative abundance and distribution of illegal activities, provided that the data is accurately collected in a way that allows analysis using reliable methods. Spatial analyses built upon continuous law enforcement monitoring data with emphasis on anthropogenic threats help wildlife managers to determine priority areas for patrolling and thus, optimize the use of resources given the fact that close proximity of people and wildlife makes poaching relatively easy and commonplace (Knapp *et al.*, 2010). In closing, the methodological framework outlined in this thesis has significant potential for aiding policy makers and local law enforcement managers in objectively identifying poaching offender clusters, which is an important step in developing a more fair and balanced approach to poaching offender policy in DR Congo national parks network.

This dissertation has shown that the long-term monitoring of key biological resources within PAs is central to maintaining the biotic integrity and the historic and social value of those conservation areas. Monitoring requires periodic data acquisition using well documented and repeatable methods for consistent and comparable assessments. Thus, the methods must be flexible and able to address multiple objectives across broad spatial and temporal scales (Townsend *et al*., 2009). Furthermore, monitoring methods need to be cheap, systematic, repeatable and verifiable; the relevant set of condition metrics should be frequently recorded, available over a long time-frame, comparable between PAs and offer a short response time that allows for the early detection of changes, thus suggesting that the need for an interdisciplinary approach to science is obvious and perhaps most pertinent in the field of conservation and sustainable development. Yet as elsewhere in DRC, effective monitoring of the two world heritage sites involves several technical and financial challenges.

6. 1. 2 Management and Conservation policy implications

6. 1. 2. 1 Institutional framework

Conservation objectives phrased in terms of a species or a habitat imply the existence of one or more threats that adversely affect species numbers and habitat and the need to take action to combat those threats. The latter are basically land-use practices and policies that have direct or indirect effects on both the species and habitats that are being protected. In this section, I seek to advance knowledge about wildlife crime places in terms of theory, empirical study, and practical application and research methods. The contributions that are included provide insight not only how illegal activity and place interact, but also as to how such knowledge may be translated into concrete crime prevention efforts.

The objective of law makers is to make prescriptions that regulate human activity for the 'greater good'. However, law makers have to reconcile a wide variety of interests and their vision of the 'greater good' may well not coincide with everyone's view of their own personal good, which give rises to the well-known general rule that laws are made to be broken. Nevertheless, those who have made laws, and who believe they have 'right' on their will wish to see that the law is enforced, that attempts to break the law are kept to minimum and that the law achieves its particular objectives (Leader-Williams, 1996). Given that monitoring consists of keeping track of the components of a system, specifically to assess their progress in relation to the objectives set for the system (Bell, 1983), it is as valid to give priority to monitoring the enforcement of those aspects of the law that relate to major management problems faced by wildlife managers (Bell, 1984c). To this end, monitoring is the prerequisite of law enforcement.

In many cases, the root cause of biodiversity loss and threats to PAs can be traced to government policies or their application (Brandon *et al*., 1998). Policy challenges to PAs are further compounded by a general lack of political commitment to conservation, reflected in the weakness of the national parks authority and the lack of adequate financing for park management. This weakness makes it difficult for park managers to challenge other government agency over actions and regional development plans that may affect PAs. Political upheaval, decentralization and the breakdown of law and order exacerbates the problem, e.g., in KBNP where illegal mining occurred as local people and special interest groups seized the opportunity to grab land and resources (EIA, 1999). Although the Country is a Party to a number of international conventions, it generally lacks the required resources to effectively implement them within PAs. The country has many environmental laws, policies, guidelines, and management plans on the books, but little implementation or enforcement of any of them. PAs often are mired in a surfeit of under trained, needy staff and immobilized by a myriad of knots tying it to the national political morass (Hart & Hall., 1996). More work needs to be done to build human and technical capacity to enforce the fisheries, wildlife, and wetlands regulations that come into play at both the local and national levels.

Effective enforcement is undermined by unclear legislation and the fact that practice in the field is disconnected from the policies designed in Kinshasa (where ICCN headquarters is located). Human encroachment of the park by the population is mostly caused by the ambiguity of the legislation concerning the PAs (IZCN-DG, 1991) and poor incentive mechanism for local people having important assets in the park. Simplicity of language is a desirable feature of wildlife legislation; it should be comprehensible and provide a source of reference, not only for lawyers and courts but also for members of the managing agency who implement the laws. As Conrad (1947) put it, “Law should be written with more emphasis on making readers understand what the law commands and with less emphasis on controlling the judges by rigid grammatical constructions.” The policy framework should provide the foundation and guiding principles on which national legislation is to be prepared. The changes and challenges outlined earlier caution against prescriptive laws which attempt to be universally applicable at all times and in all places. Rather the laws should aim to enact overarching goals and principles unequivocally, while allowing sufficient flexibility in their detailed interpretation and application to conserve biological diversity in the face of the rapid social, economic, and scientific changes underway in these PAs. In essence, this implies removing most of the existing legal limitations to sustainable use of wildlife and replacing them with fewer and more flexible instruments. The overarching goals and principles should, in as far as possible, provide the legal umbrella under which the procedures for determining and changing of local regulations are devolved to ICCN and other mandated conservation agencies, without recourse to parliamentary legislation.

In the long run, endangered species legislation on its own cannot deal with all known anthropogenic challenges. History has proven this point time and time again. On-the-ground complementary actions are needed to back up legislation. Of course, even strong laws cannot be effectively enforced when internal enforcement agency policies do not support good performance, especially when applying more sticks rather than stick /carrots approach to ensure the implementation of environmental legislation. On the whole, the morale is that legislation is only effective if it is an adequate expression of popular will; legislation that corresponds adequately with that collective will is practical, enforceable and viable in the long-term.

The legitimacy of the new approach of nature conservation legislation to the exercise of the State's police powers is no longer linked to safeguarding certain resources and activities, but is instead derived from the increasing recognized need to preserve species and biological diversity for their intrinsic value and for the use of future generation (de Klemm & Shine, 1993). PAs policy, law and administration are important inter-connected aspects affecting the successful long-term management of PA (MacKinnon *et al.,* 1989). The basis for responsive legislation and administrative authority for PAs should lie in national policy on resource conservation and development. In this regard, legislative mechanisms must be consistent with PAs policy and specially turned to the specific program needs in administration, management and enforcement.

Because prevention is better than cure, some countries are recognizing the possibility of using PAs for biodiversity along their borders as ways of promoting peace through "Peace Parks" (Hanks, 1998; Sandwith *et al.*, 2001; Plumptre *et al.*, 2007), this is the moment to improve policy formulation, design new legislation (Decree N° 10/15 dated on 10 April 2010 on the status of ICCN as public institution has just been issued while the Wildlife conservation Act is still under consideration at the parliament level. This process is being pursued by MECNT, that has prepared a bill and currently pending enactment into law. Overall, legislation must be based on policy, the ideal being to produce simple, unambiguous legislation that accurately reflects policy and is capable of being put into practices.

6. 1. 2. 2 The Effects of Conflict on Wildlife Protection

The period covered by this thesis is probably one of the most tragic chapters in the recent history of the DRC. Indeed, this decade was marked by a string of major political crises, wars and the multiple ethnic and regional conflicts that brought about the deaths of thousands, if not millions, of people. Like most other societal challenges, conserving natural resources during wartime is complex and case-specific as the economy faltered. Biodiversity can suffer from the general breakdown in law and structure. In line with the military presence in the park, two key factors helped to start re-establishing the park's authority: effective lobbying and the ability to demonstrate ICCN's capacity to fulfill a security function in lieu of the military. However, the most significant work still lies ahead. The largest military camps still exist with some of them being based at ICCN headquarters and posing a major obstacle to the re-establishment of ICCN's authority. As things stand right now, further step in reconsidering the ICCN under the Head of State office would increase political government willing to resolve the military involvement in large-scale wildlife poaching. The case study has shown that it is possible to use international conventions, in particular the WHC, as a tool to leverage this political support.

Two clear and important policy implications may be emphasized here. First, conservation organizations, rather than working only in stable ecosystems, must develop programs in war-torn regions if they are to be effective in conserving global biodiversity. Second, the long-term sustainability of conservation efforts depends on the social and political context within which they take place (Hanson *et al.*, 2008). Potential planning strategies include the development of contingencies to support national institutions and local PA staff throughout conflicts; collaboration with military professionals to reduce the effects of warfare; natural resource management training for soldiers, humanitarian workers, and peacekeeping forces; promotion of conservation and suitable use of natural resources in postwar recovery policies, including creation of peace parks along disputed borders and strengthened enforcement of international conventions governing war-related environmental damage. To that end, Van der Linde *et al.* (2001) has pointed out that besides of being the first national park created in Africa, VNP is *de facto* the first transfrontier PA well suited in the establishment of Peace Park in the great lake region (Kalpers, 2005).

The experience in VNP and KBNP has highlighted that the ecological consequences of war are based on a multitude of factors occurring in succession: at one level, conflict is associated with immeasurable levels of human suffering during which time conservation concerns cannot be prioritized. Bleak as this picture for the eastern country region, all the negative variables mentioned above – under staffing, poor pay and conditions, inadequate budgets and scarcity of equipment – are the common experience of wildlife department through the Congolese PAs network. Wildlife authorities were not immune to the predicament, which was compounded by the curtailment of existing structures of external support during the conflict. Although project field staff maintained regular valuable supplies to ICCN staff throughout the war, this was of little help in maintaining activities, particularly when the national park headquarters were systematically looted. The sharp decrease in patrol days during this period is self evident.

Conservationists and field scientists have described the challenges of preserving biodiversity in the chaotic landscape (Hart & Hart, 1997; Kalpers, 2001; Daudley *et al*., 2002; Hart & Hart, 2003; Plumptre *et al.*, 2007). These authors agree on two primary themes, the importance of maintaining continuous support for PAs throughout the conflict period and the importance of training and supporting well-trained national staff-especially when expatriate conservationists are forced to leave and communication with the park headquarters is cut. In DRC, national-level conservation funding evaporated as government control weakened and the major international development programs withdrew their support (UNESCO, 2000; Kalpers, 2001; Hart & Hart, 2003; Kalpers, 2003; Kalpers, 2005; Plumptre *et al*., 2007). The IGCP, the Dian Fossey Gorilla Fund International, WWF and WCS, however, had better flexibility to maintain contact with individual PAs. Notwitthstanding national and expatriate seniors were targets for persecution and were forced to evacuate, junior wardens and rangers did not sit back but rather undertook efforts to continue patrols and monitor human activities in accessible areas.

The eastern part of the DRC has suffered political anarchy and conflict since 1996. The wars have exacerbated the threats because PA staff have not been able to patrol effectively given the dangers involved, and with the breakdown in law and order local people have engaged in illegal activities with immunity (Pearce, 1994; Hart &Hall, 1996; Plumptre, 1997; Werikhe *et al*., 1998). As a result of years of civil war and insecurity, management of PAs was largely reduced to anti-poaching and policing measures. The impact of the civil strife has been spatially heterogeneous in the PAs network and has been imposed on pattern of wildlife distribution that is likely affected by a heterogeneous landscape of human occupation and habitat. A growing amount of anecdotal evidence suggests that habitat destruction and accompanying loss of wildlife are among the most common and far-reaching impacts of conflict on the environment, and occur for subsistence, strategic, or commercial reasons (Kalpers, 2001). Uncontrolled flow of automatic weapons and ammunitions induced by armed conflicts in different areas still remains a further threat to most of large mammals. The magnitude of the threats to biodiversity, coupled with the limited financial, technical, and physical resources available for biodiversity conservation, requires careful prioritization of our efforts (Sacha, 2002). Furthermore, there's a real need to transform wildlife observation techniques into real-time warning systems, if we are likely to prevent further biodiversity depletion in these parks.

The immediate symptoms of war, such as the widespread availability of automatic weapons and the increased demand for bushmeat, do not explain fully the collapse of effective wildlife protection regimes. The reduction in international support received by the institution responsible for maintaining effective wildlife protection (ICCN) seems to be of greater importance. Mubalama & Bashige (2006) describe a decrease of over 50% of anti-poaching resources to KBNP. This resulted largely from the confiscation and looting of equipment, but is also explained by the difficulties experienced by external donor agencies in maintaining support for anti-poaching as a result of the conflict. A new word has been added to the vocabulary: "ecocide", the destruction of the environment for military purposes, clearly deriving from the scorched earth approach of earlier times (McNeely, 2003). The use of armed force to acquire and control valuable resources was the fundamental cause of DRC's war. In contempt of a unified transition government was established when hostilities ended in 2003, these 2 parks remain under siege. Armed gangs, renegade militias, and pockets of recalcitrant rebels continue to use some sites within the park as bases and strategic outposts.

To curb wildlife trafficking, I urge urgent cooperation and coordination between national CITES authorities and wildlife law enforcement agencies, including customs. Indeed, lack of political support to improve coordination of wildlife-enforcement remains a persistent problem. This problem can be dealt with through the Lusaka Agreement Tusk Force (LATF), yet only Uganda among the three transboundary countries (DRC-Rwanda-Uganda) has so far ratified it. Thus, I recommend that the two other countries ratify the LATF (An inter-government Agreement on co-operative enforcement operations directed at illegal trade in wild fauna and flora in the Eastern and Southern Africa countries which entered into force on 10th December 1996 to improve coordination of law enforcement and cross border wildlife crime between the three countries). The task force has had some success in intercepting illegal wildlife transactions. In fulfilling its objectives, LATF has acquired ivory detectors to be used in tracking and detecting concealed elephant ivory between the three countries (LATF, 2004). It suffers, however, from law participation. At the First Meeting of the Regional Inter-Ministerial Committee (RIMC), in Kigali on 17-18 February 2005, the DRC and other RIMC members agreed that the proliferation and circulation of illicit small arms and light weapons, including antipersonnel mines, is a priority for peace and security (RIMC, 2005). Other subregional conservation efforts involve the Southern African Community (SADC) Protocol on Wildlife Conservation and Law Enforcement was established on August 18, 1999. The latter entered into force in 2003 and has a wider aspiration than the Lusaka agreement because of it deals with the harmonization of national legal instruments, enforcement of wildlife laws, the building of national and regional capacity, the establishment of transfrontier conservation areas, and the facilitation of community-based natural resources management (Louka, 2006).

Continuing allegations concerning the complicity and collusion of military and customs authorities in the illicit trade in ivory remain cause for great concern and must be addressed in a serious manner. In this regard: government should mandate an independent Commission of Inquiry and launch a formal investigation; and the results of the investigations should become a matter of public record and any guilty parties dealt with in a legally appropriate manner, including imprisonment, suspension or termination of employment. A detailed investigation of the causes of spiraling war in biodiversity hotspots is beyond the scope and purpose of this thesis but it remains a high priority for future research in biodiversity conservation. This stage was not concerned with pursuing in-depth investigations or gathering evidence of sufficient admissibility to stand in court, but rather with 'providing the basis for the formulation of initial hypotheses of investigation by giving a sense of the scale of violations, detecting patterns and identifying potential leads or sources of evidence (OHCHR, 2008). Consequently, with regard to wildlife international law violations, the mapping exercise provides a description of the violations and their location in time and space, the nature of the violations, the victims and their approximate number and the –often armed- groups to which the perpetrators belonged.

Unlike some commissions of inquiry with a specific mandate to identify the perpetrators of violations and make them accountable for their actions, the objectives of the mapping exercise was not to establish or to try establish individual criminal responsibility or given actors, but rather to expose in a transparent way the seriousness of the violations committed, with the aim of encouraging an approach aimed at breaking the cycle of impunity and contributing to this. Mapping wildlife crime remains a preliminary exercise leading to the formulation of transitional justice mechanisms, whether they be judicial or not. It represents a fundamental step in enabling the identification of challenges, the assessment of needs and better targeting of interventions. Hence, to assist the new government with the tools to manage post-conflict processes.The dissertation did, however, identify the armed groups to which the alleged perpetrators belonged, since it was essential to identify the groups involved in order to qualify the crimes legally. Consequently, information on the identity of the alleged perpetrators of some of the wildlife crimes listed does not appear in this dissertation but is held in the confidential project database submitted on regular basis by site wildlife managers to the ICCN Headquarters.

6. 1. 2. 3 Understanding Poaching Hotspots Approach and Compliance in Conservation

The term poaching hotspot is applied in this study to a geographical area that ranks particularly high on one or more axes of occurrence, numbers and intensity level of threats. At more finer-grained geographic scales, which tend to be the scale at which conservation and development decisions are made, the application of WCH analysis is more challenging. On the one hand, just as important, the choice of method for defining a poaching hotspot-whether it is based on threats, species endemism, richness or a combination of these factors – significantly influences which regions or park management unit are identified as conservation priorities. In addition, site selection algorithms based on identifying poaching hotspot tend to be the least efficient in maximizing the protection of species diversity. This is because WCH do not often include relatively rare threats – WCH are ranked highest for threat level often contain overlapping sets of common threats, while failing to capture rarer threats. The failure of WCH to capture rare threat is scale dependent. In fact, as the size of the sample group unit increases, an increasing number of rare threats will be found in WCH because the sample unit will 'need' rare threats to be considered unusually common threats.

A drawback in this study is that influence of the past on species distribution was largely ignored. One of the most important lessons that I draw from this thesis is that extent of the biodiversity illegal use is often highly localized. In defiance of high profile poaching events do not always correspond across an area, a substantial fraction of threats can be found in very small areas still. This is not to say that these hotspots are sufficiently large to contain all site-threats found in them, but it does re-affirm the emphasis that conservation strategies should place on them, thus allowing park managers to direct law enforcement to wildlife crime hotspots, and potentially stop illegal use before the wildlife is actually killed or to thwart ivory trade before it enters into an increasingly complex web of international wildlife criminal activity (Wasser *et al*., 2008).

Regardless of the utility of a poaching hotspot approach to setting conservation priorities areas at relatively coarse spatial scales; a hotspot analysis can be used at finer scales, particularly if used in combination with other analytical methods as it was done in this study. Any monitoring of the success of law enforcement activities should be undertaken bearing two basic pre-requisites in mind. First, it is necessary to make all records of law enforcement activity in standard categories. On foot patrols, these categories could include encounters with illegal entrants and hunters, sightings of live animals, foot prints and other signs of offenders, finds of carcasses, numbers of illegal hunters captured or seizures of illegal trophies in terms of numbers and weight. From this prospect, there is need to harmonize data collection using the VNP law enforcement patrol form (**Annex 9**) as well as the Management Information System (MIST) program for analysis purposes. Second, it is vital to measure all standardized categories against a measure of law enforcement effort (Bell, 1984 a). Only data which can be processed into information which is relevant and for managers and planners are collected, stored and processed in MIST (Schmitt & Sallee, 2002). When these two basic principles are followed, it is possible to derive an index of CPUE as better described in chapter 2. Such an index is an infinitely more valuable measure of the success of law enforcement activity than measures of categories lacking measures of effort.

6. 1. 2. 4 Anti-poaching Enforcement Effort in the Rough: Towards the Need for Putting Teeth in the Wildlife Act

On the basis of the analysis of CPUE indices by grid square in both PAs, I conclude that there is little evidence for the effectiveness of wildlife protection laws aimed at preventing the exploitation of large mammals through deterrence at the levels of patrolling effort currently in use, except in squares with regular trails around the patrol posts. As a matter of fact, with increased human interferences on wildlife and their habitats, most large mammals have restricted their ranges around patrol posts and limited movement into areas accessed by par staff (Verschuren, 1993; Kujirakwinja, 2010). This pattern indicates that the spatial and temporal dynamics of large mammal populations in the park can be explained by the intensity of law enforcement.

In KBNP, average patrol size during successful encounters was 5.5 ($^{+}$/- 1.1) as opposed to the average poacher group size set at 4.3 ($^{+}$/- 1.1). Encounter between a patrol group and a group of poachers may be successful when the offenders can be arrested and their firearms and trophies confiscated. The average group size of heavy armed poachers was 72% higher during unsuccessful encounters as compared to successful encounters; this may explain the frequent strategic escape by guards after limited firefights documented in KBNP.

In VNP, the average patrol size during 22 successful encounters was 6.4 ($^{+}$/- 0.5) as compared to the average poacher group size set at 3.4 ($^{+}$/- 2.1). The average group size of heavy armed poachers was 40.4% higher during unsuccessful encounters as compared to successful encounters; this may explain the frequent strategic escape by guards after exchange of shotguns. The probability to encounter illegal activity or catch probability (firearm and ivory recovered, snare seized, carcass found, poacher observed, etc.) is a function of patrol group size up to a maximum number of patrol members (a field force section consisting of 6 guards on regular convention patrol versus a field force of non more than 15 guards on sweep operation as more patrol members will not further increase the catch probability, but may even have the opposite effect of warning illegal hunters ahead of arrival.

Protection effort was set at 21.8 and 22.3 EPMD/Km^2 per guard respectively in KBNP and VNP. These figures are still far from the average of the commonly agreed 33 km^2 per ranger (Bruner *et al.*, 2001). As far as optimizing resource allocation is concerned, on one hand, the 3,291.6 km per $month^{-1}$, which potentially could have been covered with no repetition route in VNP were reduced to 1,078.7 km per $month^{-1}$, thus representing a waste investment time evaluated to 32.7% of patrol hour spent on footpath repetition. On average, 4,849.8 km^2 of the VNP was covered annually, which represents 61.4% of the park area per $year^{-1}$. The park guard force in VNP was working at 53% (instead of 70.2%) of its capacity with a mean duration of effective patrolling day of 4.30 ± 0.2 hours. On the other hand, the 2,500 km per $month^{-1}$, which potentially could have been covered with no repetition route were reduced to 1,807.7 km per $month^{-1}$, thus representing a waste investment time evaluated to 72.3% of patrol hour spent on footpath repetition in KBNP. The park field force on the other side was working at 59.3% of its capacity (instead of 79.5%) with a mean duration of effective patrolling day of 4.2 ± 0.8 hours in KBNP. On average, 1,500 km^2 of the park was covered yearly, which represents 57.8% of the effectively controlled park area per $year^{-1}$. Again, the average duration of effective patrolling day in both sites was well below the optimum duration of an effective day set at about 6:00. Therefore in order to reach the required protection effort of 33 km^2 per ranger, I recommend further increase in current protection effort per guard of the magnitude of respectively 32.4% in VNP and 34% in VNP. With such a background in mind, I do argue that there is still every reason to believe that the depletion rate can be prevented in the future.

The main factor of *in-situ* conservation of the ecological integrity of protected area is the physical presence of rangers (Bruner *et al*., 2001). Because of their ubiquitous and frequent presence in the field, rangers are the most effective source of observation of sudden change and the all-round conservation status of PAs. They are the eyes and ears of PAs administration. Rangers are not only essential in fighting tooth and nail against poaching, but also as observers; they are the first line of defense against unacceptable change (Vreugdenhil & Smith, 1998). They can take immediate action against poachers or individuals that illegally fell trees or set fires. They should routinely frequent their sectors of their area and its neighboring zones, collecting information, serving the public and enforcing the law (MacKinnon *et al.,* 1986). In this regard, CPUE can be a widely used index of prey abundance and thus, representing an alternative method for evaluating the abundance of wildlife species, determining harvest sustainability (Hill *et al*., 2003), and monitoring hunting **(**Puertas & Bodmer 2004). CPUE is useful because it relates directly to the production and socioeconomic benefits derived from the system and reflects, at least in part, community-level responses to exploitation (Lorenzen *et al*., 2006).

There is a need to reduce the current number of patrol posts to a minimum required strategic position (the practical setting should be determined on a site-by-site basis) to allow the strategic deployment of park guards. In this regard each patrol post should then staffed with two patrol units comprised of at least 6 guards each. The reason to have 2 sections per protection zone is to allow rotation and keeping the camp safe but the total number of 12 guards by outpost makes an army section. A point of great importance commonly overlooked is the expenditures in terms of the ratio of salaries to total expenditures (Clarke, 1983) required per park staff to render each one effective.

To the best of my knowledge, the majority of park staff enter the department at the lowest civil servant service rank with correspondingly low salaries. Promotion os often extremely slow and many high quality individuals were still serving at the starting salary after more than ten years of exemplary service and the acquisition of a range of professional capabilities acquired through in-service training. To this end, promotion should be made available to ensure viable career structures with opportunities for the necessary training being provided. Police regulations should include a system of increment stoppages and efficiency bars by which salary increments should be conditional on demonstrations of acquired skills and efficiency according to a predetermined schedule. Such a system could be developed to great advantage in ICCN and should be related to the development of operational procedures and appropriate training schedules undoubtedly leading to more efficient and disciplined field forces. Like the police, ICCN field force is an armed and uniformed force with powers of search, seizure and arrest. Of course, such scheme is open to abuse and its introduction would have to be carefully considered. Only an unusually high quality staff can carry out conservation duties in difficult conditions, avoid abuse of its power and minimize the risks of the job

Overall, investigation operations also appear to be far more effective in reducing large mammals poaching than conventional patrols. Given current poor law enforcement and financial shortfalls, and building upon the fact that a high probability of detection proved to be a better deterrent than a severe penalty, wildlife managers need to direct manpower into law enforcement patrols where effort should be concentrated on the protection of high identified WCH. Coupled with both tips from the new TrailGuard technology which still has to go further testing exercises and input from intelligence-based patrols, well coordinated patrols should be aimed to significantly reduce the numbers of patrols currently deployed in the wrong place at the wrong time. Conservation in many parts of these PAs needs more resources, but in the short-term more can be achieved by careful allocation of the resource already available. Overall, the threats to biodiversity loss in these two sites will only be ameliorated over time and their resolution is contingent on political stability, good governance and sound economic management.

Bushmeat provides an important source of protein in household diets for many rural and urban people around the park as shown by surveys on bushmeat exploitation both in VNP and KBNP (**Tables 5. 2. 1; 5. 1. 2 & 5. 2. 5**). From the development perspective, and with ever-growing population growth around these PAs, our interest focuses on those households living in extreme poverty with income below US$ 1 per capita per day (UNDP, 2001). I do argue that over hunting of wildlife is considered a primary reason for biodiversity loss (Fa *et al*., 2002) and a major threat to the people of those depend on wild meat for food and income. I highlight that the problem can only be tackled by looking at the wider economic and institutional context within which such hunting occurs, from household economics to global terms of trade. Successful conservation of hunted wildlife requires collaboration at all scales, involving local people, resource extraction actors, government and scientists. Given the urgency of the crisis, and the rates at which wildlife populations are declining, we need immediate actionsto ensure that actions taken are having their desired effects.

Understanding which factors influence the sustainability of hunting and determining the effects of current harvesting levels, including the index of catchability of hunted fauna is clearly a priority for future research. In this regard, combining long-term surveys of markets, households and wildlife populations is necessary to capture the whole picture, enabling us to predict how offtake can be made sustainable. In the same line of thought, bio-economics modelling can also predict the effects of policy interventions in a way that might be impossible from field studies alone (Milner-Gulland *et al*., 2003b).Overall, applied interdisciplinary research is required if the complex pathways through which human actions affect biodiversity are to be understood.

In current DRC context, despite widespread recognition of the importance of law enforcement monitoring, only few site managers do appreciate the importance of evaluating reports of poaching and other illegal activities in relation to measures of anti-poaching effort, including the area coverage of mobile patrols (Hart & Kes, 2001). Although some data collection on anti-poaching performance exists in some PAs, investment in analyzing or summarizing data remains underrated. Given the amount of less relevant research undertaken on illegal trafficking of wildlife products, protection effort, and problem animal control, greater emphasis needs to be placed upon collecting and analyzing data on the wildlife population size and distribution, as well as monitoring animal poaching (Leader-Williams, 1993; 1996) using statistical analyses and both GIS-based and remote sensing techniques. Overall, there was a slight and very negligible difference in the patrol forms (**Annexes 7, 8**) used in the two parks; therefore the use of the measure of effort was valid as the parameters relating to the patrol effort were standardized. However, in the neat future, there is a need to use only one and same patrol form (**Annex 8**) currently used in the VNP and fitting into MIST program.

Finally, it is noteworthy to mention that enforcement is costly, hence requiring investment in training, equipement and salaries. With limited resources available to conservation, particularly in the developing countries (Balmford *et al.*, 2002), enforcement at a level which produces no infractions can be prohibitively expensive (Keane *et al*., 2008). Techniques for optimizing enforcement strategies- maximizing benefits while minimizing cost- should therefore be of great interest to practical conservation.

6. 1. 2. 4. 1 Poor Law Enforcement Debriefing Performances and Future Direction in Adaptive Management System

To be useful, law enforcement activities should be monitored with data that are collected rigorously and conscientiously. Within any law enforcement unit or anti-poaching patrol, this will usually require the assignment of one staff member (Patrol secretary) to the task of data collection. Given the frequent reshuffles occurring as the result of administrative staff management, it is vital that adequate training is provided to the person collecting data through patrols, and that adequate debriefing is carried out at the end of any exercise or patrol by middle-level managers and/or research and monitoring staff who will collate and analyze the data. In the future, it will be appropriate for staff collecting data to be encouraged to note any other observations they feel are of interest and importance. These additional notes should form a vital component of the debriefing, following the end of the patrol. Law enforcement staff should be given feedback on the data they have collected once it has been analyzed and is readily presentable in graphical or geographical format. The increasing use of computers at the site level provides a good tool with which to develop an interactive forum between law enforcement and research and monitoring staff in a manner that should improve the usefulness of everyone’s work on the ground.

The complexity of gathering data for the quantitative case study analyses highlighted the fact that monitoring staff involved in enforcement chain do not maintain uniform tracking system related to the debriefing exercise. More important, the park managers do not work together with park guards to monitor the overall effectiveness of the system - Managers are concerned with control factors and scientists with response variables- (Sheil, 2001). As a result, the park is unable to adapt the enforcement activities to improve effectiveness-either individually or as a system. The debriefing should be considered as an information gathering process, as such it is essential to maintain the debriefing objectives (Verification to ensure that the LEM information is correct and correctly recorded even if patrol results do not conform with expectations; Amplification to add additional information for selected observation based on interviews with patrol secretaries and other patrol members, and Communication to improve accurate reporting of key information on the patrol report form). Debriefer should ask questions to clarify the observations that led to the interpretation once there is evidence that guard offered interpretation in patrol reporting forms.

The following process is recommended procedures for individual leading the LEM debriefing:

(i) Go over original notes for each day. Have patrol secretary read field notes aloud. Ask him to provide additional observations and seek confirmation and input from additional guard members present. The debriefer should then fill in the summary for the day on the summary form. Read it back to the secretary to be sure that the observations are correctly reported

(ii) The patrol debriefer should write down additional observations provided by the patrol secretary verbally during the debriefing. Pay particular attention to differences between what was recorded on the patrol sheets and what is reported in the debriefing. If there are problems with the notes as they were written, make the corrections on the field forms using colored pen (do not erase any original notes, even if mistaken) and explain what you are doing and why you are doing it

(iii) Go over field maps with the patrol secretary and other members of the field team

(iv) Provide amplified notes

(v) Request recommendations for follow-up activities based on comments from patrol leader or secretary as this can sometimes lead to additional critical information

(vi) Provide a summary of the patrol results, as obtained through the debriefing report for the PA manager. A more accurate information on the location/toponym of each incident is necessary for future studies as spatial data with coarse resolution reduces the accuracy of the analysis. Consistency in the spelling of place names must be maintained when recording in the incident report book. At present individual place names, particularly in KBNP were spelt in a number of different ways making investigations difficult for anyone not familiar with every locality.

(vii) File a final copy of the summary patrol form and debriefing report for the PA warden

The RBM program is a key tool for monitoring wildlife population status and the threats to its conservation. With improved follow up and appropriate data collection, a strengthened RBM program could reduce the need for frequent compete and costly censuses of the population. The need for undertaking a full census should be decided after assessing the information that is available from the RBM program and then determining, given the information, if a full census is necessary. The accuracy of RBM in detecting changes in large mammal populations should be tested and strengthened in combination with more traditional scientific monitoring. I am in no way opposed to scientific research or regular biological census of wildlife populations, but I'm just alerting on the following: why should local resources be used to collect information irrelevant to management amidst insecurity? How does species counting translate into a management response (Sheil *et al.*, 1999)?

We need such information to demonstrate trends over a period of time and hence formulate appropriate conservation and management strategies. But given the present situation, continued annual surveys of charismatic keystone species will wipe out the limited resources that could otherwise have been used to save them. Much of the current scientific emphasis is on watching problems proceed rather than trying to halt them. Example of such 'watching' include counting dwindling and ever endangered elephant population in KBNP with increasing level of precision rather than dissuading heavy armed poachers. The biological data may be useful for scientists, but it is far more valuable to identify problem, threats, and prevention strategies early and ensure that adequate management interventions can be taken.

Indeed, it is evident that despite the considerable research efforts and biodiversity loss-related meetings reports of pending environmental disaster overflowing satellite telecommunication into international media, funding and commitment that have been devoted to large mammals, these species continue to decline at an alarming rate and their conservation to pose the greatest problems and challenges. While recognizing that the present status of most large mammals is alarming, we should also knowledge the efforts that have been directed across the two PAs by ICCN, and both bi and multilateral donors and international NGOs towards the conservation of these species under the most difficult of conditions (Draulans & Krunkelsven, 2002). Looking at these efforts, one wonders why the species continue to become increasingly endangered though large sums of money are being used to count the species and to hold meetings. Whenever the results of such counts are compiled and meetings are held, one thing remains obvious with most wildlife populations; the numbers are lower than those of the previous years (**Tables 3. 15. 8 & Figures 4. 5. 1. 3; 4. 5. 3. 3 & 4. 5. 5. 3**), and the next year's counts are expected to show a further depletion. The most common explanation given for the trend is the woe in poaching. Then a list of recommendations – some of which are excellent- is made in the final report. However, when funds are next available, and in particular from a donor agency, more keystone species surveys are planned and conducted, and none of the previous recommendations on poaching control are considered for implementation. If this plight is to be arrested and then reversed, present conservation efforts must concentrate on full scale anti-poaching operations with limited biological surveys.

If annual or two-year counts of keystone species as well as the biodiversity meetings are thought to be so desirable at this particular period in time, and continue to take the lion's share of conservation budget, I am afraid it will not be long before we count these species to extinction. Conservation of these species must now more than ever focus on the single decimating factor – poaching upsurge – or else we will simply be compiling information that will be used to write a history of a once abundant but then extinct species. The management of Mikeno massif crisis (**Figure 4.5.5.1.1**) within the ranges of more intensively studied mountain gorilla area, along with the charcoal battle in VNP and the recent Code-named "*Operation Interconnexion*" in the KBNP support the view that LEM by park guard field teams provides important conservation benefits (Pusey *et al*., 2007). As I intend to submit this thesis, the VNP management has launched a two month unprecedented sweep-code named "*Plan de stabilization*" involving a squad of 201 FARDC soldiers and 193 guards. It has mobilized 3 speedboats, 1 ordinary boat, 5 trucks, 6 pick-ups, 3 motorbikes, 2 binoculars, 25 HF-radios, 30 GSM. 1 VSat. One of the outcomes of the sweep is that poaching was brought under control in the central sector of the VNP and 800 people were removed from illegal human settlement. Previous to the sweep, a 6 week military re-training has taken place in Lulimbi (Balole, pers. comm.). Such operations confirm the crucial role of anti-poaching over research for the time being. It is true that biological research of many kinds may ultimately be valuable, but ought not to be conducted at the cost of failing to halt the overwhelming anthropogenic threats now facing the two parks.

However, science has at least three means of influencing the practice of nature conservation. First, an available body of scientific theory and application can provide some of the raw material for constructing policies. Second, science can offer solutions when called upon to assist in the implementation of policies and conventions, while also clarifying the social and economic implications of alternative methods or scenarios (this role is best filled when science is integral to the process, not simply called in for peer review or when technical or political problems emerge. Third, science can and should be used to review the effectiveness of political processes for achieving stated biodiversity goals. As things stand, the uneven division of attention between assessment and application has led to the so-called implementation crisis (Knight *et al*., 2006). To top it all, current insecurity context precludes any ecological monitoring (Klug & Hart, 2006).

Together with this appeal to spend more on anti-poaching and less on research and wildlife population surveys in the two ecosystems currently wracked by political strife and economic hardship, there is also a need to look more deeply into the entire question of poaching. As argued earlier, the spate of poaching is indicative of the possible far-reaching consequences when militia gangs, rascal elements in the FARDC military command or their collaborators, park guards, local communities and even foreigner poachers (Kujirakwinja, 2010) come to the forefront. This can largely be attributed to the economic crisis in DRC, whereby the national economy deteriorated significantly during the civil strife. The region is still struggling with high unemployment amid a sluggish-at-best economy recovery during post-conflcit period. The crisis affected both the guards' government salaries and the income generating activities of the guards and their families (de Merode, 1998). There were no functioning vehicles during this period, and patrols were restricted to the immediate periphery of the park headquarters (de Merode, 1998) as shown by **Figures 3. 9. 1 &. 4. 4. 5. 1**.The fundamental answer to the documented cases of bribery induced by the starvation wages is to raise salaries of wildlife enforcers above what they could get elsewhere. Efforts to curb poaching will have to come with a high cost over the near future.

6. 1. 2. 4. 1. 1 Liability and Wildlife Staff Responsibilities

Recently, gun-related public policy issues have captured the country's attention. Tragic park staff shootings and their accidental deaths have made headline news as passions over the issue run high across the country. The felonious deaths of rangers, who regularly risk their lives to enforce wildlife's rules and protect biodiversity, have a particularly profound impact on society.

Notwithsthanding many proposals have been set forth to reduce this violence, there is little quality evidence about how gun control laws affect the lives of wildlife officers and park staff. Indeed, poachers' gangs have become better armed with semi-automatic weapons and sometimes using heavy machine guns explaining the stepping out of the picture strategy adopted by park staff during armed encounters. What the media has popularly termed park's "shoot-to-kill" policy in fact represents basic self-defensive action on the part of ICCN staff; in this regard, when poachers started to play rough, park staff did the same while them tracking down.

While criticism has been raised both inside and outside of the country, particularly during the election campaign, against the taking of human lives to protect wildlife, it remains unrealistic to expect heavily armed poachers to drop their weapons, and accordingly surrender following warning shot fired in air as directed under article 13 of Law No 75-023 (**Box 1. 1**) and article 8 of wildlife Act 69-041 (**Annex 1**) when detected by park staff on the ground. Poachers know a jail sentence awaited them if they were caught red handed, and they will not hesitate to resist capture by strategically avoiding heavily patrolled conservation areas! Surprising armed poachers in the dark in a thicket or before leaving the park at daybreak can be extremely dangerous as at times like this the possibility of the odd loose shot adds to the danger. So let's shot and run to get ahead of them is their tip! Not surprisingly, most of armed successful encounters with armed poachers took place early morning (5h45 - 6h57). The proficiency of park staff in the use of weapons was often inadequate. Equally, there was often confusion over the circumstances under which a guard may use his firearm to defend himself fro attack. This must be clearly spelt out and all staff must be instructed and trained on the correct reaction in such circumstances, remembering that a 'split-second' decision means life or death (Bell, 1984d).

The recommendation is that guard should be instructed to properly use firearms when they have reason to believe that they are in danger of death or serious injury that can be avoided in no other way and in case of firing on humans, the aim should be to wound rather than kill. The case of warning shots needs to be worked out and the use of blank ammunition at the top of the magazine should be considered. The procedures for the use of frearms should be clearly laid down in agreement with the police and the judiciary and if necessary included in primary legislation. A procedure should be worked out for assessing cases involving death or injury of members of the public by ICCN, which would give staff the confidence to carry out their duties and defend themselves when necessary without the threat of protected legal procedures and imprisonment. In sum, overwhelmed by an upsurge of game poaching, the guards will undergo tailor made courses within the national parks to impart them with ethics of park staff and to boost anti-poaching squad over the entire park and not just in limited sectors prefered by NGOs.

One of the most important reasons for recording observations when, or soon after, these sightings occur is that a court will often tend to give weight to evidence of this nature. This is because courts generally recognize the fallibility of human memory and prefer to rely on ‘contemporaneous notes’. Notes taken at the time can be of invaluable assistance to a wildlife officer who is called on to be a witness in a trial, particularly when the trial is held long after the actual event. Photographs and video-tapes can also be extremely valuable as evidence because they record details which may have escaped the attention of the observer at the time but which may prove vital at a later stage, particularly to disprove any inaccurate statements made by the defence. Wherever possible the cameras used during patrols should be set to record the date and time on the picture or video-tape. The photographer must keep the film in a secure place after it is removed from the camera and record exactly what he or she is in a position to confirm in court that it was not tampered with. When making and recording observations, wildlife officiers should always keep in mind the fact that the judicial officier will want to be able to understand events unfolding in chronological order through the explanation of the wildlife staff in court. Apart from current weapons, there is a need to look into using ‘no-lethal weapons’ such as Taser X26, an electric shock firearm developed for law enforcement that shots probes into a target’s skin, the target’s muscular control is lost briefly, making it easier for guards to overpower the target.

At the moment, offenders once arrested are rarely prosecuted as individuals. In reality, poachers do not operate singly, and several other figures behind the scenes, who are often key members of the operation, from the initial planning stage to the final selling of wildlife product, are neither investigated nor subjected to judicial proceedings. These people include guards who often come from within the local communities (de Merode *et al*., 2007; Van Schuylenbergh, 2009; Robinson *et al*., 2010) or among the game staff themselves, the actual poachers, the transporters of the ivory out of the country and the final overseas buyers. The park management should consider small-scale shifting of park staff between PAs network as a whole. With such a background in mind, I do argue that there is still hope and every reason to believe that the extinction of large mammal species can be prevented provided that coordinated patrols are being stepped up by prioritizing law enforcement efforts. If poaching is to be eradicated, then anti-poaching efforts must also aim to bring these people to book while keeping the hunt on for the suspects behind a rush of poaching targeting key species. Wardens and guards alone cannot achieve this. Other government departments have to be involved, such as the police force, the criminal investigations department, the judiciary, customs and excise, the intelligence services and the general public. If the anti-poaching efforts capture the ‘artillery-men’ of the enemy in this war, then their ‘infantry’ will be paralyzed, and we will have won the battle (Boshe, 1989).

Once the park management has gained full control of all PMUs, further specific research studies are needed to better understand the key factors driving the large mammal populations, distribution, growth rates, etc (including ecological factors, population dynamics and human disturbance), in order to assess the significance and implications of the observed pattern of distribution and abundance of wildlife populations, and to allow improved estimates of the carrying capacity of the area. Efforts to monitor wildlife are complicated by the difficulties inherent in observing and censusing tropical forest species. Nevertheless, anti-poaching efforts in isolation of wildlife assessment in peaceful time may not provide adequate protection; they do not take into account the multiple effects of human activities on those species that are slated for conservation. In this regard, RBM should help to identify potential factors for further investigation and provide useful baseline information for such studies. Once the data from such national parks statewide biodiversity inventories are in hand, we can determine which lands and resident wildlife populations are at greatest risk of extinction and the capital losses on existing wildlife stocks. Until this happens, current focus should be solely on anti-poaching efforts.

Looking back over five years of war, I learned that despite illegal exploitation and human encroachment, both two PAs retain their basic wilderness character and continue to represent enormous potential for *in situ* conservation. An anti-poaching strategy anchored in PA coupled with community-based program represents the best option for the future of wildlife conservation as it seems almost impossible for any park to support large-scale and long-term conservation without generating significant wildlife value for both national and local interests. Wildlife in the two PAs is globally unique and must be protected, but to exclude local population from benefiting from the resource is unrealistic and unfair, even if done in the name of global biodiversity protection. What is needed for long-term large mammal conservation to be sustained is for economic value to reach local markets? Redirecting tourism income flows to local populations through community initiatives may support both economic and intrinsic value enhancement. Trans-boundary initiatives if adequately executed may support this process, especially if they were to attract increased global scientific support (VanderPost, 2007). To this end, environment education still remains a key variable in future conservation efforts.

6. 1. 2. 4. 2 Deterrent Effects of Regulatory Enforcement and Improvement of Effectiveness

The *PDI model* incorporates parameters other than just geographical deployment (by density or by strategy), which does avoid wasting effort in zones where needs in guards or any other law enforcement personnel are minimal. As defined in Tucker (2003), the *PDI model* is rooted in the proportional allocation of patrol effort by levels of threats, threat directional movements, available information, logistical constraints, etc. As such, the development of the *PDI model* originates from the choice theory (Allingham, 2002) wherein actions are ordered preferences by virtue of the principle of *maximizing utility* (Allingham, 2002). The principle of *maximizing utility* presupposes that a choice is useful if and only if it can be explained by a preference ordering (Allingham, 2002). These strategies should be aimed at reducing poaching by including both enforcement measures such as increasing the number of anti-poaching patrols to reduce supply, and community-based programs as alternatives to poaching (Barrett & Arcese, 1996; Hilborn *et al*., 2006).

Including the costs of conflict, and recognizing that guards who feel in danger are less likely to want to risk apprehendly people in the framework of current community-based conservation strategy, I do agree with Robinson *et al*. (2010) findings and suggest that an optimal strategy should put increased emphasis on detection rather than punishment, and possibly legalizing less harmful activities. However, this does not preclude from law enforcement improvement. Coercive and draconian enforcement measures remain essential ingredients in any compliance regime, even where a high degree of compliance via the twin forces of moral obligation and social influence. This may mean that enforcement authorities should target chronic and flagrant violators of the regulations, punishing them accordingly, while tolerating to some degree minor violations by individuals who normally comply with the regulations. As Clark *et al*. (1993) put it clearly, yet even with community-based management, some level of enforcement is almost inevitably required against poaching and other illegal uses of forest and park resources. Otherwise, flagrant rule-breakers would appear to flaunt their violation of the law and to be immune to the regulations. This sends so far two signals to normally law-abinding participants in the context of both two parks: one is that regulatory procedures are unfair, having no effect on flagrant military and militia gangs violators; the other is that the regulatory program is not so far effectively achieving its purpose. Each of these signals weakens the moral obligations to comply and the moral basis on which social influence is exercised. As moral obligation and social influence are weakened, compliance begins to erode among those park staff who would normally comply with the regulations (e.g., case study depicted by the *Kutukura/Ishengera* phenomenon documented in Rumangabo is woth mentioning here). Their subsequent noncompliant behavior influences others not to comply with the regulations, and ultimately compliance breaks down (Sutinen & Kuperan, 1999).

While this research suggest the benefits of focusing park staff interventions on places, it is also necessary to consider whether such a focused approach is an efficient use of park staff resources. My view suggests that it is for multiple reasons: (i) crime is highly concentrated in WCHs and such wildlife crime concentrations are greater than the concentration of crime among park staff. In this sense, place-based policing is efficient because the park staff can focus on a relatively small number of places and gain relatively larger wildlife crime prevention benefits. Importantly, wildlife is not only concentrated at place, there is also strong stability in WCH over time. In contrast to chronic offenders who often age out of crime quickly, poaching hotspots seem to continue to be 'hot' over long periods. In this context places are an efficient focus for park staff, because the patrolling force does not risk wasting resources on targets that would evidence lower illegal activity over time. And poaching hotspots represent an easy to 'find' focus for park staff. Unlike offenders who move from place to place and are difficult to track, in the most basic sense wildlife crime places stay in the same place. Finally, wildlife crime prevention at places does not simply lead to crime displacement. Indeed, according to Weisburd & Braga (2006), there is strong evidence today that hotspot policing is more likely to a diffusion of crime prevention benefits to areas nearby. This only strengthens the argument for the efficiency of place-based policing

6. 1. 2. 4. 3 Challenges in Evaluating Measure of Hunting

Unsustainable hunting of wildlife is well established as a major threat to biodiversity in tropical forests (Robinson & Bodmer, 1999). While people have lived and hunted in tropical forests for tens of thousands of years exploitation of ''bushmeat" and ''wild meat" (Milner-Gulland & Bennett, 2003a) is estimated to have increased in recent years (Robinson & Bodmer, 1999), due to a combination of increasing human populations, changing hunting technology and an absence of alternative sources of protein (Robinson & Bennet, 2000). As a result, hunting has been considered a more serious threat to the conservation of tropical biodiversity than deforestation (Redford, 1992).The alarming rate at which the biotic basis of plants and animals is being reduced is agape. In other words, the loss of biodiversity actually constraints and counteracts economic development, which is the immediate goal of all nations of the world (Kim & Weaver, 1994).

The dissertation results have important implications for how future studies should measure hunting effort in order to assess properly the biological impact of bushmeat hunting, but further comparative studies are needed to investigate the existence of biased effort measures in a range of hunting systems. They further suggest that the magnitude of the overlap between severe, multifaced poverty and key PAs as the backbone of the conservation biodiversity is great and needs to be fully acknowledged in order to identify illusive, yet possible, win-win solutions.

The relationship between time spent hunting and the probability of mortality experienced by trap-caught species may not be clear cut. The probability of mortality for trap-caught species might be better explained by the number of traps set in an area, rather than the time taken to check them. However, if the time spent checking traps is correlated with the number of traps, then either may be an adequate measure. Quantifying trapping effort so that it reflects prey mortality is further complicated by the fact that different trap types may be used to target different species. For hunters in tropical forested areas, traps are often thought to be indiscriminate, selective only by body size, and not by species, age or sex (Noss, 1998a). If trap groups contain equal proportions of all trap types then effort quantified as total trap numbers will accurately reflect the relative effect on prey mortality of each trap type. However, if trap group composition is variable and biased toward certain types of traps, then the use of total trap numbers will not accurately reflect the probability of capture for prey targeted by less commonly (Rist *et al*., 2008).

A caveat of this method is that it will not be possible to determine at which scale the decline that is detected actually occurs. Hence, when quantifying catch for biological monitoring purposes, a biologically relevant measure that accounts for these sources of 'wastage' is required, whereas hunter management may require the use of catch measures that are economically relevant for hunters (Crookes & Milner-Gulland, 2006). However, if the proportion of wastage is relatively consistent across locations or seasons, as found in this study, then wastage can be adjusted for in order to obtain a more biologically relevant measure of catch. Typically trapping is thought to be the more wasteful method of hunting and previous studies (Noss, 1995; Fa *et al*., 2000) have reported very high trap wastage levels.

Measures of catch have been shown to differ greatly depending on whether they are taken from a hunter or prey perspective, suggesting that indirect methods of recording catch data may offer considerable opportunities for underreporting. Whether or not handling time is correlated with catch, it may only become important in the calculation of trap hunting effort if trap groups become saturated, so that the probability of an animal being captured is affected by a previously caught animal blocking a trap (Charnov, 1976).

A better understanding of how these different measures of effort and catch relate to each other will allow future studies to collect catch-effort data that more accurately represent the true biological impact of hunting, and so better enable us to manage bushmeat hunting to ensure better biological and economic outcomes. Furthermore, consideration should also be given to the cost-effectiveness of collecting data using these different measures in order to assist researchers in choosing the best measures for future research. Finally, the relative importance and magnitude of the biases identified here may vary on a case-by-case basis, and the generality of our findings to other sites may therefore depend on the type of hunting system in place. As such, the measures identified here are intended as a guide to illustrate where bias in quantifying catch and effort can occur. Further comparative studies are now needed to assess the general applicability of our findings and the validity of different measures for quantifying effort and catch in different hunting systems over PAs network in the country.

6. 1. 2. 5 Re-establishing the Rule of Law and Order within the National Parks: Blowing Hot and Cold.

During the civil strife and much of the study period, the headquarters and patrol posts of several tropical forest World Heritage sites in DRC were taken over by the military, including VNP, KBNP (McNeely, 2003), as a consequence, they were destroyed and equipment looted. Essential infrastructure has to be rebuilt so as guards can be able to live in minimally acceptable housing, which is not the case at the present in most patrol post where guards are provided with house composed of only one small dining room and one bed room. Access needs to be improved and headquarters need to be able to function properly, with the requisite administrative infrastructure and workshops. Equally important, the management and organization of park headquarters need to be addressed. After years of neglect, there is a need to re-examine the way that patrol posts are managed, how security measures are enforced, and how discipline is maintained.

The development of a genuine culture of conservation, coupled with a collective institutional memory should be revitalized at the national as well field levels. From this prospect, the *Esprit de corps* should enable the emergence of a real sense of pride at the very heart of the institution (Inogwabini *et al*., 2005a), and the rebuilding of trust in troop leadership through para-military training of all park warden and assistant park warden and duly taking the oath allowing them to officially act as *Officiers de police judiciaire* (OPJ). Although the ICCN has suffered greatly, in part from a slow institutional decline that began in the 1980s, and in part because of the repeated political and military crises of the past decade, the institution still retains some potential for a promising new beginning and can still be hailed as a conservation success story.

The presence of armed groups in and around the sites and the proliferation of weapons in wrong hands remains one of the biggest challenges for the conservation of the sites. Armed groups are currently the single biggest threat to the integrity of the sites. As part of the peace process, demobilization and disarmament should remain high on the political agenda as many donors are prepared to assist this process. Although the issue goes beyond the mandate of ICCN, it is felt that it is critical to focus the attention on the PAs as they often serve as a base for the armed groups. As things stand, it is unclear what role of ICCN and its partners can be because as such, these military-induced vexing environmental problems are considered to be "crimes against humanity" (Winter, 2001).

At the height of armed poaching upsurge in 2006, the UN have agreed to carry out anti-poaching patrols at Nyakakoma in the Virunga National Park to help stem the catastrophic hippo poaching. In an ICCN meeting with the UN commander Colonel Shivrain, the latter agreed to deploy a company of MONUC peacekeepers on a two day patrol to help put pressure on the *Mai Mai* to reduce the level of poaching. He has also agreed to try and encourage *Mai Mai* leader Colonel Mosubu back to the table for discussions after he boycotted a meeting to discuss the problem. While anti-poaching operations are not in the official UN mandate, the hippo poaching went so out of control that the UN have had to step in. The *Mai Mai* were poaching on average 150 hippos a week in what the UN commander believed was a last ditch effort to gather as much ivory as possible before the elections took place (Wildlife Direct, 2006). At this time, it was expected that once the elections have passed, the *Mai Mai* will be forced to accept integration into the Congolese army or demobilisation into civil society and in case they resist either, they will be removed from the equation. However it seems that the *Mai Mai* were heavily supported by the *Interehamwe* who were much stronger and better resourced, and MONUC forces were concerned that any punitive action taken right now against the *Mai Mai* could impact negatively on the upcoming elections, the countries first for over 40 years. In the meantime, according to Wildlife direct (2006) the story went as follows: Sit tight! But for how long?

One possibility would be to suggest to MONUC that a senior environmentalist expert should be placed within the Mission with a clear mandate to facilitate cooperation on the anti-poaching issues. Particular attention should be given to consolidating the existing guards-MONUC soldier's joint patrols though in the early years of the UN mission, reports of resource trade were rife. Very recently, a BBC research team reported how Indian and Pakistani blue helmets have been trading gold with militia in Ituri district and North Kivu, who received weapons in return (BBC News, 2002; van de Giessen, 2005). Moreover, according to the same report, the Indian peace keepers flew a UN helicopter into VNP, where they exchanged ammunition for ivory. These acts of misbehaviour by a small group of UN soldiers are of course extremely counterproductive (van de Giessen, 2008). To be successful, a mix of commitment by the government and technical measures will be needed. In addition, as soon as a return to peace is completely established and control over the militias within and around these sites is carried out, it will be crucial to tackle this problem and ensure that all the military factions leave the park.

6. 1. 2. 6 Financial Costs and Shortfalls of Managing Protected Areas

Securing sufficient financing to monitor and mitigate excessive resource use over time is often cited by wildlife managers as a key factor militating against effective biodiversity conservation (Biodiversity Support Program; 1993 Ntiamoa-Baidu *et al*., 1998; James *et al*., 1999). The operational budget used for the KBNP and VNP was respectively set at 95 and 89.3 US$. The KBNP and VNP received an average of respectively 39.6% and 37.2% of the funding that is necessary for basic conservation management (James *et al*., 1999). The slightly higher operational budget in KBNP as opposed to VNP can be explained by the concentration of most of the NGOs budget expenditures in the southern sector, thus reducing the cost effectiveness of the law enforcement in the entire VNP. This level of law enforcement budget is lower compared to the required $US240 (James *et al*., 2001). Taking into account the costs of supporting staff, transport, subsistence, incidental expenses and funds for management, the study analysis holds that effective *in situ* large mammals conservation and habitat protection requires a funding commitment of close to $US240/km^2 (James *et al*., 2001), a financial burden that the park management has not been able to shoulder. The magnitude of the threats to biodiversity, coupled with the limited financial, technical, and physical resources available for biodiversity conservation requires careful prioritization of the park protection efforts within high poaching risk areas as without sufficient funding and proper allocation of the funds to support the field force, the effect of the law enforcement effort may be negligible. In improving the resources, greater emphasis should be put on intelligence section of the law enforcement budget bearing in mind that poachers may strategically position themselves in areas with high concentrations of wildlife.

Under funding-jeopardizes the ability of park staff to safeguard biodiversity and the benefit that intact nature provides to society (Bruner *et al*., 2004). How should one bridge this yet chronic funding in order to ensure sound conservation of these PAs? To date, there are only a handful of proven reliable ways to achieve sustainability. These include the establishment of conservation trust funds and the development of self-financing mechanisms via park entrance and tourism fees. A long term financial mechanism for monitoring and management of the two parks should be designed if a structured environmental improvement is to be realized in the region. This should be built upon the experience of the Mgahinga and Bwindi Impenetrable Forest Conservation Trust Fund (MBIFCT) which was one of the first conservation trusts established in the world. Knowing that trust fund approach can be very useful as a mechanism for funding conservation and development work, the World Bank is currently striving to establish a Multi-donor Trust Fund for funding conservation and development activities in the DRC.

6. 1. 2. 7 Capacity-building Enforcement and Science-based Information

The main duty of law enforcement staff is to undertake patrolling rather than to collect data. (Jachmann, 1998) Therefore a compromise has to be reached that does not overburden law enforcement staff with data collection requirements that detract from their main duty.

Improvement of the capacity of field staff to cope with the increasing pressure on the sites should be the focus in the framework of the development of a training strategy. Training should be targeted at field staff both at managerial level (park wardens) and at implementing level (park guards). Training topics are law enforcement and other park management techniques, conflict resolution, community conservation and communication with local populations.

Overall, a majority of all park staff are more than 40 years old, which present a serious demographic hurdle for future management (Inogwabini *et al*., 2005a). Fifty two percent have technical training in wildlife management, and the remainder has little education. ICCN has trained most of its wardens at Garoua in Cameroon (IUCN, 1992). The curriculum at Garoua cannot cope with all the new conservation challenges in PAs (Inogwabini *et al*., 2005a). Quite recently, some ICCN guards have been sent to the College of African Wildlife Management in Mweka, Tanzania where in addition to biology and paramilitary tactics, courses are offered in improving relations with local populations. But so far, very few of the ICCN guards have studied there as many staff are being still trained on the job. Until the 1980s, ICCN staff set the standard in Africa for their level of professionalism and training, but two decades of abandonment of ICCN by the state has changed the situation. Indeed, recent instructors and lecturers in anti-poaching and law enforcement from South Africa and Mweka were shocked by the low levels of competence of Congolese trainees, even in simple tasks such as handling a classic firearm or basic anti-poaching techniques. The training organized for them in the DRC (Lulimbi, Ishango) and abroad (South Africa Wildlife College) has mostly emphasized paramilitary training and anti-poaching techniques. In addition, it is regrettable that the ICCN does not yet have an internal team of instructors that can guarantee continuous training of its guards. Therefore it's common place to have ICCN staff appointed as chief park warden without any formal paramilitary training background.

The National Parks Institute should amplify opportunity of training-targeting academic training, including training conservation biologists from national universities-rather than just attempting to train personnel in PA management as it's the case in Garoua Wildlife College. On-duty training is also needed to improve the level of current personnel and to ensure that staff members keep up with changes in technology, the theory and application of conservation biology as well as the state-of-the art GIS tools to management. The supervision of the young by older, experienced guards, and the transmission of an *esprit de corps* and loyalty to the institution remain important values to revive (d'Huart & Kalpers, 2009b). The training given at Mweka and South Africa Wildlife College would be the most appropriate to fill the gap, but the language barrier remains very sad reality as courses are being taught in English in Tanzania and South Africa). Beyond this are many other aspects, including data base and base map management, rudimentary statistical analysis, use of computer and the GIS tools, which are not yet fully developed. Recent effort aimed at setting a PA Information Management System (Système de Gestion de l'Information des Aires Protégées-SYGIAP) and its associated training sessions were designed to meet these crucial needs, but they still require harmonization with existing practices. Long-term historical data sets will provide valuable insights.

It is noteworthy to mention that many staff have reached retirement age, and the youngest are now being confronted with financial and logistical problems that undermine their effectiveness. The objective in the near future should be to energetically rejuvenate the personnel. Those who are ready for retirement – there are many – should leave after being well paid for the long lasting patriot and valuable services they rendered to the Nation and those who remain should be trained. The park staff should be composed of well-trained, well-equipped and well-paid staff to efficiently curb poaching pressure. ICCN plans to replace 100 staff for the VNP and about 30 others in KBNP by March 2011 (Languy, pers.comm.).

As security improves, it will become possible to assess the impact of the war on the sites values and integrity. Indeed, it is important to survey all key species, especially the keystone species that lay at the base of the World heritage designation (*Gorilla beringei beringei*, *Gorilla beringei graueri*, *Loxodonta africana* sp, etc). Accordingly, impact on the habitat and the integrity of the sites will also be assessed. These biological data will consolidate the existing base line information and thus, help to improve and re-orient monitoring system already in place at the two sites where biological surveys has shown that field researchers teams might provide relevant information in far remote areas than routine patrols can. By the same token, monitoring of socioeconomic information should also be planned as baseline data are collected around the two landscapes. These will include measures of wealth, use of forest products and attitudes towards conservation. In addition, though forensic techniques can be expensive and time intensive, with the specific tests (e.g., DNA analysis) requiring high levels of training and special equipment, I suggest to start brainstorming as well on how the genetic analyses (Baker *et al*., 2000; Wasser *et al*., 2008) and isotope signatures (Amin *et al*., 2003) can link confiscated goods from caught violators to particular geographic locations within and around the park. According to Lin *et al*. (2009), the use of space-time and other anciliary information with GIS can be quite helpful for forensic investigation. Although fingerprints are the most prevalent impression evidence, shoeprints, tool marks, and plastic tracks are routinely collected at wildlife crime scenes. While fingerprint evidence provides a greater than 95% probability of linking a suspect to a crime scene, shoeprints and other impressions have a much lower probability of positive association between evidence and offender. However, Hamm (1989) conlude that improved information can enhance the level of confidence and lead to either a positive identification or an exoneration of a suspect. In the long run, future law enforcement fieldwork might continue along this particular research frontier to enhance the hotspot model presented in this dissertation.

This component will also strengthen the work stated in terms of setting up a uniform information gathering mechanism for the sites (SYGIAP). The first aim is to continue to gather LEM data collected at sites and make them available for the site managers in such a way that decision making can be facilitated. Parallel, information has to be transmitted in a systematic organized way to the data management unit at the Headquarters of ICCN in Kinshasa, where it can be made available not only for the internal management decisions but also to inform the decision making on natural resources management issues by other relevant ministries and government services, such as the Ministries of Environment, Nature Conservation and Tourism, mining, planning, agriculture and land use. In addition, data will also be readily available and facilitate the reporting obligations under various Conventions, including the World Heritage Convention, CITES and the CBD. It's expected that this specific outcome will contribute to strengthening the ICCN information management system while information technology applied to generate computer maps of 'up-to-the-hour' crime data in PAs todays gives wildlife department a distinct advantage in criminal ivestigations.

6. 1.2. 8 Shift in the Ruling Paradigm of Protected Areas

In Genesis, God blesses human beings and bids us to take dominion over the fish in the sea, the birds in the air, and every other living thing. We are entreated to be fruitful and multiply, to fill the earth, and subdue it (Gen. 1:28). The bad news, and the good news, is that we have almost succeeded, thus suggesting that human beings are stewards of nature whether we like it or not (Sanderson *et al*., 2002). The long-term impact of human influence, positive or negative, benign or catastrophic, depends on our willingness to shoulder responsibility for our stewardship. Conservation organizations and biological scientists have demonstrated surprising solutions that allow people and wildlife to coexist, if people are willing to apply their natural capacity to modify the environment to enhance natural values, not degrade them, while making their living (Sanderson *et al*., 2002). In this context, the shift in the ruling paradigm of PAs is worth trying.

Indeed, for almost forty three years now, Hardin's (1968) concept of the "Tragedy of the Commons" involving the pasture 'open to all' has influenced debates and thinking about the conservation of natural resources. Thus one of the real solutions to environmental policy lies in a specific transformation of values-the transcendence of human-based systems of ethics and the development of an "ecological ethic" (Katz, 1994). The pivotal role of CBC lauded as a new school of thought and better approaches to PAs management (Mugisha & Jacobson, 2004) have been much less considered as far as law enforcement is concerned.

The Vth IUCN World Parks Congress is a turning point for the role and place of PAs in the sustainable development and biodiversity agendas. By taking the World Parks Congress theme as 'Benefits beyond Boundaries', participants at the Congress recognized that PAs cannot remain in isolation from the surrounding areas of land and from the communities and the economic activities in and around them. Most important, participants sought to promote the importance and value of PAs to society as a whole now and in the future (IUCN, 2003).

In line with the policy goals, conservation of biological diversity must be seen within the wider context of national economic and social goals. In this respect, conservation should move beyond the strong anti-development stance of the 1970s. - The main objective of wildlife policy in the past was to preserve as many animals as possible, and the main instruments of policy were departments organized to police and enforce a battery of prohibitions about legal and illegal activities regarding wild animals. This policy was correct for its time. In these circumstances, ‘preservation wherever possible’ was the only rational policy, and has had a great benefit of ensuring that DRC possesses now a wildlife resource worth managing.

Strong and effective public agency action to protect biodiversity is long overdue. The wildlife Act is a safety sagging under the strain of the sheer magnitude of species needing attention, such as the mountain and grauer’s gorillas that have ideological significance for conservation internationally. As it is currently being implemented, the wildlife Act can be compared to emergency room medical care. Inded, the tendency has been to do too little late, with strong medical care on high-tech solutions to problems in a crisis atmosphere. We have waited until the parients are dying before we administer aid. Too few of the patients ever make it to the operating table. Too little has been done to prevent the crisis in the first place. From that less proactive prospect, the bottom line is not how many species we save from extinction in the next decade but how many species will survive the next hundred years or more (Cutler, 1994). The preservation of biodiversity will be achieved by the transformation of human value. It is for this reason that the concept of “biodiversity” must be linked with “ecological justice”; it is as well for this reason that the problem of a diminishing planet biodiversity is a crisis in moral value. Leopold (1970) and Katz (1994) conclude: A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community, it is wrong when it tends otherwise. In the near future, it will be easier and more cost-effective to protect ecosystems while they are still functioning and intact than to wait until crisis management has to be invoked for one endangered species after another.Without political help from nongovernmental organizations, it’s likely that the wildlife department could not whistand the predictable pressure to exploit commodities and pursue other economic-development opportunities associated with PAs. Countervailing pressure has always been the name of the environmental protection game. The private environmental-protection advocacy credo should be help to fight for biodiversity or lose it (Cutler, 1994).

Most of the people who carry out poaching and other illegal activities are the poorest people living around the forests (Plumptre *et al*., 1997) and are involved in this in order to survive and care for their families, thus conservation today should be firmly embedded in national aspirations and regarded as the foundation supporting the sustainable use of all natural resources. Around the world it is also conceded that biodiversity cannot be sustained in an atmosphere of poverty or uncertainty over use and access rights. In the new ethos to which DRC subscribes as signatory to the Biodiversity Convention on 15 September 1994, conservation and development are twin aspects of a single goal – that of a better quality of life for all individuals. Such policies will address rural livelihood issues while maintaining conservation goals, and reflect a less confrontational relationship between conservation agents and the resource-dependent rural poor.These policies may be motivated by fairness considerations in terms of the burden on local people of providing environmental services, and poverty alleviation goals.

The approach to PA management will require new skills and training for park staff-in social and political as well as biological skills. It will require a shift in the ruling paradigm of PAs. The concept of national park as inviolate haven of untouched nature, controlled by an all powerful central agency, will have to give way to concept of conservation through careful manipulation to achieve both conservation and local human development objectives (Hough, 1988). One approach to enforcement is the establishment of a protection strategy (which stresses integration of conservation with local human needs) through such worthy devices as Biosphere Reserves (Batisse, 1982). In this regard, community-based conservation strategy is a more realistic policy and a response to both old-style protectionist policies of the past and the profound economic and environmental crisis that the ever-growing rural people face. Increase in the number of staff (6 guards in regular patrol and not more than 15 guards in sweep operation) and subsequent law enforcement has to be paralleled by the biosphere reserve concept strategy; without the cooperation of rural people, wildlife conservation efforts would be doomed.

Biosphere Reserves have a new role to play at the global level: not only are they a means of allowing the rural people who live and work in and around them to attain a balanced relationship with the natural world, but they also let us explore ways in which to meet the future sustainable needs of society as a whole. Therefore I do suggest that the VNP be put forward for consideration and nomination as a United Nations Educational, Scientific, and Cultural Organization (UNESCO) Biosphere Reserve, as well as a region of interest in the Man and the Biosphere (MAB) Program. Only the three recognized fishing villages (Vitshumbi, Kyavinyonge and Nyakakoma) and the identified villages within the KBNP should be considered for the buffer zoning following respectively **Figures 4. 8. 2. 3 & 3. 22. 1. 1**. In the KBNP, settlements were particularly abundant between Nzovu and the highland sector where some of the villages were quite large with over 100 people living in then, surrounded by cultivated land. Drawing on thorough on-the-ground research conducted before (Roe *et al.*, 2000), CBC can work both as a conservation approach and complement enforcement by improving communities' attitudes and reducing human pressure, but can't replace enforcement.

Some questions still remain controversial whichever approach is adopted. What are acceptable changes in ecosystems? Where do we draw the line between human welfare and conservation? Do we let people cultivate in national parks when they run out of other patch of land? In the light of this, it is likely that different people will wish to draw the line in different places, and lines are badly needed. But there are good ethical and practical reasons why conservationists should not assume poverty is someone else problem. As long as people surrounding the park will heavily rely on wildlife species, destruction of wildlife will continue regardless of law enforcement efforts. While rigorous population control policies in these areas are imperative, poverty reduction strategies seeking to create more opportunities that will divert human pressures away from wildlife species and habitats should be developed. The current benefit-based strategies are flawed in meeting these challenges.

Clearly it is not a question of ‘either/or’ but rather of finding a better balance (Kaimowitz & Sheil, 2007). In the end, biosphere reserves, as special places for people and nature, are a key tool to develop truly sustainability systems, this is relevant here and underlines the view of the biosphere as the the ‘global garden’ as ecological sustainability is an ideal established by people and will only be achieved by appropriate human behavior (Bridgewater, 2002). But the battle against biodiversity depletion will only be won on the frontlines by involving local people.

I therefore recommend a more comprehensive and integrated study that will offer more innovative and effective options in view of making the Community Conservation initiatives more plausible. The options should seek to increase more opportunities that will divert the communities from heavy reliance on wildlife species and habitats for survival. The benefits should be more realistic and lead to improvement of local people’s living standards at the household level. In the light of such background, the conservation of biodiversity and ensuring its sustainable management should underpin all of ICCN’s future fieldwork in these two studied sites.

6.1. 2. 9 Governance, Education and Awareness

Good governance is essential for successful application of the ecosystem protection approach. It includes sound environmental, resource and economic policies and administrative institutions that are responsive to the needs of the people. Corruption and political pressure provide impediments to effective law enforcement efforts. As Robinson *et al*. (2010) put it straightforward, if the guards are often sympatic to the reality that the new laws governing PAs have deprived villagers of their traditional access to forest products, they often ignore illicit extraction by locals for home use from forest reserves and national parks.

At the village level, many people are ignorant of the natural resources laws and do not understand the importance of sustainable use of the environment and natural resources. In this respect, management of natural resources, according to the ecosystems protection approach, calls for increased inter-sectoral communication and cooperation at a range of levels (government ministries, management agencies). Because awareness is the first step to solving any problem, there is a need for environmental awareness and education at all levels, from the top ministers down to the school children in the villages. There is also a need to integrate the ecosystem protection approach into agriculture, fisheries, forestry and other production systems that have an effect on biodiversity and accordingly, integrate PAs into broader development and land use planning. It should be noted that activities, supported by training, education and awareness campaigns, have often been some of the most successful aspects of ICDPs, helping to build local "ownership" and support for PAs. The greater challenge is to strengthen national commitment to conservation by increasing the awareness of policy-makers and other major stakeholders of the myriad social benefits of PAs and their critical role in protecting key environmental services (McKinnon *et al.*, 1986). To this regard, community involvement in zoning and planning at their local level would also help alleviate this pressure, all the more so since there is evidence that if rules are perceived as being fair, they are more likely to be accepted (Sutinen & Kuperan, 1999).

ICDPs are no panacea for assuring the long-term viability pf PAs. Nevertheless in a world where government (central and local) and donors are increasingly focused on poverty alleviation, it is clear that PAs will increasingly have to be justified in terms of their linkages and synergies with sustainable development, provision of livelihoods and benefits, and ability to suuply society with ecosystem services. To sum up, ICDPs, with their shortcomings and challenges ahead should be a goal worth trying in the attempt to meet some of these challenges as in conservation agendas it has been recognized that conservation and development are two sides of the same coin (Leyens *et al.*, 2009). Under current circumstances, the support of local authorities for conservation activities is essential, but state-level suggestion to designing the two parks as Biosphere reserves should be looked after. In the face of human population growth, I argue that attention should be put on wildlife as a renewable but finite resource to halt people illusion of boundless wildlife populations (Leopold, 1949). In this regard, there are no easy answers, but education is a start.

6. 1. 2. 10 Park Zoning Perspectives: A Food for thought

The findings of this study have important management and conservation implications for the two ecosystems. Although current management and zoning plans within ICCN does not plan for multiple use zones, there has been pressure to allow human access to parts of these parks. While community conservation strategies aimed at providing local communities, with benefits derived from PAs (such as multiple use zone programs), can help improve attitudes towards conservation (McShane & Wells, 2004), there is limited evidence that illegal activities are reduced in multiple use zones. Indeed in Bwindi Impenetrable National Park which is just a stone's throw away from the VNP and where there are multiple use zones close to the edge of the park adjacent to certain parishes, high levels of human disturbance are often found in multiple use zones (Olupot, 2004). Given that illegal activities are already frequent in the Mikeno massif sector, it would be more prudent to concentrate on other ways of generating benefits for local communities and improving attitudes through gorilla-based tourism revenue sharing (now representing 40% of the revenue sharing), trust funds, enterprise development, etc. Once security resumes and if animal numbers ever reach the levels of the 1960s again these two parks will provide a huge attraction and will strongly compete with Kenya and Tanzania parks as a result (Plumptre *et al.*, 2007). It is important that tourism's primary target – Mountain and Grauer Gorillas- does not remain the only attraction. Only through diversifying the attractions of an area can one maximize the length of time individual tourist will wish to stay. Against this background, I do agree with Kalmowitz & Sheil (2007) that conservation poses tough choices and if species become scarcer or disappear, local people's already difficult lives will be made harder. I therefore argue that conservation activities designed to meet local people's basic needs deserve more attention as wildlife is the essential element of daily life.

In addition, the small area of the Mikeno massif and its elongated nature means that it will be influenced by edge effects, which because of the distribution of altitudes will mean that the lower mean altitude and most species rich habitats will be affected. This situation is similar to the highland sector in KBNP. A look at the shape of the KBNP highland sector indicates that the geometrical rules of reserve design (Schoener, 1988) were not, as it is often the case for many African parks, taken into account when the park was created. These rules advocate for round shapes rather than elongate area. This is because the core 'bar shaped' reserves is more exposed to the external activities then in the case for 'circular' reserves (Ekobo, 1995). Therefore these two particular areas (Mikeno and KBNP highland sector), including the Tshiaberimu should not be buffered when considering the opportunity of nominating the two parks as a Biosphere reserve.

6. 1. 2. 11 Land Security and Conservation

Land has always been a very important and highly contested resource in the Great lake region. As land scarcity is increasing due to human population growth the struggle for land is likely continue to be intense, thus leading to new inter-ethnic confrontations. As a productive asset, land is one of the most difficult assets to acquire, own and develop. For many smallholder farmers surrounding the parks, issues of access to land, clear land property rights and land use present major challenges. Potential ecological consequences of rural encroachment and increased human proximity adjacent to PA include intensification of edge effects, direct reduction of the effective size of PA, and reduction in linkages between PA and resulting disruption of ecological flows (Hansen & DeFries, 2007). As natural lands are converted to agricultural uses, the likelihood of negative edge effects increases (Park & Harcourt, 2002), and the effective area for dynamic processes is reduced (Noss & Harris, 1986).

The absence of appropriate land policies that facilitate equitable access to land and guarantee secure land ownership and use makes it difficult to realize the potential contribution that land can make to agriculture, food security and nature conservation. As a consequence, the kinds of land investments that are required to increase agricultural productivity, improve the environment and conserve nature are thwarted. This prompts, hence the need for sound land policy as an instrument for achieving the goals of sustainable agricultural development, food security and nature conservation (Tambi, 2010).

With the return of refugees and internally displaced persons (IDS) to their homes and the resumption of economic activity, a resurgence of those tensions seems inevitable. It is, therefore recommended to take preventive measures on the ground and to clarify the judicial muddle linked to land law and the status of chieftainships (Crisis Group, 2008). To this end, various new solutions to ensure security of tenure have emerged. In order to address the unequal distribution of land and other natural and mineral resources, the government of the DRC should take the following measures as defined by the international Crisis Group: (i) establish a land commission, composed of provincial authorities and representatives of all communities, mandated to review title deeds and recommended practical measures for the redistribution and re-allocation of estates and ranches in Masisi and Rutshuru (**Annex 13**) so as to reinstall/reinsert landless IDS and refugees, improve inter-communal relations and prevent renewed disputes (UNFCCC-UNEP, 2007), (ii) Initiate a process of consultations with the aim to present to parliament revised draft of the land laws that clarifies the status of traditional chiefs, (iii) Ensure strict application of the mining code of mineral wealth in North and South

Kivu by strengthening agencies responsible for tax collection and supervision of mines and creating mechanisms for the certification and tracking of minerals and other natural resources, (iv) order the military prosecutor to initiate official investigations into the alleged complicity of officers of the FARDC in the illegal exploitation of natural resources and mining, and initiate a judicial investigation into illegal exploitation of wood (Crisis Group, 2008).

Last but not leat, as Mbaya (2010) puts it ‘Women are often restricted through laws or traditional practices which do not allow land to be registered in their names, which hamper or deny them the right to make independent decisions about the use of the land that they utilize, and enter into land transactions. Yet women are widely recognized as being more effective in channeling the proceeds of agricultural activity towards household well-being and livelihood. Hence, central to the step up poverty alleviation efforts will be a call for women’s secure tenure over land and resources, especially given the fact that illegal wood collection is practiced by the majority of women; as such surveillance patrols are always a bone of contention between villagers and the wildlife department. The marvelous quote from Bean (1994) recognizing that the storm clouds gathering around wildlife Act portend a difficult and trying future for advancing a broader vision of, and a deeper commitment to, the conservation of biological diversity since politically-driven threat such as demand for excision of park land remains a crucial park concern.

6. 1. 2. 12 *Does Law Enforcement Monitoring linked to GIS Applications Matter? Are there still Puzzling Methodological Flaws?*

This work deals with the identification of potential WCH using GIS and RS tools. The identification of poaching hotspot is a crucial conservation problem in protected areas where both hunter and hunted are elusive, and where a large number of illegal activities is going on as a result of fast, and relatively unregulated, population growth over the past decade. A large dataset describing known legal and illegal activities and the context of their location was used to perform a spatial statistical analysis to select factors and criteria allowing for the identification of the WCHs. The final result is a map showing the likelihood of WCH to be located at any arbitrary location, thus implying the necessity to direct law enforcement to WCH where wildlife often adopted a siege strategy incurred by human pressure.

The importance of the integration of GIS and remote sensing is highlighted and represents a key instrument for conservation management and for the spatially-distributed characterization of possible uncontrolled poaching hotspots widely seen as important areas of high species turnover, because this is where species may be better able to adapt to changing environmental conditions.

Conservation of biodiversity in PAs involves making decisions on appropriate action from a wide range of options. For conservation to be effective, wildlife managers need to know what actions do and do not work or how effective a given action has been in achieving objectives. However, since the primary purpose of patrols is to uncover, deter and reduce illegal offtake at acceptable level, with LEM data collection often all forms of encounter data might be prone to violations of the basic law enforcement assumptions set in Chapter 2. Therefore there are many questions to be answered about how LEM data can be best collected and analyzed so as the results can be used as a feedback mechanism to steer and optimize field operations by assessing relative quantities and trends in illegal wildlife use, thus informing management decision. This will enable to wildlife manager to direct law enforcement effort towards priority areas and compare the effectiveness of different approaches (Jachmann, 1998). From that prospect, how the number of infractions detected change over time and in relation to changes in protection effort is the key question towards the fulfillment of the wildlife management issue.

6. 1. 2. 12. 1 Monitoring Change in Encounter rates Pattern versus Protection Effort: Relevance for Conservation Policy

If the assessment and subsequent monitoring of animal populations is the foundation of effective wildlife management (van der Hoeven, 2007), how does counting species or illegal incident translate into management response is the key focus of any law enforcement monitoring. Indeed, measuring is not protecting (Sheil *et al*., 1999). Much of the current scientific emphasis is on ‘watching’ problem proceed rather than trying to halt them. Indeed, the data may be useful for scientists, but good resource managers know that taking stock is not the priority (Sheil, 2001) during wartime. It’s therefore far more valuable to identify problems, threats, and prevention strategies early and ensure that adequate management interventions can be taken. Threats must be identified and priorities revisited in order to underpin management and conservation practices.

Catch per effort indicators or encounter rates of illegal activity are estimates of relative abundance of illegal activity that bear a certain relation to the actual quantity of illegal activity (Jachmann, 1998). As such, an increase in patrol effort is expected to produce two opposing effects: (i) a decrease in the total number of infractions due to deterrence and (ii) an increase in the proportion of those infractions which are detected (Burton, 1999). Examining the case in VNP and KBNP, it clearly appears that increase in enforcement effort may lead offenders to make fewer hunting trips, and others to change the deployment on the ground. **Figure 4. 4. 3. 3** on armed contact encounter rates shows that human incursions have penetrated deeper into the VNP; suggesting that the composition and *modus operandi* of the poaching gangs should have changed as a mean of adaptive strategy. Alternatively, however, offenders might substitute one type of infraction for another (Becker, 1968). This is consistent with Nyahango *et al*. (2005) indicating that hunters in Tanzania responded to increasing costs of enforcement by travelling at night. Moreover, reflecting recent thinking, Robinson *et al*. (2010) argues that rule-breakers may also adopt other forms of avoidance behaviours, trading off increased costs or lower efficiency for a reduction in the probability of being caught.

6. 1. 2. 12. 2 ***Hotspots Policing on the Ground and Setting Conservation Priorities***

The effectiveness of the hotspot polcing has strong empirical support and such approach would be much less useful, however, if they simply displaced wildlife crime to other nearby places as a result of focused intensive enforcement hotspot patrols. In order to ensure that research into rule breaking can be used to underpin management and conservation practices, a close reciprocal relationship between models and data is needed. Models can guide data collection and help to determine the minimal data requirements for robust decision-making (Keane *et al*., 2008). In the same line of thought, Salafsky *et al*. (2001) have promoted adaptive management approach to ecological monitoring and project appraisal. Such an approach could be taken with enforcement to allow data to be collected in a more targeted and systematic manner. From that prospect, I do agree with Keane *et al*. (2008) that future research should also explore other potential avenues for the collection of data about rule breaking including novel interview methods for the collection of sensitive information, such as the randomized response technique (Solomon *et al*., 2007).

As things stand right now, the understanding of the effects of WCH remains very general. In policing, most innovation has been developed using what might be termed "clinical experience model". Hotspots policing developed here is a model for the integration of research in the world of policing, and this integration has produced what is, according to empirical evidence, the most effective police innovation of the last decade. However, as I noted earler, there is still much to be learned, including how specific policing strategies affect specific types of poaching hotspots (Weisburd & Braga, 2006). Nonetheless, we don't know enough about how other forms of displacement, such as changes in methods of wildlife crime affect the crime control benefits of hotspots approaches.

While a strong body of evidence for the effectiveness of hotspots policing is convincing, I do think that there are still significant gaps in current knowledge about the effects of these law enforcement interventions. One of the key gap remains that little is known of which specific hotspot strategies work best in which specific types of situations. As Braga (2001) pointed it out "while there is strong evidence that focusing on hotspots reduces crime and disorder, research has not yet distinguished the types of hotspots strategies that lead to the strongest crime prevention benefits". In the meantime, recent assessments have shown that opportunities for conservation outweigh the available funding, and hence some form of prioritizing law enforcement operations within geographic areas for conservation is needed. Indeed, funding for conservation is needed in many parts of the park management units; thus there is no shortage of potential recipients. The current form of WCH analysis will assist conservation-planners, scientists and financiers in allocating their efforts where the potential benefit per both species and habitat is greatest in reducing offenders' ecological footprints in the park.

Most spatial analysis of crime reports that has a strategic objective identifying spatial concentrations referred to here crime hotspots. Law enforcement agency is particularly interested in analytical frameworks that identify wildlife poaching hotspots. Spatial analysis techniques in spatial statistics are primarily based on several hypotheses and require a lot of computational effort. One of most common types of tactical crime analysis are geographic profiling (Rossmo, 2000) which helps to identify key area helps to identify key areas of activity of a particular offender. However, one commonly used tool with several tools for both strategic and tactical analysis is CrimeStat (Levine, 2007). CrimeStat is windows based and interfaces with most desktop GIS programs. It contains utilities such as spatial description, distance analysis and travel demand modelling. Indeed, one of the major shortcomings of CrimeStat is its lack of computational scalability to analyze large crime datasets (Celik *et al*., 2007). Current tools such as CrimeStat take around 2.5 hours to compute crime hotspot on a databse of 14,852 crime reports. With the increase in the amount of wildlife crime reports that are being archived on a day-to-day basis, park management requires computationally efficient analytical methods that can scale to very large datasets. If analytical tools as CrimeStat had been used by law enforcement in the above scenario the wildlife crime analysis caveat could have likely been solved much earlier. It would be more helpful in the near future if current analytical tools and methods could be improved so that the temporal semantics of spatio datasets into account in order to identify the frequent routes taken by particular types of rule-breakers. This is, in my view, the next step to explore in the attempt to respond to the basic question of spatial analysis on crime datasets which is “Why does wildlife crime concentrate where it does? (Buchanan, 2008). To that end, human activities analysis from a time-geographic perspective is paramount.

6. 1. 2. 12. 3 ***ArcGIS at the Heart of Law Enforcement Monitoring and a strong Backbone for Conservation Strategies***

For each patrol, a standardized patrol form should be completed, including general information on the patrol, information on wildlife sightings and carcasses, encounters with illegal activity or indicator of illegal activity and information relating to the patrol route followed. This method appears to be labour intensive on two accounts: (i), patrol movement was obstructed because the patrol secretary had to continuously stop every incident, and (ii), data extraction required a minimum of 3 permanently staff working full-time on LEM data entry at the headquarters. Such work overload prompts the need to use of Cybertracker to ease patrol deployment in the future.

Important consideration which is often neglected in LEM analyses of encounter datasets is the effect of incentives faced by the data collectors (Chapter 2). Quantification of law enforcement effort deals with patrol activities with emphasis on the time spent actively patrolling on foot or actively engaged in investigation.The link between guards reward and the effort they invest, or number of infractions they detect, is not always clear (Keane, 2010) as they may face strong pressures to turn a blind eye to offences committed by friends’ family or neighbours (Abbot & Mace, 1999) or may face threats to their safety (Hart *et al*., 1997). Mounting evidence in KBNP has shown that persistent decrease in the numbers of fuelwood collection (**Figure 3. 8. 2**) and mining (**Figure 3. 8. 1**) is rather the indication of the “familiarity” of the park staff with the offenders to the point that park guards and wardens often depended on kickbacks from illegal mining to survive following their starvation wages (Chapter 3). To this end, patrol reports (Bell, 1984b) may be subject to technical error, accidental or deliberate omissions, and falsification.

Unsupervised guards face some flexibility in determining how they record and book a particular offence. Booking the lesser offence reduces deterrence for serious crimes but it does allow the guards to spend the reduced booking time on patrolling instead. By booking a lesser offense rather than no offence at all the staff are also signaling to the wildlife managers that they are doing their job in as much as they are patrolling, detecting and accordingly punishing illegal activity. Another reason why forest staff and wildlife managers may not be inclined to book more serious offences is the low rates of conviction that reduce the deterrence effect of the forest laws and further reduce the incentives for guards to incur the extra cost of processing a ‘prosecution’ case.

Park guards can also choose to take a bribe – perhaps influenced by the relative wealth of the illegal extractor - rather than make a formal charge as it's seen in fishing, fuelwood and charcoal extraction in these two parks. In this regard, bribes do provide some regulation of natural resource extraction; and indeed they create an incentive for the guards to put more effort into apprehending individuals (Mookherjee & Png, 1994). But with such informal regulation, much needed funds do not reach the wildlife manager, and little data can be collated concerning the number of illegal acts that are detected and punished. In addition, some points outside of the park were noticed with an average distance of 3.5 km to the nearest park limit; they ranged from 1 m to 15 km. These distance discrepancies can likely be attributed to human error through incorrect data entry or map interpretation. Digital field input using Cybertracker or efficient handheld GPS receivers could help alleviate some spatial registration problems, because even a 1° error in entering a latitude coordinate results in an error of approximately 111 km. The latter traducts into about three week park force patrolling coverage. Therefore the debriefing exercise is a way recommended in minimizing such setbacks in data collection. One of the findings from the evaluation that emerged from the SYGIAP Goma workshop is that up to 40% of patrols in the WHSs were operating without GPS units. This means that no geo referenced data could be collected from these patrols, thus greatly reducing the value of the information that they gathered (Aveling, 2007). Purchasing of a suite of additional GPS units in order to increase the number of patrols that can collect geo referenced LEM information remains crucial.

Evidence from the field has shown that biological surveys were likely to be less prone to deliberate manipulation, but in many situations they even provided data in remote areas where routine law enforcement patrols could not reach at the height of civil strife. In sum, and building upon Jachmann & Billiouw (1997) finding in Luangwa Valley, Zambia where increasing manpower input and increasing average cash bonuses to scouts correlated with reductions in the numbers of elephants that were killed, I do agree with Keane (2010) that well designed management programs can provide incentives for effective patrolling and accurate reporting. For optimal deterrence, part of the guard force should be deployed in a number of patrol post, strategically deployed over the conservation area with the effective staffing density of 33 EPMD no matter the type of illegal activity prevailing. To all intents and purposes, less than 20% of the field force should be involved in non-patrol duties (Jachmann, 1998) well described in Chapter 2.

How much is enough in estimating the minimum sampling required for effective species and illegal events monitoring? For the sack of efficiency, guards' patrols, hunters and fishermen tend to concentrate their effort in areas where there is a high probability of encounters. When effort is 'intelligence-led' (e.g., acting on prior information about where encounters are likely), the relationship between effort and the number may be difficult to predict. In the addition to the difficulties it creates for defining an appropriate measure of effort, Keane (2010) and Holmern *et al*. (2007) recognize the potential problems the use of informants raise for analyses of patrol effort. The scale at which patrol and other forms of encounter data are collected therefore has important consequences for how it can be used, and how it must be analyzed.

Other factors can lead to non-random sampling patterns, such as ease of access (Gaveau *et al*., 2009). Alike the present research, several studies of enforcement measures have compared rule-breaking at the level of entire national parks over a number of years (Jachmann & Billiouw, 1997; Hilborn *et al*., 2006). This approach is reasonable so long as the patrol effort is near-randomly distributed within the parks (**Figures 3. 5. 2 & 4. 2. 2**) but, if patrol coverage is patchy or inconsistent, apparent changes in the level of illegal activity might be real or might be caused by biases due to changing sampling or poaching patterns (Walters, 2003). If data are analyzed at an appropriate fine scale to distinguish between patrolled and unpatrolled areas this need not to be a problem, but interferences cannot be made about the areas which are not adequately represented within the sample (Walters, 2003). Achieving high resolution requires greater patrol effort and interpreting data at finer scale may require sophisticated analytical techniques that might not be available at sites level. In fact, often management decisions (for surveillance, tourism, etc.) don't require statistically significant results (Sheil, 2001). Park managers need a steady flow of real-time information which is delivered without disruption, and a management decision can often be taken based on a less scientifically rigorous approach (Chapter 2).

When surveying clustered species of illegal incidents, a common approach is to treat each cluster as a single encounter and then scale subsequent estimates according to the average (Rosenstock *et al*., 2002). Where data are collected opportunistically; as is the case in patrolling, autocorrelation cannot be reduced by design but may be tackled by the incorporation of spatial covariates or explicit modelling of the autocorrelation (Nishida & Chen, 2004). A related problem is that of selection bias (Ferraro, 2005). Patrols and rule-breakers occupy heterogeneous landscapes, and factors such as ease of access may influence the decisions of both set of actors about where they concentrate their effort. Consequently, areas that are easily accessed (e.g., near to park limit, paths or rivers) may be used more often by offenders and also patrolled more often, potentially creating spurious correlations (Chapters 3 & 4). This kind of problems of endogeneity and selection are common in the social sciences (Kennedy, 2001), so the analysis of patrol data remains an area where closer collaboration at all scales involving scientists and wildlife managers. By working together, the two groups can forge a new and more robust method for improving the analysis of patrol data and accordingly, a sustainable future with these parks' wildlife. We're not quite on the right track-yet.

On the other side, standard statistical techniques to encounter data, such as generalized linear model, assume that every data point is independent. However, at finer scales this assumption breaks down. Encounter data collected at relatively fine spatial and temporal scales often include large number of zero observations with no encounters. This may complicate statistical inference, and is referred to as zero-inflation if the number of zeros is greater than can be adequate by standard probability distributions (Zuur, 2009). Zero observations may be classified as 'true' zeroes (e.g., area in which the species or incident was not present) and false (e.g., area where the species or incident was present, but remained undetected) for some reason (Martin *et al.*, 2005). False zeroes can occur if ranger if guards fail to report infractions either because they face incentives to cover them up, or because of inadequate training or persistent insecurity in the area under control. In patrol data, the probability of detecting infractions may sometimes be close 1 (e. g., Jachmann & Billiouw, 1997), but it will often be the case that some illegal activities go undetected despite patrol effort.

The collection of better data must go hand in hand with the adoption of appropriate analytical techniques, and each process should be designed with the other in mind (Keane, 2010). I argued that effective protection and law enforcement is recognized as among the most important factors affecting conservation of PAs. As such, LEM should be kept as simple as possible and associated with field staff payments; as such it can keep going even through both periods of peace and armed conflict

Since during wartime, it's nearly impossible to acquire such information purely on the basis of field assessment and monitoring (Heywood, 1995), satellite data from several time points allows the creation of land cover maps (**Figures 3.20.1 & 4.5.1.1**) over greater spatial extents and more frequent time steps than is possible with expensive and detailed field studies (Jensen, 2000). The use of such analyses in the future will allow determining a spatially specific response of a landscape to an event, a time period, or something such as a policy or tenure change in the VNP and KBNP ecosystems dominated by ever-growing population. To sum up, if one is to protect what is left, he/she is needs not only to provide real time relevant information, but also to be at the forefront of the decision-making processes, particularly in the present digitally connected age.

While maintaining detailed records using standard recording forms and GPS units, simple classical paper and pen recording system may still be effective if well designed and supported. The opportunity of using the Cyber Tracker device is worth trying (Steventon, 2002). The latter has proved to be the most efficient method of field data collection which requires no programming skills, and allow one to customize an application for his/her own data collection needs and design the electronic field guides with species identification filters. CyberTracker is the most efficient way to gather large quantities of geo-referenced data for field observations at a speed and level of detail not possible before with an icon interface enabling significantly faster data collection than text interfaces or written methods. Observations can be entered with a simple Radio List or a Check List while the number and text fields can also be entered by means of conventional key pads or keyboards. In addition, the automatic GPS Timer Points records the path followed by the observer and makes it possible to measure the Effort of data gathering, hence facilitating the debriefing exercise and consuming data clearing processes.

Patrol has been measured in many different ways, particularly in bushmeat system where the most commonly used measures of effort are likely to reflect the inputs to harvesting more accurately than harvesting-induced mortality (Rist *et al*., 2008). The most useful and simplest measure of effort is EPMD per unit time (month or year) per unit area (conservation area, park management unit, or grid square for conventional patrols). Greater standardization of the data collected by patrols via use of tailored MIST system database already in place could enable large scale comparisons of enforcement and illegal behavior between different PAs. As the PAs base maps stand now, there are no cartographic features supporting the physical demarcation between patrol posts. There is cruical need to generate patrol post boundary shapefiles in the near future.

Overall, a conservation and adaptive management strategy anchored in law enforcement monitoring using CartoGIS tools represents the best option for the future of protected area biodiversity, and in particular for its large-bodied mammal population. Rules, whether implicit or explicit, remain at the heart of every conservation and natural resources management system. The mere existence of rules does not guarantee that they will be followed (Rowcliffe *et al*., 2004), so the success depends on the ability of wildlife managers to influence the behaviour of resource users, and enforcement therefore has a vital role to play in the conservation of natural resources if the park has to remain the cornerstone of efforts to protect biodiversity. From that prospect, I would like to recommend that the new Wildlife Act under consideration empowers ICCN to fulfill the following four overriding roles in the near future: (i) law enforcement and control of illegal activities; (ii) communities conservation activities designed to reduce conflict between the park management and local communites and build local support for conservation; (iii) research and monitoring, and finally (iv) supporting tourism development. Without compliance, however, laws and regulations to guard the public interest are meaningless so rules, and the measures to enforce them, are at the heart of protection of PAs is essential if conservation is to be successful. Bearing in mind such compliance, the next question for protected area managers remains “Are we managing what we say we are?” (Parrish *et al*., 2003).

Validating patrol data with alternative source of information as epitomized in (Chapter 5) proved useful as some of the problems of interpreting patrol data only be overcome through comparison with alternative sources of information on illegal activity. Assessment methodologies should stress the importance of identifying both existing and potential threats, as effective management seeks to be pro-active in preventing degradation before it becomes severe. Recognizing the sources of threats – that is, the underlying or root causes – and the impacts caused by the threats can both be important for a more complete understanding of the context.
While evaluation protection effort on regular basis helps management to adapt and improve through a learning process, effectiveness assessments should at least record the quality of relationships between PA managers and local people. To that end, collaboration is paramount.

Finally, law enforcement’s efforts in safeguarding PAs have been enhanced in recent years by the growing use of more robust and user-friendly desktop GIS applications. The study shows that when poaching upsurge occurs, accurate maps are essential to help guide anti-poaching and reconstruction operations within PAs. Indeed, CartoGIS was instrumental in developing recovery effort strategies for the KBNP and VNP. GIS has proved powerful tool for assessing illegal activity patterns and prioritizing needs. It was on the frontline helping park staff deal with the myriad tasks required in handling multiple poaching incidents in the midst of political instability. It further illustrates how the effects of natural resources depletion can be estimated using CartoGIS so that mitigation efforts and emergency response can be planned in helping to cope with wildlife crime. One fact rings certain; cartography has never been so critical to ICCN mission for protecting wildlife. Whether preventing, responding, or mitigating the effects of man-made or natural perils, GIS proved an invaluable tool for wildlife management. Ranger-Based Monitoring through CartoGIS allows wildlife managers to run law enforcement operations efficiently and cost-effectively, even in times of uncertainty, providing up-to-date and real-time information on which to make informed decisions for a conservation area. To this end, geographical technology such as GPS receiver and Sate-of-the art GIS has now become mainstream as far as tackling tomorrow’s threats and protecting biodiversity in the park is concerned. In sum, CartoGIS has initiated major shift in the day-to-day management paradigm of PAs in DRC- let's make this asset intelligent for further protection of biodiversity. The future of asset mapping lies in the provision of a single web-based service that maps all PAs network utilities' assets at DG-ICCN so that site-based data managers nationwide can store data in different environment, hence securing the benefits from data backup exercise. Although conservation policies and activities are developing progressively towards a more protection of biodiversity, we are still far from halting or at least slowing down the loss of this biodiversity (Van der Hoeven, 2007) basically due to heavy armed poaching. Notwithstanding, one can therefore confirm beyond the shadow of any doubt that law enforcement monitoring linked to CartoGIS application matters in protecting wildlife through essential information flow.

6. 1. 2. 12. 4 Areas for Further Research

The relevance of this thesis articulated in Chapters 1 & 6 indicates that despite number of relevant insights into the efficiency of enforcement measures generated through hotspot analysis and other validated by socioeconomic method many questions relating to the practical implementation of enforcement measures remain to be answered. The work reported in this thesis has outlined some key issues for further consideration. Future development of this work should include the following:

Mounting evidence suggests that human are substantially reducing the diversity of biological resources at an unprecedented rate through hunting. While the relevance of this issue has been widely recognized, the practical significance aimed at designing appropriate conservation interventions remains poorly explored. It is increasingly clear that there is no panacea to solving conservation dilemmas (Ostrom & Nagendra 2006). Understanding factors that influence the success of protected areas in curbing unsustainable resource consumption is essential for determining best management strategies and allocating limited resources to those projects most likely to succeed (Kendra, 2009). Furthermore, understanding which factors influence the index of catchability of harvesting and determining the sustainability levels of natural resource use in current context in which the park management goal is both to conserve the resource and to meet the needs and aspirations of the people using that resource is clearly a priority for future research. To this end, algorithms for assessing the sustainability of hunting should take into account the production, stock-recruitment and harvest models within the catchment area.

The study results point to several avenues of further research, including dynamic of biodiversity at large spatial scales (Pettorelli *et al*., 2010). Future efforts could examine geographic profiling, wildlife crime prediction, and the spatial displacement of offenders as a means to mitigating wildlife crime (Wing & Tynon, 2005). More sophisticated wildlife crime analyses using space-time accessibility approach might address causality in relation to protection efforts. Research on space-time accessibility in law enforcement field should focus on determining and assessing the opportunities for rule-breakers activity participation making allowances for network-based travel times, and analyzing offenders' activities and travel possibilities from a time-geographic perspective (Neutens *et al*., 2008). In this regard, cluster criteria could include nearest neighbour, farthest neighour, centroid method, group averages, and minimum error using improved version of current CrimeStat tools (Levine, 2007). Other scientific challenges relate to the optimal management of PAs, where ideas based on adaptive management are becoming more popular (McCarthy & Possingham, 2007).

Despite being one of the most common pieces of information used in assessing the status of natural resource stocks, relative abundance indices based CPUE data, as used by Myers & Worm (2003), are notoriously problematic (Hilborn & Walters, 1992; Walters, 2003). Raw CPUE is seldom proportional to abundance over the entire geographic range, because many factors affect catch rates. Since good prediction of catch or CPUE does not necessarily infer into good estimation of abundance, but is often assumed to estimate a year effect, required future research should include (i) exploring new methods for standardizing CPUE, anticipating changes in requirements of management and rule-breakers response, (ii) developing tests to determine which methods provide the best index of relative abundance, (iii) defining what data should be collected in the future to capture changes in relationships between catch and effort, and to ensure information context and usefulness of long-term data series; and (iv) exploring new methods for standardizing.

The current available standardization methods that are generally applicable can be examined using simulation analyses. These analyses should include many different combinations of population, catch, and effort trajectories, e.g., many possibilities which might represent some realized situation. Looking ahead, one might hope that as more data become available, this index method can be used to fine-tune the tracking of the status of mammal populations and illegal activity into the future, hence adding value to investments already made in PA monitoring, and yielding further useful insight for conservation. Other methods can be further tested and improved as well, e.g., these indexes could be used directly to measure progress towards the

CBD and successive targets, or their utility could be increased further by combining them with other indicator data, such as remotely sensed habitat information (Joppa *et al.*, 2008). At any rate, I do hope to contribute to these and other related studies in the future.

On rather economic groung, Cost-Effectiveness Analysis (CEA) provides an objective assessment process that can help us to evaluate the effectiveness of different conservation programs and adjust them in adaptive manner to improve the chances of success. Therefore ecological and economic evaluation should be a key component of biodiversity conservation programs since it underpins the efficient allocation of resources (Laycock *et al.*, 2009). The long and the short of it is that CEA and other objectively-constructed methods should form an important part of the wide body of evidence base for conservation and evaluation.

In light of the participatory demarcation of the park boundaries, all efforts to demarcate the spatial extent of the parks have as only goal the restriction of the human habitations and the park boundary violation. Above all, the legitimizing of digital spatial boundaries by governing agencies is critical for the advancement to legally accurate cadastral information systems. From a legal and regulatory perspective, time specific comparisons of reliable park boundary position frequently form the basis for establishing title to valuable ecosystem property and defining the geographic scope of jurisdiction regulations. Such comparisons are equally significant to wildlife managers and scientists seeking to identify future boundary movement; and determine potential impacts of relative rates in park encroachment level rise. In this regard, Mague & Fowler (2008) argue that, due to a lack of understanding of mapping principles and technologies, the legal description can be inadequate to develop a mapping solution.

Integrated all relevant governing agencies would be critical to build an effective park cadastre system and, for capacity building, the land surveyors and the scientist would need to work together to build efficient land cadastre system for PAs. Data depicting park limit will enable to overcome the toponymic inadequacy of the existing maps and the ambiguities deriving from the large number of local languages. Each boundary landmark should be a unique point named after the park limit identification number so that it can be queried and data can be attached to it. Integrating cadastral mapping will ensure that information is stored in the database and displayed by clicking on it. Data related to physical park limit should be managed by authoritative sources, including the Ministry of land and the National Geographic Institute (IGC) as well as the ICCN at both sites and Kinshasa headquarters levels.

The target audience for this thesis has primarily been wildlife managers involved in the day-to-day PA management; however the study illustrates the importance of linking socio economic approach to long-term LEM data in a research designed to investigate and understand issues surrounding poaching and factors affecting it. In this regard, successful conservation of hunted wildlife requires collaboration at all scales involving local people, scientists and wildlife managers. By working together the three groups can forge a new and more robust method for humans to share a sustainable future with the park's wildlife. The problem of poaching can only be tackled by looking at the wider socioeconomic and institutional context within which it occurs, from household economic to national and global terms of trade. However, since compliance with the rules of resource management systems cannot be taken for granted for one hundred pourcent, in some cases, therefore it may be desirable to identify situations where rules of thumb can adequately inform day-to-day decision-making (Keane *et al*., 2008).

An understanding of ecosystem dynamics is also vital in the face of increasing demand for fuller and more diverse human use of PAs. Simply compiling inventories of plants and animals is insufficient. Research must illustrate causal and controlling elements of ecosystem processes. Ultimately, this requires a commitment to long-term monitoring, and thus is probably the most fruitful avenue for future research in PAs. As Croze says (1984), "Without the kind of understanding which ecological monitoring priorities provides, a PA cannot be properly managed and that means a PA will not long survive". In the final analysis, both research and management must be people-focussed and link directly to policy formulation. Information derived from scientific research must be incorporated into meaningful management practices and must have input into research priorities. By highlighting the importance of crucial sources of bias that might otherwise be neglected, a better understanding of patrol data stands to benefit management practices in every field that relies on encounter data. To that respect the next generation utility will have three primary goals, including operational efficiencies, environmental stewardship, and service reliability. ArcGIS information-based LEM data will be crucial to each of these. Any utility without the right GIS data is blind as data model is part of a parcel solution.

Given the importance of policing for the protection of biodiversity in the park, it seems reasonable that wildlife crime policing should start thinking of the development of a new model taking into account the fact that placed-based policing within the parks will not simply move "crime around the corner" but patrolling interventions directed to specific WCH are more likely to lead to a diffusion of crime control benefits to areas nearby as well as the modes of adaptation to park force interventions, including the methods of committing illegal acts. What then should the wildlife management do in the face of break-ruler modes of adaptation to park strike forces interventions? While such a shift is largely an evolution in trends that might have begun over the last few years, it will nonetheless demand a slight changes in data collection and tactics in policing, in the organization of staff patrolling.While the net gain in wildlife crime prevention may still be large for hotspots efforts, these findings suggest the importance of continued investigation of possible non-spatial displacement outcomes in hotspot policing.

The research results suggest that the prospects for wildlife conservation in studied areas known as 'pearls' of wilderness look rather bleak as the result of the depletion of the natural resources at an alarming rate at a time when we need it most for sustaining human life. Given the current trends, we can expect our legacy to be a landscape dominated by relatively empty forest patches. Without informed conservation decision processes, adaptive management taken as an iterative process integrating monitoring directly and a strong political will from the government, we are unlikely to contain the relentless hemorrhage of some of the most charismatic components of these sites. The ultimate goal of a wildlife manager building upon the LEM program should be to protect and utize the resource efficiently by meeting the needs and aspirations of the present without compromising the ability to meet those of the future (World Commission on Environment and Development-WCED, 1987). Addressing these issues will require input from social and natural scientists, as well as policy makers and practitioners (Sanderson, 2005). Above all, the results presented here show that Pas in DRC need urgent support if they are to successfully preserve their biodiversity in perpetuity. One of the problems with the idea of sustainability is that it can only be defined on the basis of what is known now. What about the many factors that are unknown or unpredictable? Thus sustainability has ecological, economic and sociopolitical dimensions. How such strategies can best be achieved remains an open question, particularly when the potential benefits from illegal or unregulated hunting of wildlife can be considerable (Hofer *et al*., 2000).

6. 1. 2. 13. *Future Policy Framework in Responding to the Daunting Challenges ahead*

The policy framework which follows provides the foundation and guiding principles on which the national law governing wildlife is to be prepared. The changes and challenges outlined earlier caution against prescriptive laws which attempt to be universally applicable at all times and in all places. Rather the laws should aim to enact overarching goals and principles unequivocally, while allowing sufficient flexibility in their detailed interpretation and application to conserve biodiversity in the face of the rapid social, economic, and scientific changes underway in DRC and globally. In essence, this implies removing most of the existing legal limitations to sustainable use of wildlife and replacing them with fewer and more flexible instruments. The overarching goals and principles should, in as far as possible, provide the legal umbrella under which the procedures for determining and changing of local regulations are devolved to ICCN and other mandated conservation agencies, without recourse to parliamentary legislation.

With conservation now springing up around the world with the fundamental goal of the policy was taken to be the maximization of returns from wildlife as a natural resource. Government policy should thus encourage the best long-term combination of land uses and fair distribution of benefits accruing from those uses. Such uses were to be promoted and regulated by the Wildlife Service in the interests of making a net contribution to DRC's economic and social development. Such policies outlined are consistent with evolving government guidelines on current decentralization, economic liberalization and poverty alleviation through the provision of economic and social opportunity to the poorest Congoleses, as outlined in the Strategic Document on Growth and Poverty alleviation (RDC, 2006). In an effort to reverse the top-down preservationist approach to conservation underlying the growing human-wildlife conflict, the policy explicitly suggests starting on the ground where the biodiversity is and the problems lie. The grassroots approach begins with the identification of the legitimate stakeholders and encourages the formation of partnerships, recognizing the sliding scale of jurisdiction that ICCN and other governmental agencies have on lands ranging from national parks and reserves to private and communal lands. The partnerships are to be mobilized, given legal standing and the capacity to identify the threats to biodiversity and incentives to conserve it. They should permit a great deal of flexibility in adapting a broad set of national goals to local circumstances.

More recent research shows that human impact can be a positive as well as a negative force ecologically, depending on the type and level of disturbance. The removal of certain disturbance factors such as fire, pastoralism and shifting cultivation can be as prejudicial to biodiversity as over exploitation, particularly in ecosystems where human activity has played a shaping hand ecologically over several millennia. Despite common prejudices, human impacts in the tropics are not always wholly detrimental, and many land-use alternatives have biodiversity benefits as well as costs. Many species can and do flourish in nonpristine environments (Robbins *et al*., 2006). For example, in Bwindi National Park, it was found that gorillas (*Gorilla beringei beringei*) like to feed where thick herbaceous growth follows disturbance and so may have benefited from logging (McNeilage *et al*., 2001). Human activity must therefore be judged in terms of its impact on biological diversity, rather than whether it natural or not. Therefore management in PAs should, as far as possible, be used conservatively and only when habitat fragmentation, the loss of mobility and ecological disruption threaten biological diversity. In as much as human activity has long been an element in all ecosystems, the principles guiding its significance should be whether it creates or degrades biodiversity. Other factors such as aesthetics, economics and cultural considerations should be evaluated within this context

The rights of use over wild animals in proposed biosphere reserve are to be linked to responsibilities. The granting of user-rights should not exclude any particular use of wildlife resource which adds support to the conservation of biodiversity, provided that use is deemed humane and sustainable by ICCN, and is covered by legal provisions. ICCN shall, in granting user-rights, also define the terms of withdrawing those rights. The conditions shall include the right of ICCN to inspect management facilities, count or monitor wild animals, establish and enforce legislation and regulations, arbitrate disputes over user-rights and conditions, or appoint an approved agent to do so on its behalf. The intent in so doing is to promote incentives to conserve while simultaneously reinforcing the laws, regulations, and contractual arrangements applying to the user. In line with such a locally-driven approach to conservation, structural and functional changes are required within ICCN. Finally, an implementation strategy using a step-by-step approach is called for, based on learning from the experience of what works and fails.

Based on the principle that the more reasons to conserve biodiversity the better, ICCN should explore all possible avenues to encourage conservation. The avenues for doing so can be broadly classified under conflict mitigation (reduction of costs), and incentives to conserve (creation of benefits). In a broader sense, conflict mitigation includes any measure giving relief or benefits to landowners to the extent that they are more willing to accommodate wild species. In this sense it also includes the use of wildlife resource and cost-coverage/benefit-sharing programs. And, given that the conflict is a two-way process, conflict mitigation also includes any measure leading to greater mutuality between people and wild species, including education, training and deterrence. Support groups such as ‘friends of national parks’ should be encouraged.

Finally ICCN, has a legal mandate to enforce wildlife laws and regulation following recent wildlife Act (RDC-Primature, 2010). The functions outlined in the above mentioned document should continue to be the top priorities for ICCN. However, given the broadened mission statement spelt out in the wider policy goals, including *in* and *ex situ* aspects, protected area management should reflect these changes. ICCN should formulate a strategic plan of action for implementing the new policy. The strategic plan should be experimental and sequential, proceeding cautiously on the basis of successes and failures. In as far as possible, direct use should commence experimentally in areas of high human-wildlife conflict and on problem animals. Compensation for crops and livestock, on the other hand, has proved financially insupportable and subject to corruption and abuse. The victims of wildlife depredations rarely received any compensation and claims were easily falsified. Alternative ways of covering the losses of genuine victims of wildlife depredations should, nonetheless, be explored. One option involves wildlife associations entering into group insurance schemes or, alternatively, establishing their own compensation funds to compensate the most affected members of their association. Emphasis should be placed on compliance with the terms of use among partnerships and finding the right balance between incentives and enforcement. A free-for-all policy is likely to accelerate losses, given the evidence of the open-access use which is at the root of over-exploitation of wildlife and other natural resources, especially among poorer communities. Overall, the policy framework suggested here addresses the need to lay out an achievable biodiversity strategy by establishing a problem-solving process rather than a rigid blue-print for conservation. It also creates an enabling atmosphere in which biodiversity conservation in DRC protected areas network can thrive locally and nationally

6. 1. 2. 13 ***From Horror to the Audacity of Hope***

Dreams! My hope is for a new beginning based not on the destruction of the old but on its reevaluation. If lucky, we may succeed in making the KBNP and VNP not the master of the earth (a trivial goal), but rather an example to other nations of what is possible and beautiful. In closing, this thesis builds upon good prognosis and marvelous quote distilled fromVedder *et al*. (2001) and stressing the following: As the DRC is entering a new post conflict era, enduring peace remains elusive as soldiers, militias, and racketeers continue to terrorize local citizens and plunder the wildlife, minerals, and forests. But we can still draw hope for the both war-torn parks by looking at the case of Uganda. Indeed, throughout the 1970s and much of the 1980s, Uganda was the prime example of political, economic, and social chaos in Africa. Hundreds of thousands were killed in its political pogroms and recurrent civil wars, as a consequence many refugees fled into parks and reserves.

During this period, the Ugandan government has lost control of wildlife and parks entirely and many guards on patrol in park were outgunned and frequently killed by gangs and rogue soldiers. Other game guards poached wildlife in parks. Rhinoceros, cheetahs, African wild dogs, and roan antelopes were completely eliminated in Uganda. Elephant herds were decimated, only young tuskers tuskless animals survived. With the advent of peace in 1987, Uganda civil society began to rebuid. As Ugandan’s civil society recovers, the country’s wildlife and natural environment also proved resilient. The national government now publicly endorses conservation in many areas, promotes collaborative forest management with local communities. Elephant herds are growing quickly and some Ugandan conservationists are lobbying to reintroduce some wildlife species extirpated during the war. The healing process is fraught with tragic choices made in attempt to balance the needs of still fragile wildlife populations with urgent demands of the rural poor. Still the esperience of Uganda gives hope to those in neighboring DR Congo. Africa has been through many ordeals, and has survived them all. Like the forest, its people have remarkable capacity for recovery and renewal.These national parks can once again boast that they still stand among the African's top-ranked ‘pearls’ of wilderness and breath a sign of relief provided that a fairly healthy protection effort and noteworthy government support are going on in the most efficient manner.

The insecurity in Eastern DRC including national parks is a symptom of broader governance failures and the inability of the Congolese state to control the monopoly of violence. In that respect a top priority for policy makers should be to build a functioning national army based on a unified chain of command, which is both operationally effective and accountable. There should be a unified framework of foreign assistance to pursue a single approach to doctrine, training, provisioning and the establishment of an effective accountable payment structure to ensure soldiers receive living wages, rations and medical health care in an effort to reduce their pressures on protected areas’ resources. Protected areas must be cleared of both unchecked government soldiers and militia gangs before major progress are possible in the framework of ongoing wildlife agency restructuring. Only so, can we express the hope to put an end to current pernicious effects of the tragedy of the commons, especially, at this very point in time when the conservation of biodiversity stands at the crossroads. Conservationists could then view biodiversity within protected areas as a ‘glass part full’ rather than a‘glass part empty’.

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ANNEX 1 : ORDONNANCE-LOI N° 69-041 DU 22 AOUT 1969 RELATIVE A LA CONSERVATION DE LA NATURE

Le Président de la République,
Vu la Constitution, notamment l'article IV du titre XI ;
Vu l'ordonnance n° 67-514 du 1er décembre 1967 portant création de l'Institut des Parcs Nationaux du Congo,

ORDONNE

Titre 1 : Les Réserves Naturelles Intégrales

Article 1

Toute partie du territoire de la République peut être constituée par ordonnance en « réserve naturelle intégrale » lorsque la conservation de la faune, de la flore, du sol, des eaux et, en général, d'un milieu à toute intervention susceptible d'en altérer l'aspect, la composition et l'évolution.

Article 2

Les Parcs Nationaux actuellement existants, à savoir le Parc National Albert, le Parc National de la Garamba et le Parc National de l'Upemba, constituent des réserves naturelles intégrales au sens de la présente ordonnance-loi. Ils sont régis par les textes spéciaux qui les concernent et par la présente ordonnance-loi.
Ayant été domanialisées, les terres situées à l'intérieur de ces Parcs ne peuvent former le siège de droits coutumiers autres que ceux qui ont été expressément réservés.

Article 3

Les terres domaniales situées dans les réserves intégrales ne peuvent être ni cédées ni concédées. Elles ne peuvent recevoir d'affectation incompatible avec la protection de la Nature.

Article 4

Sous réserve des exceptions prévues par la présente ordonnance-loi ou par les textes créant une réserve intégrale, il est interdit de pénétrer, circuler, camper et séjourner dans les réserves intégrales, d'y introduire des chiens, de pièges, des armes à feu, d'y détenir, transporter ou d'en exporter des animaux sauvages vivants, les peaux ou autres dépouilles ou des produits végétaux non cultivés.
L'interdiction de circuler ne s'applique ni aux fonctionnaires dans l'exercice de leurs fonctions, ni aux ministres des cultes, ni aux médecins ou auxiliaires médicaux appelés d'urgence auprès d'un malade ou d'un blessé, ni à leur caravane ou leur suite, ni aux personnes habitant les terres situées à l'intérieur d'une réserve intégrale.

Article 5

Sous réserve des exceptions prévues par la présente ordonnance-loi ou par les textes créant une réserve intégrale, il est interdit, dans les réserves intégrales :

1. De poursuivre, chasser, capturer, détruire, effrayer ou troubler, de quelque façon que soit, toute espèce d'animal sauvage, même les animaux réputés nuisibles, sauf le cas de légitime défense. En cas de légitime défense, si l'animal a été blessé ou tué, l'auteur du fait devra en faire la déclaration, dans un délai de quarante-huit heures, à l'Institut prévu à l'article 14. Il incombera à l'intéressé d'établir la preuve qu'il s'est réellement trouvé en état de légitime défense et n'a provoqué, ni directement ni indirectement, l'agression dont il prétendait avoir été victime. Faute de preuve suffisante, il sera passible des peines prévues par la présente ordonnance-loi.
2. De prendre ou détruire les œufs et les nids ;
3. D'abattre, de détruire, de déraciner ou d'enlever les plantes ou les arbres non cultivés ;
4. D'introduire n'importe quelle espèce d'animal ou de plante ;
5. De faire des fouilles, terrassements, sondages, prélèvements, de matériaux et tous les autres travaux de nature à modifier l'aspect du terrain ou de la végétation ;
6. De bloquer les rivières, de prélever ou de polluer directement ou indirectement les eaux ;
7. De se livrer à tout fait de pêche ;
8. De faire évoluer un aéronef à une hauteur inférieure à 300 mètres

Article 6

En vue d'organiser le tourisme ou de permettre le déplacement indispensable ou développement économique de population, l'Institut prévu à l'article 14 peut, par dérogation aux dispositions de l'article 4, autoriser l'entrée, la circulation, le séjour, et le campement dans les parties des réserves intégrales qu 'il désigne.

L'Institut peut subordonner l'octroi des autorisations à telles conditions qu'il détermine, ainsi qu'au versement d'un cautionnement et au paiement de taxes dont il fixe le montant. Les taxes sont perçues à son profit.

L'inobservation des conditions mises à l'octroi de l'autorisation peut entraîner la confiscation totale ou partielle du cautionnement au bénéfice de l'Institut. La confiscation est prononcée par le Directeur Générale de l'Institut ou son délégué.

Article 7

L'Institut prévu à l'article 14 peut lever, au profit de personnes qu'il désigne et sous les conditions qu'il détermine, les interdictions prononcées aux articles 4 et 5 ; il peut les lever notamment dans le cas suivants :

1. Lorsque, à l'occasion des travaux de recherches scientifiques, il s'agit de prélever des matériaux d'études (animaux, végétaux, minéraux), de faire des fouilles, terrassements, sondages, et tous autres travaux de nature à modifier l'aspect du terrain ou de la végétation ;
2. Lorsque, dans un but de conversation des espèces animales ou végétales, il est indispensable d'enrayer la multiplication excessive de certaines d'entre elles ou d'intervenir de toute autre manière ;
3. Lorsque pour l'étude des mœurs des animaux ; il est nécessaire de les approcher déranger, de les photographier, de les capturer ou de les tuer.

Article 8

Quiconque aura détruit un animal sauvage en contravention à la présente ordonnance - loi sera puni d'une servitude pénale d'un mois à un an et d'une amande de 10 à 100 zaïres.

Si l'animal est un gorille, un éléphant, un rhinocéros, une girafe, un okapi, un zèbre, un buffle, un hippopotame, un hylochère, un phacochère, un lion, un léopard, un guépard, un grand Kudu, un élan, un hyppotrague, une antilope bongo, une antilope topi, un oréotrague ou une situtunga, la servitude pénale sera d'un à dix ans. Si l'animal jouit d'une protection totale ou partielle suivant les annexes I et II du décret du 21 avril 1937 sur la chasse et la pêche, l'amende sera 1.000 zaïres.

La dépouille de l'animale sera saisie. Si elle est comestible, elle immédiatement mise en vente par l'Institut prévu à l'article 14 ; le prix en sera confisqué en cas de condamnation. Si elle n'est pas comestible elle sera confisquée.

Les armes, instruments de chasse et moyens de transport utilisés par le délinquant seront saisis et confisqués.

Article 9

Quiconque se sera installé en contravention à la présente ordonnance-loi sur une terre située à l'intérieure d'une réserve intégrale sera puni d'une servitude pénale d'un ans à dix ans et d'une amande de 10 à 100 zaïres.

Article 10

Seront punies d'une servitude pénal d 'un mois à un an et d'une amende de 10 à 100 zaïres, toutes autres infractions à la présente ordonnance loi.

En cas d'introduction illicite de bataille, celui-ci sera saisi et immédiatement abattu par les soins de l'institut prévu à l'article 14. Si la dépouille est comestible elle sera immédiatement mise en vente par l'Institut précité ; le prix en sera confisqué en cas de condamnation. Si elle n'est pas comestible elle sera détruite.

En cas de pêche illicite le poisson sera saisi et immédiatement mis en vente par l'Institut prévu à l'article 14 ; le prix en sera confisqué en cas de condamnation. L'embarcation et le matériel ayant servi aux délinquants seront saisis et confisqués.

Article 11

Le décret-loi du 13 mars 1965 relatif à la majoration des amendes pénales n'est pas applicable aux amendes prévues par la présente ordonnance - loi.

Article 12

Le produit des amendes et confiscations prononcées en vertu de la présente ordonnance - loi sera attribué à l'Institut prévu à l'article 14, sous la déduction du cinquième de ces amendes et confiscations lequel sera attribué à l'agent qui aura constaté l'infraction, sans que cette allocation puisse excéder 50 zaïres pour chaque infraction.

Article 13

En plus des peines prévues aux articles précédents, tout fonctionnaire civil ou militaire qui aura commis une infraction à la présente ordonnance - loi sera puni de la peine disciplinaire de la révocation ou de la peine disciplinaire immédiatement inférieure à celle-ci.

Titre 2 : Annulé et remplacé par ordonnance-loi n° 72/6012 du 21 février 1972 portant modification des statuts et de la dénomination de l'I.N.C.N.

Titre 3 : Dispositions Finales

Article 34

Sont abrogées :

1 L'ordonnance loi n° 67-514 du 1er décembre 1967 portant création de l'institut des arcs Nationaux du Congo.

2° L'ordonnance loi n° 52-444 du 21 octobre 1958 portant création du Corps de Garde des Parcs Nationaux du Congo.

Article 35

La présente ordonnance loi entre en vigueur à la date de sa signature.

Fait à Kinshasa, le 22 août 1969

JD MOBUTU
Lieutenant Général

ANNEX 2 : DECRET DU 21 AVRIL 1937 SUR LA PECHE

(N.B Ce texte traitait de la chasse et de la pêche seule la partie sur la pêche est encore en vigueur).

Article 57

La pêche est permise sur tout le territoire du Congo belge, sans préjudice de l'application du décret du 12 juillet 1932 relatif aux concessions de pêche et des exceptions prévues ci-après.

Article 58

Nul ne peut pêcher dans les eaux qui appartiennent à autrui si le fonds dont elles dépendent n'est grevé d'un droit de pêche à son profit, ou s'il n'y a consentement du propriétaire ou de ses ayants droit.

N'appartiennent pas à autrui, aux termes du présent décret, les eaux territoriales, lacs, étangs et cours d'eau dont le lit fait partie du domaine de l'Etat.

Article 59

Les indigènes exercent leurs droits traditionnels de pêche, notamment au moyen de barrages, nasses et filets, dans la mesure fixée par la coutume et dans les limites de la circonscription, sous réserve des restrictions du présent décret.

Il est interdit de détruire ces installations. Toutefois, si elles entravent la navigation, provoquent l'envasement ou l'ensablement des cours d'eau, ou constituent un danger au point de vue sanitaire, l'administrateur territorial peut les faire modifier ou enlever.

Article 60

La destruction du frai et des alevins, ainsi que la pêche dans les frayères, sont interdites.

Article 61

Le gouverneur général et le commissaire provincial peuvent décider, par ordonnance ou arrêté, la fermeture de la pêche, dans certains cours d'eau, lacs ou étangs, pendant certaines périodes et pour les espèces de poissons qu'ils déterminent.

Article 62

Le gouverneur général et le commissaire provincial peuvent décider par ordonnance ou arrêté que certaines eaux sont constituées en réserve où la pêche est prohibée partiellement ou totalement.

Article 63

(D. du 17 janvier 1957, art. Ier).

"Le gouverneur général et le gouverneur de province peuvent, dans les régions qu'ils déterminent, interdire ou restreindre la pêche et le commerce de toutes ou certaines espèces de poissons qui proviennent d'une eau privée conforme aux spécifications de l'alinéa Ier de l'article 66 ci-après.

Une autorisation spéciale du gouverneur général peut lever cette interdiction.

Il est également défendu de détenir, d'exposer en vente, de vendre ou d'acheter, de céder, de recevoir à un titre quelconque, de transporter ou de colporter en connaissance de sa provenance, le poisson dont la pêche est permise mais qui a été pêché illicitement.

Article 64

Dans chaque région, il est défendu de détenir, d’exposer en vente, de vendre ou d’acheter, de céder ou de recevoir à un titre quelconque, de transporter ou de colporter les poissons dont la pêche est interdite, sauf s’ils proviennent d’une eau privée conforme aux spécifications de l’alinéa 1er de l’article 66 ci-après.

Une autorisation spéciale du gouverneur général peut lever cette interdiction.
Il est également défendu de détenir, d’exposer en vente, de vendre ou acheter, de céder, de recevoir à un titre quelconque, de transporter ou colporter, en connaissance de sa provenance, le poisson dont la pêche est permise mais qui a été illicitement.

Article 65

Le gouverneur général et le commissaire provincial peuvent, par ordonnance ou arrêté, déterminer les dimensions minima que pourront avoir les mailles des filets, les mailles ou les interstices des nasses et prohiber l'emploi de certains modes, pièges ou engins de pêche.

Article 66

Les articles 60, 61, 62 et 65 ne s'appliquent pas aux eaux qui appartiennent à autrui et n'ont, avec les eaux territoriales faisant partie du domaine de l'Etat, aucune communication permettant le passage du poisson.

L'article 62 ne s'applique pas non plus aux eaux faisant l'objet d'une concession de pêche.

Article 67

Le gouverneur général et le commissaire provincial peuvent, par ordonnance ou arrêté, réglementer l'introduction d'espèces de poissons étrangers à la faune.

ANNEX 3: DECRETS RELATIFS AU PARC NATIONAL ALBERT

Kivu-Ruanda (N° 18 de la carte)

DECRET
26 novembre 1934

Sont réservées, sous l'appellation de « Parc National Albert », à la poursuite des buts de l' « Institut des Parcs Nationaux du Congo Belge », organisé par le décret du 26 novembre 1934, les parties des Territoires du Congo Belge et du Ruanda-Urundi dont les limites sont indiquées ci-après.

DECRET
12 novembre 1935

1. Secteurs du Nyamuragira, Rwindi-Rutshuru, du lac Edouard, de la Semliki, et du Ruwenzori

Enoncé des limites

D'un point partant de la rive Nord du lac Kivu et du bord Est de la coulée de lave du volcan Rumoka ;
Ensuite le bord oriental de la coulée de lave jusqu'au pied occidental de la colline Nyamutsibu ;
De là, une droite jusqu'au pied occidental de la colline Nyabusa;
A partir de ce point, une droite joignant la borne 1 située à 300 m à l'Ouest du gîte de Rusayo, sur le chemin Rusayo-Sake ;
De cette borne, une droite joignant la borne 2 située sur la pente méridionale du mont Mbati ;
De cette borne, une droite joignant la borne 3 de Kisagara, près de Rusayo, sur le chemin Rusayo-Kibati ;
De ce point, le chemin Rusayo-Kibati jusqu'au carrefour (borne 4) du sentier allant au village Mutaho ;
De ce point, une ligne joignant le pied Nord-Ouest de la colline Bubunugu (ou Mutaho) et contournant le pied de cette colline par le Nord, pour joindre le sommet le plus septentrional de la colline Bitunguru (arbre isolé) ;
De ce point, une ligne passant par le pied méridional des monts Katandali et Kanyambuzi, puis par le col qui sépare ce dernier mont du mont Mudjoga, pour atteindre la tête du ravin Kavumu, au pied Sud du mont Kavumu ;
Ce ravin jusqu'à son embouchure dans la clairière (borne 5) de Kavumu ;
Le bord méridional de cette clairière marqué par une piste aboutissant à la route carrossable Ngoma Rutshuru, à 1 Km 400 du village de Kibati (borne 6) :
A partir de ce point, le bord occidental de la route carrossable Ngoma Rutshuru jusqu'au carrefour du chemin Rugari Kanzenze Nyamulagira Mushari ;
A partir de ce point, le bord septentrional du chemin Rugari Kanzenze Mushari jusqu'à une borne située à environ 4 Km à l'Ouest du carrefour de Rugari ;
De cette borne, une ligne joignant la borne située à 2 Km à l'Est du pied de la colline Nyasheke Nord ;
Ensuite, le pied oriental de la colline Kurushari et une borne située sur le sentier Rusthuru Tongo, à 4 Km à l'Ouest de son point de jonction avec la route carrossable Rutshuru Ngoma ;
De cette borne, une droite joignant le confluent des rivières Rutshuru et Rugera ;
A partir de ce confluent, le bord supérieur oriental (côté rive droite) du ravin de la rivière Rutshuru jusqu'au parallèle du confluent de la rivière Kabarasa avec la May-Na-Kwenda ;
Ce parrallèle jusqu'à la May-Na-Kwenda ;
La rive Sud de la May-Na-Kwenda jusqu'à l'intersection du sentier Rutshru Kalimbo Kabare ;
Ce parrallèle jusqu'à la rivière Ngesho ;
Le bord supérieur méridional du ravin de cette rivière, vers l'amont, jusqu'au marais Nyamborokota ;
Le bord de ce marais, par le Sud et l'Est, jusqu'à l'embouchure de la riviière Tshabaganda ;
Le bord supérieur méridional du ravin de cette rivière jusqu'au confluent d e la rivière Kakoma ;
Le bord supérieur méridional du ravin de la Kakoma jusqu'à sa source ;
Le parallèle de cette source jusqu'à sa rencontre avec la rivière Kasozo ;
Le bord supérieur oriental du ravin de la Kasozo jusqu'à l'embouchure dans la rivière Ishasha ;
L'Ishasha (frontière de la Colonie) jusqu'à son embouchure dans le lac Edouard ;
La frontière de la Colonie, à travers les eaux du lac Edouard, jusqu'à l'embouchure de la rivière Lubilia dans le lac Edouard ;
La Lubilia jusqu'à son point d'intersection avec la route carrossable de Beni à Kasindi ;
Le bord occidental de cette route jusqu'à l'ancien sentier reliant le village de Mutwanga au mon Libona, sentier coupant les têtes des riviières Butowa et Mahindi ;
Ce sentier vers l'Ouest jusqu'à son intersection avec la route carrossable de Beni à Kasindi ;
Le bord méridional de cette route jusqu'à un point situé à un kilomètre à vold'oiseau de son intersection avec la rivière Semliki ;
De ce point, vers le Nord, une ligne parallèle à la rive droite de la Semliki et distante de celle-ci d'un kilomètre à vol d'oiseau, jusqu'à son point de rencontre avec la rivière Musenene ou Lusilube ;
La rive gauche de cette rivière jusqu'à son point d'intersection avec le parallèle du confluent des rivières Modidi et Biangolo ;
Ce parallèle jusqu'à ce confluent ;
La rive gauche de la rivière Biangolo jusqu'à son point de rencontre avec la courbe hypsométrique de 1.700 mètres ;
Cette courbe vers le Sud jusqu'à son point d'intersection avec la rivière Talya ;
La rive gauche de cette rivière jusqu'à son confluent avec la rivière Buliba ;
La rive droite de cette rivière jusqu'à sa source ;
Une droite joignant cette source au sommet du mont Buliki ;
Une droite joignant ce sommet à la source du ruisseau Kamesongo ;
La rive gauche de cette rivière jusqu'à son point d'intersection avec la courbe hypsométrique de 2.000 mètres ; Cette courbe vers l'Ouest, jusqu'à son point de rencontre avec le méridien de la source la plus septentrionale de la rivière Ulubu ;

Ce méridien, vers le Sud, jusqu'à cette source ;
Une droite joignant cette source à la source la plus méridionale de cette même rivière ;
De cette source une droite jiognant la source de la rivière Tako, affluent de la Lubilia (frontière de la Colonie) ;
La frontière de la Colonie vers le Nord jusqu'à son point d'intersection avec la rivière Rusege Sud (confluent de la Lamya et de la Rusege Sud) ;
La rive droite de cette rivière Rusege Sud, vers l'amont, jusqu'à sa source ;
Le parallèle passant par ce col jusqu'au point où il rencontre la rivière Ruanoli ;
La droite joignant cette extrémité au point de la rive gauche de la rivière Kombo le plus métrique de 1.500 m ;
Cette courbe, vers le Sud-Ouest, jusqu'au point où elle traverse la rivière Dialele ou Musanondo ;
La rive droite de cette rivière, vers l'aval, jusqu'à son point d'intersection avec le prolongement d'une droite joignant le confluent de la Mavea ou Lamya et de la Molingo au point où le sentier Katuka Pakioma Botshula coupe la rivière Djobulo ;
Cette droite jusqu'au confluent de la Mavea ou Lamya et de la Molingo ;
La rive gauche de la rivière Mavea ou Lamya, vers l'aval, jusqu'à un point situé à n kilomètre en aval de son point d'intersection avec la piste caravanière Kapamba Kinawa ;
De ce point une ligne parallèle à la piste caravanière passant par les villages de Kapamba, Kinawa, Alundja ; Kapera, Zoa et distante de cette piste d'un kilomètre, vers l'Ouest, à vol d'oiseau, jusqu'à une borne située à un kilomètre à vol d'oiseau au Nord du village de Djenda (Kasimoto) ;
La parallèle passant par cette borne jusqu'au point où il rencontre la rivière Lamya (frontière de la Colonie) ;
La rive gauche de la Lamya jusqu'à son embouchure dans la Semliki ;
La Semliki jusqu'à l'embouchure de la rivière Puemba ;
La rive gauche de cette rivière, vers l'amont, jusqu'à son confluent avec la Nyaduguru ;
La rive droite de cette dernière, vers l'amont, jusqu'à son point de rencontre avec le parallèle passant par le point où la rivière Irimba est franchie par le sentier marqué par les points d'altitude de 887 et 923 m et longeant le pied de l'escarpement de Kamariba ;
Ce sentier vers l'Ouest jusqu'au carrefour situé près de la rivière Matido ;
A partir de ce carrefour, l'ancienne piste caravanière d'Irumu et Boga à Vieux-Beni, piste de 1925 1926 passant successivement par le village actuel de Selemani (Boga) et par les anciens emplacements des villages de Bopo, Kibondo, Alimaci, Adonga, Gamala, Gamalendu, Mushanga, Baruti, Kartushi, Lupansula, Molemba, Amici, Kitihire, Kalumendo jusqu'à son intersection avec la rivière Djuma ;
La rive droite de cette rivière, vers l'amont, jusqu'à son point d'intersection avec le méridien qui passe par le point où la rivière Malulu quitte le pied oriental de l'escarpement ;
Ce méridien jusqu'à ce point d'intersection de la rivière Malulu et du pied de l'escarpement ;
De ce point, vers le Sud, le pied oriental de l'escarpement jusqu'à un point près du mont Luka, à 2 Km au Nord de l'ancien lazaret, où le sentier longeant le pied de l'escarpement et venant de Zumba (gîte) pénètre dans l'escarpement ;
Ce sentier, passant par l'ancien lazaret de Beni, par Zumba (gîte), par Kitero, entre les monts Misebere et Tahamogota, par Kasolenge et Tshamohoma (Kadiadia) jusqu'à son point de rencontre avec la rivière Lusia ;
La rive droite de cette rivière, vers l'aval, jusqu'à son point d'intersection avec le prolongement d'une droite joignant les sommets des monts Katshe et Katundu ;
De ce point, une ligne passant par les sommets des monts Katundu, Katshe, Mokondene, Daboma, Kavega, Kasiakake, Itobola et Kebo ;
Du sommet du mont Kebo, une droite jusqu'au point où la rivière Kinyamiga est coupée par cette droite joignant les sommets des monts Kebo et Walengiro ;
La rive droite de la rivière Knyamiga vers l'aval jusqu'à son intersection avec la piste caravanière passant au pied du mont Buselio ;
Cette piste vers le Sud jusqu'à son point d'intersection avec le prolongement d'une droite joignant les sommets des monts Bikingi et Buselio ;
De ce point, une ligne passant par les sommets des monts Buselio, Bikingi, Busoga, Manyoni, Tskanzu et Birimu ;
Du sommet de mont Birimu jusqu'au point de la rivière Tambwe le plus rapproché de ce mont ;
De ce point, la rive gauche de la rivière Tambwe, vers l'amont, jusqu'à l'embouchure du ruisseau Tshabolere ;
La rive gauche de ce ruisseau jusqu'à sa source ;
I,e droite joignant cette source à celle du ruisseau Kakoko, affluent de droite de la Nyamoisa ;
De cette source (au mont Kalumba), la rive droite du ruisseau Kakoko jusqu'au point où il est coupé par le sentier de Kinierere à Kasembe (Nkuku) ;
Ce sentier jusqu'au point où il coupe la crête du mont Kitolu ;
Cette crête jusqu'à la tête du ravin Karuasa se détachant de l'éperon Kitolu du mont Mandimba ;
De cette tête, une droite joignant le point où la piste caravanière de Gitse à Kinierere rencontre le ruisseau Lutimbi, à l'Ouest du village de Kinierere ;
Cette piste Kinierere Gitse, par la crête Musimba et le mont Kerongo jusqu'au point le plus rapproché de la source du ruisseau Bolekerere ;
Une droite joignant ce point à cette source ;
La rive gauche de ce ruisseu jusqu'à son confluent avec la rivière Kilibira ;
La rive gauche de cette rivière jusqu'à son confluent avec la rivière Talya ;
La rive gauche de cette rivière, vers l'amont, jusqu'au point où elle est franchie par le sentier Kitega Gitse ;
Cette piste vers le Sud, jusqu'au point où elle rencontre le prolongement d'une droite joignant les sommets des monts Beasa et Katendere ;
De ce point, la ligne de crête jalonnée par les mont Katendere, Beasa, Kanei, Niamonindu et Niondo ;
Une ligne passant par le sommet du mont Nguli et joignant la source du ruisseau Logese ;La rive droite de ce ruisseau jusqu'à son embouchure dans la rivière Tshondo ;
La rive droite de cette rivière, vers l'aval, jusqu'à son point d'intersection avec une droite joignant les sommets des monts Musenzeru et Niarusunzu ;
Cette droite jusqu'au mont Musenzeru ;

De ce mont, une droite jusqu'au mont Kasiiro ;
De ce mont, une droite joignant le sommet de la colline Musoti, le village de Nguli restant en dehors du Parc ;
De ce sommet, une droite joignant le point où le sentier Kitega Nguli coupe l'éperon Kateka Bakole du mont Niondo ;
De ce point, une ligne passant par les sommets des monts Kasanga, Busega, Katembo, Loarama, Kabelia, Garara, Bekoha, Luoto et joignant le pied oriental du mont Ihembe ;
De ce pied, une droite jusqu'au confluent des rivières Kisalala et Tangote ;
De ce confluent, une ligne joignant les sommets des monts Bokara, Kaliniro, Ibangu et Buhiria ;
De ce sommet, la crête du mont Buhiria jusqu'à son extrémité Sud ;
De cette extrémité, une ligne joignant les sommets des monts Kasanga, Mobiriri et Kalero ;
Du sommet de ce point, la crête du mont Kalero, jusqu'à son extrémité Sud ;
De cette extrémité, une ligne joignant les sommets des monts Bukweri, Lunde ou Kitobia et Bunialobo ;
Du sommet de ce mont Bunialobo, situé au Nord-Ouest du mont Kahungu, une droite joignant le point le plus septentrional de la chaîne Nialusu ;
De ce sommet, une droite jusqu'au sommet du mont Mutulio ;
Une droite joignant ce mont au mont Bukumbwa et coupant la rivière Butega (affluent de droite de la Talya) ;
La crête partant du mont Bukumbwa et jalonnée par les monts Mushenge, Kalingio, Kitanda, Kitesa, Kilambo ;
De ce mont, une droite joignant le mont Ndwale ;
Ensuite la crête jalonnée par les monts Ndwale, Kigende, Buhoywa, Kitobo, Kiboha, Shobobia, Lutare, Kahia, Mohembya ;
Ensuite, une droite joignant ce mont à l'extrémité Nord du mont Lutepa et laissant à l'Est le mont Miegenie ;
La chaîne des monts Lutepa Nyabuki ;
Une droite joignant ce mont au sommet des monts Lubwe, Berama, Kasongolere, puis la crête Kasongolelo, Boswekwa, Kierere et Kashwa ;
Une ligne joignant ce mont aux monts Kisololwe, Kiniamuyaga, Miholo ;
La crête des monts Miholo, Hangira, Kiburu ;
Ensuite une ligne suivant la crête jalonnée par les monts Katwa, Matofu, Musima et prolongée jusqu'au ravin Bahula;
A partir de ce point, le bord Sud du ravin Bahula jusqu'à sa rencontre avec la rivière Kibirizi ;
Cette rivière jusqu'au bord occidental du ravin de la Ruindi ;
La riche gauche de la Ruindi, en amont, jusqu'au confluent de la rivière Rwehe ;
Le Thalweg de cette rivière jusqu'à son confluent avec le ruisseau Kamokanda, en laissant en dehors du Parc la mine de fer du mont Kakorwe, située sur la rive droite de la Rwehe ;
Le ruisseau Kamokanda jusqu'à sa source, au pied du mont Tshahi ;
Une ligne joignant cette source au sommet des monts Tshali et Bitingu ;
De ce mont, une droite joignant la source de la rivière Kalagale, située près du mont Rwanguba ;
Cette rivière jusqu'au sentier de Mabenga à Tongo, sentier longeant le pied des monts Kasali ;
Ce sentier jusqu'à son point d'intersection avec la rivière Butaku ;
De ce point, une droite au pied occidental du mont Bugomba ;
Le méridien de ce point, jusqu'à sa rencontre avec le parallèle passant par l'extrémité Sud de la colline Butambira ;
Ce parallèle jusqu'à sa rencontre avec la piste de Tongo à Tshumba ;
La piste de Tongo à Tshumba, dans la plaine de lave, jusqu'à son intersection (carrefour de mariage) avec le sentier Rugari Kansenze (Nyamulagira) Mushari ;
Ensuite, une droite joignant ce carrefour au sommet du mont Mushebele ;
Puis la crête Mushebele Katunda jusqu'au sentier Tshumba Ngesho Gandjo :
Ce sentier jusqu'à la limite Est du bloc des concessions de Ngesho ;
Ensuite, une ligne contournant à l'Est, au Sud et à l'Ouest les concessions du Comité National du Kivu 26, 71b et 71a, jusqu'à l'intersection avec le sentier Tshumba Katumo ;
Ensuite, ce sentier vers l'Ouest jusqu'à la limite orientale de la concession Katumo 79è ;
Ensuite, la limite orientale du bloc des concessions de Ngandjo, jusqu'à la piste caravanière Ngandjo Kingi ;
Ensuite, cette piste jusqu'à son point le plus proche de la source de la rivière Bulemo ;
De ce point, une droite jusqu'à cette source ;
Ensuite cette rivière, en aval, jusqu'au bord du marais de la Nyamorogi, le marais jusqu'à l'angle Nord-Ouest, de la concession Lambert à Mugando, la limite Nord, Est et Sud de cette concession jusqu'à son angle Sud-Ouest ;
Ensuite une droite rejoignant la limite Nord de la concession 28b ;
Ensuite la limite orientale de cette concession ainsi que la concession 28a jusqu'à un point situé au pied oriental de la colline Bisegera (ou Kiseguro) ;
Ensuite une droite entre ce point et le pied occidental du volcan Tshobe, jusqu'à son intersection avec le bord occidental de la coulée de lave de Nahimbi ;
Ensuite le bord occidental de cette coulée de lave jusqu'au lac Kivu ;
Ensuite la rive Nord du lac Kivu vers l'Est, jusqu'au bord Est de la coulée de lave du volcan Rumoka ;
De plus, l'île Tshegera sera, dans son entièreté, comprise dans le Parc National Albert ;
Par contre, les terres habitées et cultivées des collines de Nzuru, Mihonga et Kabazana seront exclues du Parc ; à cet effet, la limite actuelle de ces terres sera abornée définitivement.

2. Secteur de Mikeno

Enoncé des limites

a) Partie située dans le territoire du Ruanda ;

A partir de la borne A1 de la frontière belgo-anglaise (Ruanda-Urundi), une ligne droite joignant cette borne à celle située sur la colline Burambi ;
De cette borne, une droite joignant celle du mont Barizo ;

De ce point, une droite joignant la borne de Kabutindi et prolongée jusqu'à la rivière Minoka ;
Ensuite la piste (administrative de 1931) limitant la forêt et jalonnée par les bornes Kamatanga et Ndaruka ;
A partir de cette dernière borne, le sentier conduisant au point d'eau du ravin Bukoka, à la borne de Nyamigogo, à celle de Gakore, Gimuhusa, Sinabyaye (sur le sentier du Bufumbiro, passant entre les volcans Muhavura et Gahinga) ;
Ensuite une ligne joignant successivement les bornes situées sur la colline Kato, au pied Sud de la colline Bwambuba au lieu dit Kirimbi (près du ravin Markyazo, sur le chemin Ruhengeri Bunagana Rutshuru), et enfin la borne de Kagano (près du ravin Rwebeya) ;
De cette borne, une droite jusqu'au point où le ravin Kampanga coupe la route Ruhengeri Tsharubindi ;
Ensuite le bord oriental de cette route jusqu'à la borne de Tsharubindi ;
De ce point, une droite jusqu'à la borne Ruhinga (Gahura) ;
Ensuite le chemin conduisant à la borne Mutaboneka ;
De cette borne, une ligne joignant les sommets des monts Banysogo, Buseke, Tshundura et Muguki ;
De ce dernier sommet, une ligne joignant la borne de la colline Gashinga (près du ravin Bishushwe) et la borne de la colline Ntobo ;
Ensuite une droite joignant le pied septentional du mont Rubare jusqu'à sa rencontre avec le chemin Rubare Ngando ;
Ensuite le sentier Rubare Ngando jusqu'à la limite du territoire de Kisenyi ;
Puis le même sentier jusqu'au pied septentrional de la colline Kabatwa, en passant par le bord Sud de la clairière marécageuse de Gihorwe, sans préjudice du droit des indigènes d'abreuver leur bétail dans cette clairière ;
Ensuite une droite partant de l'extrémité Ouest de l'étang Ngando, à partir du point où elle est coupée par le sentier Gihorwe Kabatwa Tamira jusqu'au sommet de la colline Butaka (borne) ;
De ce point, une droite jusqu'au sommet de la colline Bugeshi Mukuru ;
Puis une droite joignant le sommet de la colline Arama (Congo Belge) jusqu'à son intersection avec la frontière du Congo Belge et du Ruanda-Urundi.

b) Partie située dans le territoire du Congo Belge

A partir de la frontière du Ruanda-Urundi, du point où elle est coupée par une droite reliant le sommet de la colline Bugeshi Mukuru au sommet du mont Arama ;
Cette droite jusqu'au sommet du mont Arama ;
De ce point, une droite jusqu'au col séparant ce mont du mont Hebu ;
Ensuite le petit ravi qui sépare ces monts jusqu'à sa rencontre avec le sentier qui longe le pied du mont Hébu par l'Ouest ;
Ce sentier jusqu'au pied occidental de la colline Matege ;
Ensuite le sentier (piste de bétail) aboutissant à l'abreuvoir de Kikeri ;
Le marais, mais non l'abreuvoir, restant inclus dans le Parc ;
A partir de cet abreuvoir, le sentier de Kikeri à Nyarusambo, jusqu'au carrefour du sentier de Nyakibumba ;
Ce dernier sentier contournant le pied Sud de la colline Nyakibumba jusqu'au hameau Neno-ya-Batsetse ;
Ensuite le ravin qui suit le pied occidental de la colline Nyakikumba jusqu'à son débouché dans la plaine du pied Nord-Ouest de la colline ;
De ce point, une ligne joignant les sommets des mamelons Bulera et Mwebuye et prolongée jusqu'au ravin Kanyamagufa (borne) ;
Ensuite ce ravin jusqu'à sa rencontre avec la route carrossable Ngoma Rutshuru (borne) ;
Ensuite le bord oriental de cette route carrossable jusqu'au ravin Masisi (borne) ;
Ce ravin jusqu'à son origine, au flanc Ouest de la colline Kasenyi ;
Ensuite une piste allant au col qui sépare les monts Bushandjogoro et Rwanguba (borne) ;
De ce point, une droite joignant le ravin Mugari au point où il est coupé par la piste caravanière du Rugari au Kibumba ;
Ensuite cette piste jusqu'à sa rencontre avec le ravin Kifurura ;
Ce ravin jusqu'à l'abreuvoir situé à un kilomètre en amont ;
De cet abreuvoir, une droite joignant le sommet de la colline Nyamariri ;
De ce point, une droite jusqu'à l'abreuvoir du ravin Kizenga ;
Ensuite une droite jusqu'au sommet de la colline Kizenga (rive droite du ravin) ;
Puis le sentier Kizenga Katwa jusqu'au point où il rencontre la concession du Kikeri de la Mission de Tongres-Sainte-Marie ;
Ensuite les limites méridionale et orientalede cette concession jusqu'à son angle Nord-Est ;
De cet angle, une droite joignant le sommet de la colline Kabazogeye et prolongée jusqu'au ravin Kabogo ;
Ce ravin jusqu'au point où il est coupé par le sentier Katwa (Kikeri) Sesere ;
Ensuite une ligne joignant le sommet de la colline Rebero, le pied oriental de la colline Niesisi et le sommet de la colline Gashondi ;
Ensuite la crête de Dabugano, marquée parla courbe hypsométrique de 2.000 m jusqu'au ravin qui limite au Sud les trois collines de Bukima ;
Ce ravin jusqu'au point le plus rapproché de la colline la plus orientale du groupe de Bukima ;
Ensuite une droite joignant le sommet de cette dernière colline (borne) ;
De ce sommet, une ligne joignant les sommets des monts Nyangurube, Nyakiriba et Gugo ;
De ce point, une droite jusqu'au pied occidental de la colline Kizunga ;
Ensuite une ligne longeant le pied occidental de la crête Tshananke (le sommet de la crête à la courbe de 2.100 m) jusqu'au point où elle rencontre le ravin Rutabagare ;
Ce ravin jusqu'à l'étang Nyandizima ;
Le bord méridional de cet étant jusqu'à la tête du ravin Rukunga ;
De ce ravin jusqu'à son point d'intersection avec la droite joignant le sommet le plus septentrional du mont Runyoni au mont Tshanzu ;
Cette droite à partir de ce point d'intersection jusqu'au sommet du mont Tshanzu ;
Ensuite une droite joignant les sommets des monts Rurindzargwe et Mugongoyindzovu ;

Ensuite le parallèle de ce dernier sommet jusqu'à son point de rencontre avec la frontière belgo*anglaise.
Les limites ci-dessus sont établies sous réserve de l'exercice des droits miniers concédés par la Colonie à la Compagnie Minière des Grands Lacs Africains et sans préjudice des droits énumérés ci-après :

1° Droits indigènes de chasse

a) Dans la région comprise entre la rivière Semliki, la rivière Ruanolli et le sentier Lopele Semliki ;
b) Dans la région comprise entre la rivière Semliki, la rivière Musenene et la route carrossable Beni Kasindi ;
c) Dans la région comprise entre les rivières Tungula, Kamohidi, Djelube et le sentier Pakioma Malengera Kalasabango.

2° Droits indigènes de pêche

a) Droit indigène de pêche dans la rivière Rutshuru, en amont du lieu dit May-ya-Moto ;
b) Droit indigène de pêche dans la rivière Semlliki et dans le lac Edouard, en des lieux à déterminer de commun accord entre les indigènes, les autorités territoriales et médicales et l'Institut des Parcs Nationaux du Congo Belge, le jour où auront été rapportées les mesures actuellement en vigueur qui ont nécessité l'évacuation des rives de la Semliki et du lac Edouard comme moyen de lutte contre la maladie du sommeil.

3° Droits de cueillette et de la coupe de bois

a) Droit indigène de la coupe de lianes « kekere » (rotin) et de plantes « Ubuzi » (genre d'aloès) dans la forêt comprise entre la rivière Molindi et le sentier de Mabenga à Tongo, conformément à une réglementation établie par l'Institut des Parcs Nationaux du Congo Belge, et acceptée par les indigènes, de manière que la circulation soit interdite en dehors des parcelles qui seront ouvertes successivement à la récolte des susdites lianes ou plantes :
b) Droit indigène de récolte de sol sur le volcan Ramoka ;
c) Droit indigène de récolte des palmistes le long de la rive droite de la rivière Semliki entre les rivières Bioila et Musenene ;
d) Droit indigène de coupe de bois de construction sur le mont Bukuku.

4° Droits de circulation

Droit de circulation sans restriction aucune sur les routes carrossables suivantes :
a) Ngoma Tongres-Sainte-Marie Rutshuru Kigoto Kabasha Irumu ;
b) Goma Sake , le long du lac Kivu ;
c) Beni Kasindi.

ARRETE ROYAL

04 mai 1937

Parc National Albert. Modification des limites

La première annexe au décret du 12 novembre 1935, énonçant les limites des secteurs du Parc National Albert dénommés « du Nyamuragira, de la Rwindi-Rutshuru, du lac Edouard, de la Semliki et du Ruwenzori », est modifiée par l'adjonction, entre le 38è alinéa (« La rive gauche de cette rivière jusqu'à son confluent avec la rivière Buliba) et le 39è alinéa (« La rive droite de cette rivière jusqu'à sa source), du texte suivant :

La rivière Talya vers l'aval, jusqu'à son confluent avec la rivière Bongeya ;
Le méridien de ce confluent jusqu'au pied de la colline Bulima ;
Le pied méridional des collines Bulima et Ulese, jusqu'à l'extrémité Sud-Ouest de cette dernière ;
Le parallèle de cette extrémité jusqu'à son point d'intersection avec la piste caravanière de Mutwanga à Kasindi ;
Cette piste jusqu'à une borne située entre le village de Kimene et l'ancien gîte de Mutwanga ;
De cette borne, une droite de 125 m de longueur, parallèle au village de Kimene ;
De l'extrémité de cette droite, une perpendiculaire jusqu'à son point d'intersection avec le ravin situé à 50 m au Sud du signal géodésique du Mutwanga ;
Ce ravin jusqu'à sa rencontre avec la piste caravanière de Mutwanga à Kasindi ;
Cette piste vers le Sud, jusqu'à son point d'intersection avec le ruisseau Gokoye ;
Ce ruisseau jusqu'au méridien de la source du ruisseau May-ya-Moto ;
Ce méridien jusqu'à cette source ;
Une droite joignant cette source à celle de la rivière Mboa ;
Le parallèle de la source de la Mboa jusqu'à sa rencontre avec la rivière Buliba.

Les droits miniers possédés par le Comité National du Kivu sur le terrain incorporé au Parc National Albert par le présent arrêté sont réservés.

ARRETE ROYAL

17 mai 1939

Parc National Albert. Modification des limites

Dans l'énoncé des limites du Parc National Albert annexé au décret du 12 novembre 1935, le 66è alinéa ainsi conçu :

La rive droite de cette dernière, vers l'amont, jusqu'à son point de rencontre avec le parallèle passant par le point où la rivière Irimba est franchie par le sentier marqué par les point d'altitude 887 et 923 m et longeant le pied de l'escarpement de Karariba ;

Est remplacé par le suivant :
De ce point, une droite jusqu'à la source de la rivière Malibotu ;
La rive gauche de cette rivière jusqu'à son confluent avec la rivière Irimba ;
De ce point, une droite jusqu'au confluent des rivières Nkanda et Maginda ;
La rive droite de la Maginda jusqu'à sa rencontre avec le sentier marqué par le point d'altitudes 887 et 923 m et longeant le pied de l'escarpement de Kamarikba.

ORDONNANCE N° 21, 1938
03 février 1938

L'exercice de la chasse est interdit sur les terres occupées par les indigènes à l'intérieur du Parc National Albert.

ORDONNANCE N° 41, 1938
04 août 1938

L'ordonnance n° 21/Agri, du 03 février 1938, est rendue exécutoire dans les Territoires du Ruanda-Urundi.

ORDONNANCE N° 2, 1944
06 janvier 1944

La navigation sur le lac Edouard pourra être autorisée au profit de personnes déterminées par l'Institut des Parcs Nationaux du Congo Belge et sous des conditions qui seront fixées par le Comité de Direction de l'Institut.

ORDONNANCE N° 3, 1944
06 janvier 1944

Dans les limites du Parc National Albert, la coupe des végétaux pouvant servir de matériaux de construction pourra être autorisée au profit de personnes déterminées par l'Institut des Parcs Nationaux du Congo Belge et sous des conditions qui seront fixées par le Comité de Direction de l'Institut.

Modification des limites du Parc National Albert d'après les conclusions de la Commission d'enquête sur les droits indigènes.

Article 1er : L'annexe au décret du 12 novembre 1935, énonçant les limites des secteurs du Parcs National Albert dénommés « du Nyamuragira, Rwindi-Rutshuru, du lac Edouard, de la Semliki et du Ruwenzori », est modifiée et complétée comme suit :

1. Les alinéas 36 et 37 sont remplacés par le texte suivant :

« La rive gauche de la rivière Biangolo jusqu'à une borne (altitude approximative 1.700 m), puis la projection verticale sur le terrain de la polygonale reliant les points de rencontre de la courge de niveau de cette borne avec les contreforts avancés du massif du Ruwenzori et ce jusqu'à la rivière Talya » .

2. Entre les 38è et le 39è alinéas il est ajouté le texte suivant :

« La rivière Talya, vers l'aval, jusqu'à son confluent avec la rivière Bongeya ; le méridien de ce confluent jusqu'au pied de la colline Bulima ; le pied méridional des colllines Bulima et Ulese, jusqu'à l'extrémité Sud-Ouest de cette dernière ; le parallèle de cette extrémité jusqu'à son point d'intersection avec la piste caravanière Mutwanga à Kasindi ; cette piste jusqu'à une borne située entre le village de Kimene et l'ancien gîte de Mutwanga ; de cette borne une droite de 125 m de longueur, parallèle au village de Kimene ; de l'extrémité de cette droite une perpendiculaire jusqu'à son point d'intersection avec le ravin situé à 50 m au Sud du signal géodésique de Mutwanga ; ce ravin jusqu'à sa rencontre avec la piste caravanière Mutwanga à Kasindi ; cette piste vers le Sud, jusqu'à son point d'intersection avec le ruisseau Gokoye ; ce ruisseau jusqu'au méridien de la source du ruisseau May-ya-Moto ; ce méridien jusqu'à cette source ; une droite joignant cette source à celle de la rivière Mboa ; le parallèle de la source de la Mboa jusqu'à sa rencontre avec la rivière Buliba ».

ARRETE ROYAL

04 mai 1937

Parc National Albert. Modification des limites

La première annexe au décret du 12 novembre 1935, énonçant les limites des secteurs du Parc National Albert dénommés « du Nyamuragira, de la Rwindi-Rutshuru, du lac Edouard, de la Semliki et du Ruwenzori », est modifiée par l'adjonction, entre le 38è

alinéa (« La rive gauche de cette rivière jusqu'à son confluent avec la rivière Buliba) et le 39è alinéa (« La rive droite de cette rivière jusqu'à sa source), du texte suivant :
La rivière Talya vers l'aval, jusqu'à son confluent avec la rivière Bongeya ;
Le méridien de ce confluent jusqu'au pied de la colline Bulima ;
Le pied méridional des collines Bulima et Ulese, jusqu'à l'extrémité Sud-Ouest de cette dernière ;
Le parallèle de cette extrémité jusqu'à son point d'intersection avec la piste caravanière de Mutwanga à Kasindi ;
Cette piste jusqu'à une borne située entre le village de Kimene et l'ancien gîte de Mutwanga ;
De cette borne, une droite de 125 m de longueur, parallèle au village de Kimene ;
De l'extrémité de cette droite, une perpendiculaire jusqu'à son point d'intersection avec le ravin situé à 50 m au Sud du signal géodésique du Mutwanga ;
Ce ravin jusqu'à sa rencontre avec la piste caravanière de Mutwanga à Kasindi ;
Cette piste vers le Sud, jusqu'à son point d'intersection avec le ruisseau Gokoye ;
Ce ruisseau jusqu'au méridien de la source du ruisseau May-ya-Moto ;
Ce méridien jusqu'à cette source ;
Une droite joignant cette source à celle de la rivière Mboa ;
Le parallèle de la source de la Mboa jusqu'à sa rencontre avec la rivière Buliba.

Les droits miniers possédés par le Comité National du Kivu sur le terrain incorporé au Parc National Albert par le présent arrêté sont réservés.

ARRETE ROYAL

17 mai 1939

Parc National Albert. Modification des limites

Dans l'énoncé des limites du Parc National Albert annexé au décret du 12 novembre 1935, le 66è alinéa ainsi conçu :

La rive droite de cette dernière, vers l'amont, jusqu'à son point de rencontre avec le parallèle passant par le point où la rivière Irimba est franchie par le sentier marqué par les point d'altitude 887 et 923 m et longeant le pied de l'escarpement de Karariba ;

Est remplacé par le suivant :
De ce point, une droite jusqu'à la source de la rivière Malibotu ;
La rive gauche de cette rivière jusqu'à son confluent avec la rivière Irimba ;
De ce point, une droite jusqu'au confluent des rivières Nkanda et Maginda ;
La rive droite de la Maginda jusqu'à sa rencontre avec le sentier marqué par le point d'altitudes 887 et 923 m et longeant le pied de l'escarpement de Kamarikba.

ORDONNANCE N° 21, 1938
03 février 1938

L'exercice de la chasse est interdit sur les terres occupées par les indigènes à l'intérieur du Parc National Albert.

ORDONNANCE N° 41, 1938
04 août 1938

L'ordonnance n° 21/Agri, du 03 février 1938, est rendue exécutoire dans les Territoires du Ruanda-Urundi.

ORDONNANCE N° 2, 1944
06 janvier 1944

La navigation sur le lac Edouard pourra être autorisée au profit de personnes déterminées par l'Institut des Parcs Nationaux du Congo Belge et sous des conditions qui seront fixées par le Comité de Direction de l'Institut.

ORDONNANCE N° 3, 1944
06 janvier 1944

Dans les limites du Parc National Albert, la coupe des végétaux pouvant servir de matériaux de construction pourra être autorisée au profit de personnes déterminées par l'Institut des Parcs Nationaux du Congo Belge et sous des conditions qui seront fixées par le Comité de Direction de l'Institut.

Modification des limites du Parc National Albert d'après les conclusions de la Commission d'enquête sur les droits indigènes.

Article 1er L'annexe au décret du 12 novembre 1935, énonçant les limites des secteurs du Parcs National Albert dénommés « du Nyamuragira, Rwindi-Rutshuru, du lac Edouard, de la Semliki et du Ruwenzori », est modifiée et complétée comme suit :

1. Les alinéas 36 et 37 sont remplacés par le texte suivant :

« La rive gauche de la rivière Biangolo jusqu'à une borne (altitude approximative 1.700 m), puis la projection verticale sur le terrain de la polygonale reliant les points de rencontre de la courge de niveau de cette borne avec les contreforts avancés du massif du Ruwenzori et ce jusqu'à la rivière Talya » .

2. Entre les 38è et le 39è alinéas il est ajouté le texte suivant :
« La rivière Talya, vers l'aval, jusqu'à son confluent avec la rivière Bongeya ; le méridien de ce confluent jusqu'au pied de la colline Bulima ; le pied méridional des colllines Bulima et Ulese, jusqu'à l'extrémité Sud-Ouest de cette dernière ; le parallèle de cette extrémité jusqu'à son point d'intersection avec la piste caravanière Mutwanga à Kasindi ; cette piste jusqu'à une borne située entre le village de Kimene et l'ancien gîte de Mutwanga ; de cette borne une droite de 125 m de longueur, parallèle au village de Kimene ; de l'extrémité de cette droite une perpendiculaire jusqu'à son point d'intersection avec le ravin situé à 50 m au Sud du signal géodésique de Mutwanga ; ce ravin jusqu'à sa rencontre avec la piste caravanière Mutwanga à Kasindi ; cette piste vers le Sud, jusqu'à son point d'intersection avec le ruisseau Gokoye ; ce ruisseau jusqu'au méridien de la source du ruisseau May-ya-Moto ; ce méridien jusqu'à cette source ; une droite joignant cette source à celle de la rivière Mboa ; le parallèle de la source de la Mboa jusqu'à sa rencontre avec la rivière Buliba ».
« Les droits miniers possédés par le Comité National du Kivu sur le terrain incorporé au Parc National Albert par le présent arrêté sont réservés ».

3. Les alinéas 43 et 44 sont remplacés par le texte suivant :
« La rive gauche de la rivière Lume jusqu'à une borne (altitude approximative 2.000 m), puis vers l'Ouest la projection verticale sur le terrain de la polygonale reliant les points de rencontre de la courbe de niveau de cette borne avec les contreforts avancés du massif du Ruwenzori, et ce jusqu'au point de rencontre avec le méridien de la source la plus septentrionale de la rivière Ulubu ».

4. Les alinéas 56 et 57 sont remplacés par le texte suivant :
« La rive gauche de cette rivière jusqu'à son point de rencontre avec une borne (altitude approximative 1.500 m), puis vers le Sud-Ouest la projection verticale sur le terrain de la polygonale reliant les ponts de rencontre de la courbe de niveau de cette borne avec les contreforts avancés du massif du Ruwenzori et ce jusqu'à la rivière Djalele ou Musanonde ».

5. L'alinéa 66, tel qu'il résulte de l'arrêté royal du 17 mai 1939, est remplacé par le texte ci-après :
« De ce point, une droite jusqu'à la source de la rivière Malibotu ; la rive gauche de cette rivière jusqu'à son confluent avec la rivière Irimba ; la rive gauche de cette rivière jusqu'à son intersection avec le parallèle passant par le confluent des rivières Batonga et Paru (Pulu) (ce dernier étant un cours d'eau temporaire) ; ce parallèle jusqu'à ce confluent ; de ce point une droite jusqu'à la borne sise à la tête du vallon Nyamangose, en bordure de la piste « Tshabi Semliki, chefferie Watalinga » ; de ce point, le lit creusé par les eaux de ruissellement jusqu'au pied du vallon Nyamangose (borne) ; le parallèle passant par la borne sise au pied du vallon Nyamangose jusqu'à son intersection avec la rivière Maginda (borne) ; la rive droite de la Maginda vers l'amont jusqu'à son intersection avec le sentier marqué par le point d'altitude 923 et longeant le pied de l'escarpement de Kamariba ».

6. Les alinéas 101 à 114 inclus sont remplacés par le texte suivant :
« De ce point, une ligne passant par les sommets des monts Rasanga, Busega, Katembo, Loarama, Mapombo, Garara, Bekoha, Kanyiro (un des petits sommets du mont Ikanga), Liassa, Luterero, Bopkara, Kabiniri (Kaliniro), Metsseka, Kiongoto, Kasanga, Mubiriri et Kalero ; du sommet de ce mont la crête du mont Kalero jusqu'à son extrémité Sud ; de cette extrémité une ligne joignant les sommets des onts Bukweri, Lunde ou Nyamoninde, Kahungu ; la croupe méridionale, dénommée Bolambo, du mont Kahungu ; une ligne joignant ce point, dénommé « Bolambo », au confluent de la rivière Butega et de la Talya ; une ligne joignant ce mont au sommet du mont Mushenge ; de ce sommet une ligne joignant le mont Kalingio, le point Mbulamasi du mont Mushanga, le point Kaboha du mont Kitetsa, le point Kasoso du mont Kilambo ; ensuite de ce point une droite joignant le mont Ndwale ; ensuite la crête jalonnée par les monts Ndwale, Kigende, Kaboha (dénommé erronément Kiboha), Kitobo, Shobobia, Lutare, Hahie, Mchembya ».

7. L'alinéa 139 est remplacé par le texte suivant :
« De ce point une droite vers le sommet du mont Kishusha ; ensuite la limite orientale du marais sis au pied du mont Kishusha ; de là un alignement vers une borne située sur le promontoire oriental du mont Kamatembe ; de ce point un alignement vers une borne placée au sommet du ravin M'Bili ; de cette borine un alignement vers la borne se trouvant sur l'ancien sentier Ngandjo Kingi, excluant des limites du Parc National Albert les Collines Shange et Modeya ».

8. Les alinéas 142 à 146 inclus sont remplacés par le texte ci-après :
« Ensuite cette rivière en aval jusqu'au bord du marais de la Nyamuragira, le marais jusqu'à l'angle Nord-Ouest de la concession forestière Marchal à Mugando ; les limites Nord et Est de cette concession jusqu'à son angle Sud-Est ; ensuite une droite en direction du Sud-Est rejoignant le bord occidental de la coulée de lave de 1938 du Nyamuragira ; ensuite le bord occidental de cette coulée de lave jusqu'à son intersection avec le parallèle passant par l'endroit où elle se divise en deux bras ; ensuite ce parallèle jusqu'à l'endroit précité ; ensuite l e bord occidental de la branche orientale de la coulée de 1938 jusqu'au lac Kivu ».

Article 2 L'annexe du décret du 12 novembre 1939, énonçant les limites du secteur du Parc National Albert dénommé « du Mikeno », est modifiée comme suit :

1. Les alinéas 22 à 32 inclus sont remplacés par le texte suivant :

« Cette droite jusqu'au sommet du mont Hehu ; de ce point une droite jusqu'au ravin Kabagwetu (plaque Parc national Albert) ; ensuite une droite joignant l'abreuvoir de Kikeri, le marais mais non l'abreuvoir restant inclus dans le Parc ; ensuite un alignement en direction du sommet du mont Mashaye jusqu'à sa rencontre avec le ravin Kanyamugufa (borne)à ; ensuite ce ravin jsuq'à sa rencontre avec la route carrossable Ngoma Rutshuru (borne).
2. Les alinéas 44 à 47 inclus sont remplacés par le texte suivant :

“ De cet angle une droite joignant le sommet de la colline Kabazogeye ; ensuite un alignement en direction du sommet du mont Gashole (alignement qui traverse les ravins Kasasa et Margarure) jusqu'à l'endroit où il est recoupé par un autre alignement partant du sommet de la colline la plus orientale du groupe de Bukima et tangent au bord oriental de la mare Kinyamutukura ; ensuite cet alignement jusqu'au sommet de la colline la plus orientale du groupe de Bukima ” .

Article 3 : Parmi les droits reconnus aux tiers dans l'annexe au décret du 12 novembre 1935, énonçant les limites du Parc National Albert, sont abrogés :

1. Le droit indigène de pêche dans la rivière Rutshuru, en amont du lieu dit May-ya-Moto, et dans la rivière Semliki.

2. Le droit indigène de coupe de liane « Kekere » (rotin) et de plantes « ulizi » (genre d'aloès) dans la forêt comprise entre la rivière Molindi et le sentier de Mabenga à Tongo.

3. Le droit indigène de récolte de sel sur le volcan Rumoka.

4. Le droit indigène de récolte des palmistes le long de la rive droite de la rivière Semliki, entre les rivières Biola et Musenene.

Article 4 : Les arrêtés royaux des 4 mais 1937 et 17 mai 1939, modifiant les limites du Parc national Albert fixées par le décret du 12 novembre 1935, sont abrogés.

<u>ANNEX 4</u> : ORDONNANCE N° 70-316 DU 30 NOVEMBRE 1970 CREANT UNE RESERVE NATURELLE INTEGRALE DONOMMEE « PARC NATIONAL DU KAHUZI-BIEGA »

LE PRESIDENT DE LA REPUBLIQUE

Vu l'ordonnance-loi n° 69-041 du 22 août 1969 relative à la conservation de la nature, notamment l'article 1er,

ORDONNE :

Article 1er : Il est créé, dans les territoires de Kabare et Kalehe, une réserve naturelle intégrale dénommée « Parc National du Kahuzi-Biega ».

Article 2 : Les limites du Parc National du Kahuzi-Biega sont fixées ainsi qu'il suit :

AU NORD La rive gauche du ruisseau Buhoyo, vers l'amont, depuis son confluent avec la rivière Nyawarongo (borne 195) jusqu'à sa source (borne 202) ; de cette source, une droite de 500 mètres de longueur joignant la piste congolaise Kashoko Tshigoma (borne 203) ; cette même piste, vers Tshigoma, jusqu'à son point d'intercession avec la rivière Kabwali (borne 213) ; la rive gauche de cette rivière, vers l'amont, jusqu'à son confluent avec le ruisseau Lunieka (borne 222) ; de ce confluent, une ligne brisée suivant approximativement la rive gauche de ce ruisseau, vers l'amont, jusqu'à son point d'intersection avec la piste congolaise Lushasha Bataillon Museguyi (borne 226) ; cette même piste, vers Bataillon, jusqu'à 500 mètres du village Museguyi (borne 235) ; de ce point, une droite joignant le pied occidental de la colline Nyamisi (borne 236) ; de cet endroit, une droite joignant le sentier Museguyi-Chatondo à 800 mètres au sud-est de Museguyi (borne 238) ; ce sentier jusqu'à son point d'intersection avec le ruisseau Mariazo à 200 mètres au nord du village Chatondo (borne 239) ; de ce point, une droite joignant le sommet de la colline Mugasha (borne 242), en coupant la rivière Kakoko-Kasheke (borne 240) à 400 mètres de la borne 239 ; de ce sommet, une droite joignant le sentier Museguyi-Mulonge à son point d'intersection avec le ruisseau (borne 243) ; ce même sentier jusqu'à 400 mètres du village Kasiru (borne 245) ; de cet endroit, une droite d'un kilomètre joignant la piste congolaise Mulonge-Hembe (borne 246) ; cette même droite, vers Hembe, jusqu'à 300 mètres du village Lipipume (borne 249) ; de cet endroit, une ligne brisée joignant le ruisseau Mishwa à 300 mètres en amont de son confluent avec la rivière Tshiganda (borne 253) ; la rive droite de ce ruisseau, vers l'aval, jusqu'à son confluent avec la rivière Tshiganda (borne 254).

A L'OUEST. De ce confluent, la rive droite de la rivière Tshiganda, vers l'amont, jusqu'à son confluent avec le ruisseau Nyabuhobuho (borne 1) ; la rive gauche du ruisseau Nyabuhobuho, vers l'amont jusqu'à son confluent, la rive gauche de cet affluent, vers l'amont, jusqu'à son confluent avec un affluent de gauche de ce même ruisseau (borne 12) ; de ce confluent, la rive gauche de cet affluent, vers l'amont, jusqu'à sa source (borne 14) ; de cette source, la limite nord et est de la coupe de bois ex- Scouridine jusqu'au ruisseau Tshangulube (borne 18) ; de cet endroit, la rive gauche du Tshangulube, vers l'amont, jusqu'à sa source (borne 21) ; de cette source, une droite de 120 mètres joignant l'ancienne route Kavumu-Mutiko à 100 mètres du Km 33 (borne 22) ; la limite nord est de l'ancienne route vers Kavumu jusqu'au Km 26,5 (borne 33) ; de ce point, une droite coupant le marais Tshinya et joignant le bord sud de celui-ci aux environs de la limite méridionale de la concession ex-Scouridine (borne 34) ; du bord sud de ce marais, une ligne brisée suivant la limite méridionale de la concession susdite et joignant la source orientale du ruisseau Kakundu, affluent de droite de la rivière Luha (borne 41) ; de cette source, la rive droite du ruisseau, vers l'aval, jusqu'à environ 1,5 kilomètre de son embouchure dans la rivière Luha (borne 46) ; de ce point, une ligne brisée joignant la rivière Luha à 300 mètres en aval de son confluent avec le ruisseau Kashasha (borne 51) ; la rive gauche de la Luha, vers l'amont, jusqu'à ce confluent (borne 52) ; sa source (borne 58) ; de cette source, une ligne brisée jusqu'à la borne 69, située immédiatement au sud du ruisseau Basholwa, de cette borne, une ligne brisée joignant la route Biega-Rambo (borne 71) ; de ce point, le bord oriental de la route, vers le mont Biega, sur une distance de 2,2 kilomètres (borne 72) ; de ce point, une ligne joignant le ruisseau Chibuguma à environ 500 mètres de son embouchure dans le marais Lugulu (borne 80) ; de ce point, une ligne brisée joignant le marais Lushandja aux environs de son extrémité sud (borne 102) ;

AU SUD ET AU SUD-EST. De la borne 102, une ligne brisée joignant cette borne à la borne 129, située à 200 mètres où la route Kabare-Biega franchit le marais Chirere.

A L'EST. De la borne 129, une ligne brisée joignant la route Biega-Kadjedje et longeant cette même route sur une distance de 330 mètres (borne 130) ; de cette même route, une ligne brisée joignant les sommets de la colline Mushanga en passant par les sommets de la colline Mushanga, une ligne brisée joignant la limite occidentale de la plantation U.C.B. Kalonge, en passant par les sommets des collines Nakondo, Karugiri et Lichingu, jusqu'à la borne 147 ; de cette borne, une ligne suivant les limites de la plantation U.C.B. et de l'INEAC jusqu'à la borne 152 ; de cette borne, une ligne brisée jusqu'à la borne 155 en passant par les bornes 153 et 154 ; de la borne 155, une ligne brisée joignant le pied occidental de la colline Kayao (limite U.C.B. M'bayo) en passant par le sommet de la colline Isambyo ; de cet endroit (borne 160) une ligne joignant l'ancienne route Kavumu-Nutiko en suivant la limite occidentale de la concession de l'U.C.B. M'Bayo (borne 164) ; de cette route, une droite joignant le sommet de la colline Nyaminisi (borne 165) ; de ce sommet, une ligne brisée joignant le bord méridional du marais Lusheberre (borne 168) ; de ce point, une ligne suivant le bord méridional de ce marais vers l'est jusqu'à la borne 169 ; de cette borne, une ligne joignant les sommets des collines Kalambagiro et Nyangira (borne 173) ; de ces sommets une ligne joignant la rivière Luiro à 250 mètres en aval de la chute de cette dernière (borne 176) ; de cette rivière, une ligne joignant le sommet de la collline Guigi (borne 179) ; de ce sommet, une ligne brisée joignant la piste congolaise Lushasha-Musiguyi (borne 186) ; de cette piste, une ligne brisée joignant le sommet de la colline Gavuna (borne 194) ; de ce sommet, une ligne joignant le confluent des ruisseaux Nyawarongo, en suivant, vers l'aval, la rive droite de la Nyawarongo (borne 195).

Article 3 : La présente ordonnance entre en vigueur à la date de sa signature.

Fait à Kinshasa, le 30 novembre 1970

(Sé) J.-D. MOBUTU
Lieutenant-Général

<u>ANNEX 5</u> : ORDONNANCE 75-238 DU 22 JUILLET 1975 PORTANT MODIFICATION DES LIMITES DU PARC NATIONAL DU KAHUZI-BIEGA.

Article 1er

Les limites du parc national du Kahuzi-Biega sont fixées ainsi qu'il suit:

au nord

- du confluent du ruisseau Bubeye avec la rivière Nyawarenge (borne 195), la rive gauche du ruisseau Bubeye, vers I'amont, jusqu'à sa source (borne 202);
- de cette source, une droite de 500 mètres de longueur joignant la piste zaïroise Kashoko-Tshingoma (borne 203);
- de ce point, ladite piste, vers Tshigoma, jusqu'a son point d'intersection avec la rivière Kabwali (borne 213);
- de ce point, la rive gauche de la rivière Kabwali, vers I'amont, jusqu'a son confluent avec le ruisseau Lunieka (borne 222);
- de ce confluent, une ligne brisée suivant approximativement la rive gauche du ruisseau Lunieka, vers I'amont, jusqu'à 500 mètres au-delà de son intersection avec la piste zaïroise Lushasha-Bataillon (borne 226);
- de ce Joint, une droite, vers Bataillon, jusqu'a 500 mètres au-dessus du village Museguyi (borne 235);
- de ce point, une droite joignant le kilomètre 53 de la route Bukavu, Kisangani, à I'endroit où la rivière Tshangulube, affluent de la rivière Tshiganda, croise cette route (borne 18);

à l'ouest

- de ce point, la rive gauche de la rivière Tshangulube, vers l'amont, jusqu'à sa source (borne 21);
- de cette source, une droite de 120 mètres joignant l'ancienne route Kavumu-Mutiko, à 100 mètres du kilomètre 33 (borne 22);
- de ce point, la limite nord-est de ladite route, vers Kavumu, jusqu'au kilomètre 26,5 (borne 33);
- de ce point, une droite coupant le marais Tshinya et joignant le bard sud de celui-ci, aux environs de la limite méridionale de la concession ex-scouridine (borne 34);
- de ce point, une ligne brisée suivant la limite méridionale de la concession susdite et joignant la source orientale du ruisseau Kakundu (borne 41), affluent de droite de la rivière Luha;
- de cette source, la rive droite du ruisseau Kakundu, vers l'aval, jusqu'à environ 1,5 km de son embouchure dans la rivière Luha, 300 mètres en aval de son confluent avec le ruisseau Kashasha (borne 51);
- de ce point, la rive gauche de la Luha, vers I'amont, jusqu'à ce confluent (borne 52);
- de ce confluent, la rive gauche du ruisseau Kashasha, vers I'amont, jusqu'à sa source (borne 58);
- de cette source, une ligne brisée jusqu'à la borne 69, située immédiatement au sud du ruisseau Bashoiwa;
- de cette borne, une ligne brisée joignant la route Biega-Bambe (borne 71);
- de ce point, le bord oriental de la route, vers le mont Biega, sur une distance de 2,2 km (borne 72);
- de ce point, une ligne joignant le ruisseau Chiguma à environ 500 mètres de son embouchure dans le marais Lugulu (borne 80);
- de ce point, une droite joignant le sommet de la colline Kabuya;
- de ce sommet, une droite joignant la source de la rivière Nyakagera;
- de cette source, la rive gauche de la rivière Nyakagera jusqu'à hauteur de la colline Besi;
- de ce point, une ligne brisée passant au sommet des collines Besi, Mitumba et Kamami;
- du sommet de la colline Kamami, une droite joignant le point d'intersection des rivières Luka et Kiri;
- de ce point, la rive droite de la rivière Luka jusqu'à 500 mètres au sud des villages de Idambo, Iseka et Utu et joignant le sommet de la colline Matebo;
- de ce sommet, une droite allant jusqu'à 500 mètres à I'est du village Nyamilenge;
- de ce point, une droite joignant la source de la rivière Ezeze;
- de cette source, la rive droite de la rivière Ezeze jusqu'à son intersection avec la rivière Tshamaka, de ce point, une droite passant au sommet du mont Kikimba, coupant les rivières Duma et Kanzuzu et rejoignant la rivière Ezelza jusqu'à sa source;
- de cette source, une ligne brisée passant au sommet de la colline Bituzi, à 500 mètres à I'est du village de Topetope et à 500 mètres à l'est du village de Nzovu, jusqu'à la rivière Lubimbe;
- de cet endroit, la rive gauche de la rivière Lubimbe jusqu'à sa source (Kanioso);
- de cette source, une droite joignant le sommet de la Crète Mishibili;
- de ce point, une ligne brisée suivant cette crête et descendant ensuite jusqu'au pont de la rivière Lushanja, sur la route Walungu-Ninja (limite des deux collectivités);
- de ce point, la rive gauche de la rivière Lushanja jusqu'à la pointe sud du marais Lushanja (borne 102);

au sud et au sud-est

- de la borne 102, une ligne brisée joignant la borne 129, située à 200 mètres à I'est, ou la route Kabare-Niega franchit le marais Chirere;

à l'est

- de la borne 129, une ligne brisée joignant la route Biega-Kadjedje et longeant cette même route sur une distance de 330 mètres (borne 130);
- de ce point, une ligne brisée joignant les sommets de la colline Muchaga en passant par les sommets des collines Iwembiri (borne 135);
- des sommets de la colline Muchanga une ligne brisée joignant la limite occidentale de la plantation ex-UCB Kalonge, en passant par les sommets des collines Nakondo, Karugiri et Lichinga, jusqu'à la borne 147;
- de cette borne, une ligne suivant les limites de la plantation ex UCB et de l'lnera jusqu'à la borne 152;
- de cette borne, une ligne jusqu'a la borne 155 en passant par les bornes 153 et 154;

- de la borne 155, une ligne brisée joignant le pied occidental de la colline Kayao (limite UCB M'Bayo), en passant par le sommet de la calline Isambayo;
- de ce point (borne 160), une ligne joignant I'ancienne route Kavumu-Mutiko en suivant la limite occidentale de I'ancienne concession de I'UCB M'Bayo (borne 164);
- de ce point, une droite joignant le sommet de la colline Nyaminisi (borne 165);
- de ce sommet, une ligne brisée joignant le bord méridional du marais Lusherebe (borne 168);
- de ce point, une ligne suivant le bord méridional dudit marais, vers l'est, jusqu'à la borne 169;
- de cette borne, une ligne joignant les sommets des collines Kalambagiro et Nyangiria (borne 173);
- de ces sommets, une ligne joignant la rivière Luiro, à 250 mètres en aval de la chute de cette dernière (borne 176);
- de cette rivière, une ligne joignant le sommet de la colline Guigi (borne 179);
- de ce sommet, une ligne brisée joignant la piste zaïroise Lushasha-Musiguyi (borne 186);
- de cette piste une ligne brisée joignant le sommet de la colline Gavuma (borne 194);
- de ce sommet, une ligne joignant le confluent des ruisseau Nyawarongo, en suivant, vers I'aval, la rive droite de la Nyawarongo (borne 195).

Article 2

L'ordonnance 70-316 du 30 novembre 1970 est abrogée.

Article 3

La présente ordonnance entre en vigueur à la date de sa signature.

Fait à Kinshasa, le 22 juillet 1975

MOBUTU SESE SEKO KUKU
NGENDU WAZA BANGA
Général de Corps d'Armée

ANNEX 6 : SOCIO-ECONOMIC DATA QUESTIONNAIRE

1. Date :

2. Location :

3. Village :

4. Familial status :

5. No of people in household:

6. How long in village?

7. Primary occupation and previous employment, if any

8. Means of revenue:
   - most important:

   - Sale of various products?

   - Where?

9. No of gardens per family:
   - Crop grown:

   What type of bush preferred for garden?

   Why?

   Length of fallow before clearing again

   Is it easy/difficult to find suitable land?

   Where do you get most cooking and construction woods?

10. Do you hunt with a gun?
   - age at first hunt

   Taught by? What method learned first?

   Methods employed now to exploit game (Only two most important):

11. Best time of the year to hunt; why?

12. Do you hunt all year long?

13. Best time of day hunt:

14. Activities/factors affecting hunting frequency

15. Species preferred for consumption: (Five of them):

16. Species most frequently taken during hunts (five of them and preferred habitat):

17. Largest animal killed with a gun:

18. Most recent kill(s) last time hunting or trapping:

19. Frequency of hunting forays per week? Success rate?

20. Of game taken, how much of 3 is consumed/sold

21. Is there less/more game in forest than in the past 5 years? Why?

    - Is it easy/difficult to find game near village:

    - Best areas for hunting at present:

    -Any species diminishing in local area?

22. Do you have a hunting camp within the park?

    - Distance from village:

    - How often do you hunt at camp: times/year; duration of stay?

    - Is ti easier to find game there?

    - Of game harvested at camp, what proportion of 5 do you sell/consume?

23. Do you have traps?

    - No of lines and traps total:

    - Location:

    - Best time of year for trapping:

    - How often do you check traps?

    - Species most frequently trapped:

    - Largest animal trapped:

    - How often do you change trap lines? Factors involved:

24. Apart from bush meat, are there other forest resources which are important to your livelihood?

ANNEX 7 : LAW ENFORCEMENT MONITORING AUTHORIZATION FORM

REPUBLIQUE DEMOCRATIQUE DU CONGO

INSTITUT CONGOLAIS POUR LA CONSERVATION DE LA NATURE
I. C. C. N.

PARC NATIONAL DE KAHUZI-BIEGA
P N K B

AUTORISATION DE PATROUILLE

SITE: **SECTEUR:**
No. IDENTIFICATION: …… **TYPE DE PATROUILLLE:**
DATE : Débit……. Fin……. SAISON: **VISIBILITE:**

DEPLOIEMENT: Moyen de Transport: 1. **Temps mis:** **Distance parcourue:**
2.
3.

NOM	FONCTION	ARMES	MUNITIONS		
			Remises	Utilisées	Restituées

ORDRES:

ITINERAIRE:

1.RESUME RESSOURCE

PERSONNEL	Nombre	Garde.jrs		Total Jours x Patrouillle	
Armé				GPS Fichier	
Non armé				Ref. Cartes utilisées	
TOTAL				Transport utilisé	

SIGNATURE:..**DATE**.............................

ANNEX 8: KBNP LAW EBFORCEMENT MONITORING DAILY PATROL FORM

REPUBLIQUE DEMOCRATIQUE DU CONGO

INSTITUT CONGOLAIS POUR LA .... PARC NATIONAL DE

CONSERVATION DE LA NATURE .... KAHUZI-BIEGA

I.C.C.N. .... **P.N.K.B.**

Page ___ de ____ Pages totalesb

UNESCO/UNF/DRC/ MIKE-CITES

LAW ENFORCEMENT MONITORING /MONITORING DE L'APPLICATION de la LOI

RAPPORT DE PATROUILLE JOURNALIERE/CONTINUELLE

SITE: ______________________________ **SECTEUR:** ______________________________

TYPE DE PATROUILLE ____________ . ____________ **Objectifs** ____________________ **No. ID PATROUILLE** ____________________

DEBUT Date: ____________ **Heure** ______ **Localisation:** ______________ **FIN: Date** ________ **Heure** __________ **Localisation:** ________________

CARTE UTILISEE: __________ **Indiquez votre itineraire et observations sur la carte et Notes supplémentaire sur le verso de cette fiche:**

CONDITIONS DE TERRAIN:

Observer f	Date	Heure	POSITION		INDICATEURS d'ACTIVITES HUMAINES				ACTIONS PRISES ET RESULTATS		OBSERVATIONS FAUNE				OBSERVAT. FLORE		NOTES
			GPS/ Quadrat	Nom lieu	Indicateurs / Observations	Classification	Durée/Détails	Qté	ACTIONS	RESULTATS	Types de Signes	Espèce	Age	Qté	Esp	Typ observat	

ANNEX 9: VNP LAW ENFORCEMENTMONITORING DAILY PATROL FORM

ICCN INSTITUT CONGOLAIS POUR LA CONSERVATION DE LA NATURE

REPUBLIQUE DEMOCRATIQUE DU CONGO
INSTITUT CONGOLAIS POUR LA CONSERVATION DE LA NATURE
I. C. C. N

NOM DU SITE ET/OU STATION: **Pat ID** ______

STATION		Nbre pers.		Patrouille pedestre		Jour		Patrouille		Dist.patrouille	
Secteur patrouillé		Date		Patrouille lacustre		Type de patrouille		A/R	S/tente	Type de GPS	

N°	HEURE	LIEU	WP ID	COORDONNEES GPS				RESULTATS SUR TERRAIN								
				Nord/Sud	Est/Ouest	DIRECTION	Distance	Observations (N/C/Mort)	Adulte	Juvénile	Tot	Age	Unité	Action prise	Type d'habitat	Objets saisis

<u>ANNEX 10:</u> DEMOGRAPHY AROUND THE KAHUZI-BIEGA NATIONALPARK (2003-2007)

2003

Ref	Territoire	Groupement	Homme	Femme	Garcons	Filles	Total
1	Kabare	Ihembe	1165	1465	1675	1676	5981
2	Kabare	Luhago	968	1101	1429	1463	4961
3	Kabare	Irega-Baronyi	1011	1190	1322	1630	5153
4	Kabare	Bushwira	7415	8432	5927	7320	29094
5	Kabare	Bugobe	378	398	724	728	2228
6	Kabare	Miti	1023	8047	2204	2195	13469
7	Kabare	Katana	5770	7967	6906	6947	27590
8	Shabunda	Baliga	11195	12332	9392	9638	42557
9	Walungu	Kaniola	5338	9867	10328	11401	36934
10	Walungu	Ikoma	3614	2647	6125	6168	18554
11	Walungu	Izege	2285	2683	5786	5707	16461
12	Kalehe	Bulonge	1212	1685	2006	2443	7346
13	Kalehe	Bitale	3516	3871	5043	9956	22386
14	Kalehe	Musenyi	1053	1406	1478	2006	5943
15	Kalehe	Ndando	804	1188	1260	1680	4932
16	Kalehe	Kalonge	1104	1005	1075	1182	4366
17	Kalehe	Bagana	2110	2117	2231	2310	8768

2004

Ref	Territoire	Groupement	Homme	Femme	Garcons	Filles	Total
1	Kabare	Ihembe	2200	1509	1725	1926	7360
2	Kabare	Luhago	997	1134	1472	1507	5110
3	Kabare	Irega-Baronyi	1041	1225	1362	1678	5306
4	Kabare	Bushwira	4944	5222	3952	4880	18998
5	Kabare	Bugobe	389	410	745	767	2311
6	Kabare	Miti	1054	8288	2270	2261	13873
7	Kabare	Katana	5943	8206	7113	7156	28418
8	Shabunda	Baliga	16822	18497	14088	14457	63864
9	Walungu	Kaniola	8007	10172	15491	17101	50771
10	Walungu	Ikoma	5754	7179	9279	9528	31740
11	Walungu	Izege	3427	4024	8678	8560	24689
12	Kalehe	Bulonge	1248	1746	2066	2517	7577
13	Kalehe	Bitale	3622	3987	5189	10255	23053
14	Kalehe	Musenyi	1085	1448	1522	2066	6121
15	Kalehe	Ndando	828	1224	1297	1734	5083
16	Kalehe	Kalonge	1236	1207	1307	1038	4788
17	Kalehe	Bagana	1001	1022	1134	1207	4364

2005

Ref	Territoire	Groupement	Homme	Femme	Garcons	Filles	Total
1	Kabare	Ihembe	1747	2197	2512	2514	8970
2	Kabare	Luhago	1451	1652	2144	2210	7457
3	Kabare	Irega-Baronyi	1516	1784	1983	2042	7325
4	Kabare	Bushwira	11122	12655	8890	10980	43647
5	Kabare	Bugobe	4411	4652	8465	8504	26032
6	Kabare	Miti	1085	8537	2338	2329	14289
7	Kabare	Katana	8505	10450	16358	16422	51735
8	Shabunda	Baliga	17329	19052	14511	14890	65782
9	Walungu	Kaniola	8247	10477	15956	17614	52294
10	Walungu	Ikoma	5926	7395	9558	9814	32693
11	Walungu	Izege	4144	8944	8938	8818	30844
12	Kalehe	Bulonge	1285	1799	2128	2592	7804
13	Kalehe	Bitale	3731	4106	5351	10563	23751
14	Kalehe	Musenyi	1118	1491	1568	2128	6305
15	Kalehe	Ndando	853	1260	1336	1786	5235
16	Kalehe	Kalonge	1124	1286	1305	1048	4763
17	Kalehe	Bagana	745	797	1012	1088	3642

2006

Ref	Territoire	Groupement	Homme	Femme	Garcons	Filles	Total
1	Kabare	Ihembe	1200	1509	1725	1726	6160
2	Kabare	Luhago	5494	1702	2208	2276	11680
3	Kabare	Irega-Baronyi	1562	1837	2043	2103	7545
4	Kabare	Bushwira	11456	13035	9156	11309	44956
5	Kabare	Bugobe	4543	4792	8719	8759	26813
6	Kabare	Miti	1118	8793	2408	2399	14718
7	Kabare	Katana	9060	10763	16849	16915	53587
8	Shabunda	Baliga	17849	19624	14946	15336	67755
9	Walungu	Kaniola	8521	10791	16435	18142	53889
10	Walungu	Ikoma	6104	7596	9745	10108	33553
11	Walungu	Izege	3635	4268	9206	9082	26191
12	Kalehe	Bulonge	1240	1646	1850	1900	6636
13	Kalehe	Bitale	2340	2963	2836	3925	12064
14	Kalehe	Musenyi	598	789	903	940	3230
15	Kalehe	Ndando	815	1058	900	996	3769
16	Kalehe	Kalonge	11956	12641	16575	17336	58508
17	Kalehe	Bagana	1074	1356	1930	1950	6310

2007

Ref	Territoire	Groupement	Homme	Femme	Garcons	Filles	Total
1	Kabare	Ihembe	1236	1554	1777	1778	6345
2	Kabare	Luhago	5659	1753	2274	2345	12031
3	Kabare	Irega-Baronyi	1609	1892	2105	2166	7772
4	Kabare	Bushwira	11800	13426	9705	11648	46579
5	Kabare	Bugobe	4680	4936	8981	9022	27619
6	Kabare	Miti	1151	9057	2480	2471	15159
7	Kabare	Katana	9331	11086	17354	17422	55193
8	Shabunda	Baliga	18555	20314	17440	18308	74617
9	Walungu	Kaniola	8776	11115	16928	18686	55505
10	Walungu	Ikoma	6287	7824	10038	10411	34560
11	Walungu	Izege	3744	4396	9482	9355	26977
12	Kalehe	Bulonge	462	507	689	792	2450
13	Kalehe	Bitale	1644	1834	1501	1619	6598
14	Kalehe	Musenyi	424	464	471	591	1950
15	Kalehe	Ndando	142	164	232	253	791
16	Kalehe	Kalonge	12415	13020	17072	17856	60363
17	Kalehe	Bagana	627	748	1030	1079	3484
2008							
Ref	**Territoire**	**Groupement**	**Homme**	**Femme**	**Garcons**	**Filles**	**Total**
1	Kabare	Ihembe	2797	2910	3701	4002	13410
2	Kabare	Luhago	1140	1214	3105	3341	8800
3	Kabare	Irega-Baronyi	4877	5194	9604	10477	30152
4	Kabare	Bushwira	12153	18425	8468	10695	49741
5	Kabare	Bugobe	4775	4597	11020	11601	31993
6	Kabare	Miti	2005	2361	6813	6455	17634
7	Kabare	Katana	10029	10468	16402	16614	53513
8	Shabunda	Baliga	18555	20314	17440	18308	74617
9	Walungu	Kaniola	8078	10396	15706	17333	51513
10	Walungu	Ikoma	5669	7076	9324	9376	31445
11	Walungu	Izege	3404	4023	8689	8579	24695
12	Kalehe	Mulonge	472	522	710	816	2520
13	Kalehe	Bitale	4932	1889	1546	1668	10035
14	Kalehe	Musenyi	435	478	485	609	2007
15	Kalehe	Ndando	146	169	239	261	815
16	Kalehe	Kalonge	12787	13410	17584	18392	62173
17	Kalehe	Bagana	645	770	1060	1112	3587

Source: Division provinciale de l'Intérieur, Décentralisation et Sécurité Sud Kivu : 2003 ; 2004 ; 2005 ; 2006 ; 2007 ; 2008

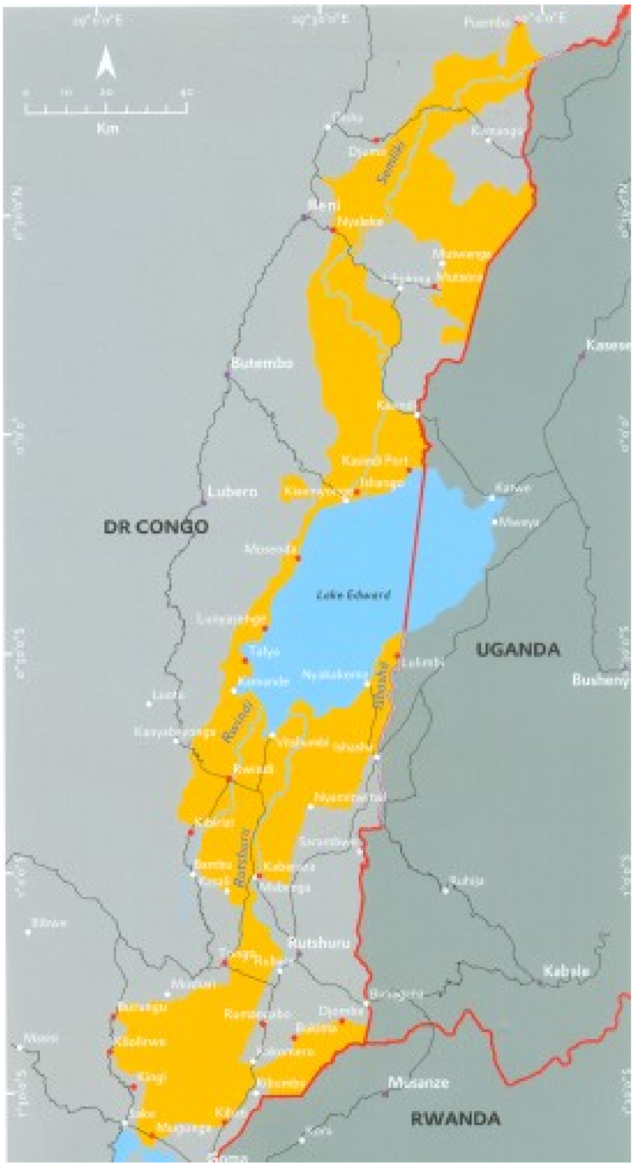
ANNEX 11: DEMOGRAPHY AROUND THE VIRUNGA NATIONAL PARK (2007-2008)

Entité	Superficie en Km2	Population en 2007	Densité au Km2
VILLE DE GOMA	75	265584	3541
VILLE DE BUTEMBO	190	555603	2924
VILLE DE BENI	104	56144	540
TERRITOIRE DE.BENI	7484	957241	128
TERRITOIRE LUBERO	18096	981251	54
TERITOIRE RUTSHURU	5289	618147	117
TERRITOIRE NYIRAGONGO	163	66949	411
TERR TERITOIRE MASISI	4734	580343	123
TERR TERITOIRE WALIKALE	23475	794883	34
PROVINCE DU NORD KIVU	**59610**	**4876145**	**82**

Entité	Superficie en Km2	Population en 2008	Densité au Km2
VILLE DE GOMA	75	265584	3541
VILLE DE BUTEMBO	190	555603	2924
VILLE DE BENI	104	561144	5396
TERRITOIRE DE.BENI	7484	957241	128
TERRITOIRE LUBERO	18096	981251	54
TERITOIRE RUTSHURU	5289	618147	117
TERRITOIRE NYIRAGONGO	163	66949	411
TERR TERITOIRE MASISI	4734	580343	123
TERR TERITOIRE WALIKALE	23475	794883	34
PROVINCE DU NORD KIVU	**59610**	**5381145**	**90**

Source : Division Provinciale du Plan avec fichier des entités administratives du Nord Kivu, 2007-2008

Source: Languy & de Merode, 2009a



Annex 12: Map of the Virunga National Park showing principal locations.

Source: SYGIAP Project, 2009
Annex 13: General Map of VNP.

Source: SYGIAP Project, 2009
Annex 14: General Map of the Kahuzi-Biega National Park.

Recent assessments of the conservation status of wildlife present an alarming picture of ongoing declines, emphasizing the overriding need for informed conservation actions through law enforcement monitoring with patrolling park guards acting as the eyes and observers of any illegal activity and ecosystem change. Many ill-functioning weapons continue to be carried by game staff in an attempt to sustain the desired image, but no match against groups of well armed poacher's gangs. Notwithstanding, subsistence hunters in surrounding areas were aware of the reality on the ground and not surprisingly showed scant respect for the guards. On the face of the comments, it appears that conservation activities designed to meet people's basic needs deserve more attention as the region's ever-growing human population struggles to eke out a living. To all intents and purposes, Ranger-Based Monitoring allows wildlife managers to run law enforcement operations efficiently and cost-effectively, even in times of uncertainty, by providing real-time information on which to make informed-decisions for a conservation area. To this end, geographical technology such as GPS device and State-of-the art GIS has now become mainstream and a strong backbone as far as tackling tomorrow's threats and safeguarding biodiversity in protected areas are concerned.