


Multiplying Factors of Disturbance of Mammalian Fauna during Evolution in the Itombwe Nature Reserve in DR Congo

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How to cite this paper: Mutula, O.-S.M., Mutugi, R.C., Githaiga, J. and Muzusangabo, C.K. (2025) Multiplying Factors of Disturbance of Mammalian Fauna during Evolution in the Itombwe Nature Reserve in DR Congo. *Natural Resources*, 16, 153-171. <https://doi.org/10.4236/nr.2025.164008>

Received: January 7, 2025

Accepted: April 18, 2025

Published: April 21, 2025

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Abstract

The Itombwe Nature Reserve, like many other protected areas, is home to a relatively diverse and particularly important mammalian fauna. But over time there have been disturbances that have exposed this fauna to serious threats within this protected area. This work aims to bring out, through a descriptive analysis, the multiplying factors which have contributed to the disruption of mammalian wildlife over the course of its evolution in the Itombwe Natural Reserve, since 1998. The responses of 332 interviewees, hunters, bushmeat suppliers and sellers as well as artisanal miners through semi-structured discussions and focus groups, 79.5% support the idea of species decline, 16% rarity and 4.5% stability. It follows that in the Itombwe Nature Reserve there are several multipliers that are at the root of species alteration including political conflicts leading to the creation of armed groups that take refuge in the reserve and engage in different exploitation of resources, socio-economic developments, for a poor population that must survive as well as the growing influence of hunting. Two factors have impacted the evolutionary trend of species; firstly the *extrinsic or anthropic* emanating from armed groups, logging, intense hunting, increase in hunters, gold panning and demand from the bushmeat market. Second, *the intrinsic arising* from the size, slow gestation, large litter of young, territoriality, group living and cosmopolitanism species. A spatial distribution over different types and periods of observation emerged to explain the trend of disturbance focused mainly on the emblematic species of the Democratic Republic of Congo in the Itombwe Natural Reserve; these are *Gorilla gorilla*, *Loxodonta africana*, *Manis gigantea*, *Manis tricuspis*, *Panthera pardus*, *Pan troglodytes* and *Syncerus caffer*.

Keywords

Species Alteration Multiplier, Disturbance, Evolution, Wild Mammalian Fauna, Itombwe Nature Reserve (INR), Democratic Republic of Congo

1. Introduction

The effects of global change are increasingly visible in the Congo Basin, where habitat loss, forest fragmentation and uncontrolled hunting have increased in recent decades. This has resulted in a significant reduction wild mammalian species [1] [2] which remains less studied in these regions. In this context, protected areas can play the role of ecological refuge [3] by conserving species wild mammals threatened with high mobility and adaptation capacities [4]. Unfortunately, this role of ecological refuge is difficult to assess in some African countries and in the Democratic Republic of Congo in particular where most protected areas have been established on a minimal basis of knowledge of resources, and especially of wild mammalian fauna [5]. The taxa of the wild mammal have not been adequately inventoried before and after the establishment of many protected areas [6], and in particular that of the Itombwe Nature Reserve, which is constantly emerging, following monitoring actions.

The conservation of nature in protected areas and its ecosystem services and values constitutes a major challenge for managers of these spaces [7]-[9].

Several reasons are cited to justify the depletion of mammalian fauna in the Democratic Republic of Congo, the most recurrent being demographic, economic and technological factors [10]-[15].

Notwithstanding this mentioned state, the statuses of mammalian wildlife values in the Itombwe Nature Reserve must be updated in order to assess the effectiveness of their management [9] [16]. This task provides reliable information on the level of conservation of wild mammalian species [17]. When it comes to this, the ecological integrity of these environments in the interest of current and future generations can only be maintained by excluding any form of exploitation or occupation incompatible with the objectives of conservation. It is with this in mind that this study is conducted.

Its overall objective is to come out the causes of wildlife disturbance over the past 25 years since 1998, a period characterized by wars and land occupation in the Itombwe Nature Reserve and in the Democratic Republic of Congo in general.

2. Methods

2.1. Description of the Study Area

2.1.1. Legal Framework

The Itombwe Nature Reserve (INR) is recognized by Ministerial Order No. 038/CAB/MIN/ECN-EF/2006 of October 11, 2006 [18]. Located in the northwest corner of Lake Tanganyika, within a region surrounded by the Territories of Fizi,

Mwenga, Uvira and Walungu. Its total area recognized since 2015 is 5732 km², the Central Integral Conservation Zone: 2080 km² (*i.e.* 36.3%), the Buffer Zone (2 km wide transition zone around the central zone): 554 km² (*i.e.* 9.7%), Multiple-use zone: 3097 km² (*i.e.* 54%) [19].

The mountain ranges, “Itombwe Mountains” of which the INR is a part, are located in the province of South Kivu, south of the city of Bukavu, in the east of the Democratic Republic of Congo. Its area is between 2° 40' - 4° 30' South latitude and 27° 50' - 29° 10' East longitude [20]-[22] (**Figure 1**).

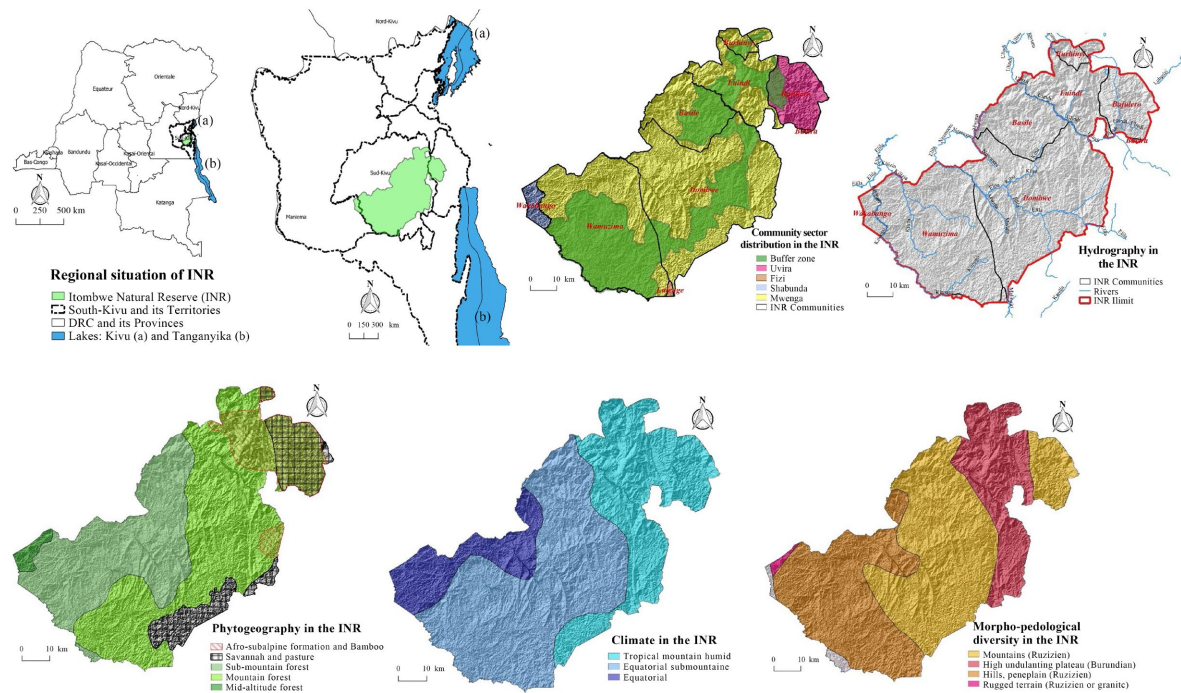


Figure 1. Maps of the Itombwe Nature Reserve area.

2.1.2. Climate and Precipitation

INR is characterized by diverse climates, in particular the sub-montane equatorial lowland climate from the center to the west, covering a significant area, the humid tropical mountainous climate of the plateaus in the east and the equatorial climate of the northwestern extremities (**Figure 1**).

Maximum rainfall is usually between March and April, with the second highest rainfall occurring in December. The minimum value is from June to July to August, with the second minimum occurring from January to February [20] [23] [24].

2.1.3. Morpho-Pedological Diversity

The morpho-pedological diversity of the INR part (**Figure 1**). The Ruzizian formation of hill-peneplains and mountains covering the major part is dominated, then the undulating highlands of the Burundian formation. We also observe the Ruzizian part on granite including the rugged terrain in the West [22] [25] [26].

Most of the Itombwe Mountains are over 1500 m high and consist of highlands

of 2000 m above sea level. The highest peak, over 3000 m above sea level, is dominated by the Lake Lungwe area and the height between Uvira and Nundu.

2.1.4. Hydrographic Network

The INR, part of the Itombwe Mountains Region, consists of a dense river network that is entirely part of the Congo Basin (3,684,000 km²; average discharge: 39,000 m³/s). Most of the mountains west of the highest peak are drained to the north and south by the Ulindi, then the Elila and its tributaries, and the tributaries of the Luama. At the eastern end, the surrounding river network is part of the Lake Tanganyika watershed. The Ulindi, Elila and Luama rivers flow directly into the Lualaba River (the name of the Congo River upstream of Kisangani). The area of the Ulindi River basin is estimated at 30,240 km² and the area of Elila is estimated at 27,360 km² [26] [27]. It should be noted that, as an indication, the point flows measured several kilometres from the mouths of the Ulindi and Elila rivers vary between 300 - 1700 m³/s and 200 - 1400 m³/s respectively. These runoff fluctuations are closely linked to the monthly and annual precipitations that feed the water table.

2.1.5. Phytogeography

The phytogeographic map [28] shows the main vegetation lines within the INR limit (Figure 1). In the north and east, we observe inclusions of Afro-subalpine and bamboo formations in a dominance of mountain forests and sub-montane forests. The north-east and south are covered with savannas and pastures.

Human activities have seriously degraded this landscape, particularly on the eastern flank of the mountains in the highlands. The summit itself is still overgrown, but logging is inevitable.

2.1.6. Wildlife

Several studies in the INR [21] [29] [30], refer to a rich zoological biodiversity. Firstly, the diversity of birds, specifically the Congo Bay Owl (*Phodilus prigoginei*), the Schouteden's Swift (*Schoutedenarpus schoutedeni*), the Prigogine's Nightjar (*Caprimulgus prigoginei*) and the Hall's Bubul (*Andropadus hallae*). Secondly, a large population of mammals including Grauer's gorillas (*Gorilla beringei graueri*), eastern chimpanzees (*Pan troglodytes schweinfurthii*). Third, an endemism in amphibians, speaking of 34 species identified with 16 endemics and about twenty species and subspecies recorded above 1500 m, the greater part has a limited distribution including *Hyperolius castaneus constellatus*, *Hyperolius leleupi*, *Chrysobatrachus cupreonites*, *Rana* sp, *Schoutedenella vercammeni* and *Laurentophryne parkeri*. Fourthly, a census of 35 species of reptiles including 5 endemic [19] [31] [32], among them the Nile Monitor (*Varanus niloticus*) and the Grauer's Chameleon (*Chamaeleo graueri*, which remains unresolved) and fifthly, the aquatic fauna in the watercourses of the forests at high altitudes has been little studied with few fish identified, this following the significant disturbances of the gold panning activities which are too widespread in the landscape although the ichthyological fauna is richer at lower altitudes.

2.1.7. Socioeconomic

The INR landscape extends over the Mwenga area, the largest comprising the communities of Itomwe, Wamuzimu, Lwindi, Luhwinja, Burhyinyi and Basile, then the Uvira area comprising the communities of Bafulero and Bavira, then the Fizi area comprising the community of Lulenge and finally the Shabunda area in the community of Wakabango.

The component ethnic groups are mainly from the Régas community who are indigenous and landowners in Mwenga and Shabunda. We also find the Bafulero and the Bavira of Uvira; the Babembe of Fizi and the Bashi who are migrants too present throughout the region because they are the community characterized by trade.

The communities found around the reserve are mainly farmers and fish farmers; they have limited financial means and are mostly poor.

2.2. Data Collection and Analysis

In order to know how perception describes the level of knowledge of the indigenous people regarding conservation in the INR landscape; the questionnaire survey technique allowed us to open different semi-structured discussions and focus groups, in order to show the expression and the allegation of this community in the concept of the safeguarding of mammalian wildlife.

Various authors support interviews as tools constituting an appropriate method to address issues of perceptions in protected forest entities [33] [34]. The sample consisted of 332 interviewees in the INR landscape. The questions were therefore divided into three parts: identification of the respondent, perception on conservation in the INR and knowledge on the composition and faunal use of the INR. The data were collected on Kobocollect, then analyzed using Excel and R (R version 4.3.0; R Core Team, 2023) and QGIS to bring out the evolutionary perception of the wild mammal as recognized and cited by the interviewers within the INR.

The questions were designed in accordance with the ethics statement for data release, participation in this study was voluntary and informants had to read a short consent form supported by a brief explanation before they could begin answering our questions.

For the identification of wild mammal species in the INR, preliminary surveys were carried out and allowed the establishment of a list in the local language supported during identification by images from The Kingdon field guide to African mammals (2015).

2.3. Ethics and Data Availability Statement

Participation in this study was voluntary and informants were required to read a short consent form before they could begin answering our questions. Participants were free to participate or withdraw from the study. The study was doubly approved by the second author's institutional ethics committee before and after data collection. The dataset used for this study is available upon request.

3. Results

3.1. General Characteristics of Informants

Table 1 presents the main characteristics of the 332 respondents in the INR landscape.

Table 1. Identity classification of interviewees in the INR landscape.

Identity classification		Effective	Percent (%)	Statistics (Chi2)
Activities	Bushmeat seller	179	53.8	X-squared = 75.042, df = 2, $p < 0.001$
	Hunter	102	30.8	
	Ore digger	51	15.4	
Sex	female	57	17.3	X-squared = 143.14, df = 1, $p < 0.001$
	Male	275	82.7	
Age	Adult (18 - 45 years)	198	59.6	X-squared = 105.19, df = 2, $p < 0.001$
	Old (45 years and over)	77	23.1	
	Youth (Under 10 - 18 years)	57	17.3	
Education	Primary	89	26.9	X-squared = 175.01, df = 3, $p < 0.001$
	Secondary	179	53.8	
	University	38	11.5	
	Whithout	26	7.7	
Ethnic group	Bembe	83	25.0	X-squared = 101.16, df = 3, $p < 0.001$
	Fulero	45	13.5	
	Rega	160	48.1	
	Shi	45	13.5	

The table above statistically demonstrates that the different classifications among the participants are highly significant with a $p < 0.001$.

The discussions on species were insisted especially with hunters, because they are the first in direct interaction with animals by regularly visiting hunting areas in the INR. This helps to explain the level of involvement of the latter in conservation, although their professional activities are multiple, in addition to hunting, they are a first-rate supplier of bushmeat, and are also mining diggers, one of the illicit activities within the reserve (**Table 1**).

3.2. Evolutionary Trends Observed in the Fauna in the INR

Table 2. Trend of INR species by interviewer category.

Status	Effective	Percent	Statistics (Chi2)
Decreased	264	79.5	X-squared = 325.2, df = 2, $p < 0.001$
Disappeared	53	16.0	
Stable	15	4.5	

Overall, the trend in mammal observations in the area shows a progressive decrease in all species over the last 25 years, since 1998.

In particular (**Table 2**), it is clear that there is a large significant difference ($p < 0.001$) in relation to the evolutionary status of species in the Itombwe Nature Reserve. According to the different perceptions of the interviewers; and hunters in particular, 79.5% agree on the progressive decrease of species, against 16% who think of the disappearance and 4.5% who think of the stability of the few species.

Overall (**Figure 2(a)**), of the 42 species recognized and cited through discussions, 4 species have disappeared or almost disappeared (*Loxodonta africana*, *Expirus wilson*, *Neotragus batesi* and *Syncerus caffer*); three have remained stable (*Cephalophus monticola*, *Cephalopus calliigus* and *Cercopithecus hamlyni*) and all the others, *i.e.* 35 species have totally declined.

Hunters have listed a number of species that are constant or regularly observed in the Reserves studied. These are *Atherurus africanus*, *Cricetomys emini*, etc. Of these so-called diminished species, none is cited by a majority of hunters as having declined drastically.

3.3. Factors That Impacted the Evolutionary Trend of Species

Two factors have influenced the evolution of species in the Itombwe Natural Reserve. First, the intrinsic factors (**Figure 2(b)**) which are values given to the characteristics specific to the species including size, slow management, occupation of territories, nocturnal or diurnal activities, life in small groups and the presence of cosmopolitan species. Second, the extrinsic factor (**Figure 2(c)**), which gives values to natural actions, here anthropic which influence the species, these are logging, intense hunting, the increase in hunters, the occupation of armed groups in the Reserve, the presence of gold panning activities in the Reserve, high demand for bushmeat in the markets.

As for extrinsic factors, it is appropriate first of all that the decrease in wild species in the RNI is marked by intensive hunting, followed by the activities of armed groups that have set up small camps within the RNI, as well as the increased demand for bushmeat in the markets. Then the species that are declared stable have a tendency that is influenced by intense hunting, and finally those that are said to be stable are much more mobile, hence anthropization is considered an act harmful to the conservation of wildlife if it is not well controlled.

As for the intrinsic factors (**Figure 2(c)**), it happens that no influence of the trends cited by a majority of hunters as having drastically reduced the species within the INR, which appears to say neither the life in small groups (gathering), nor the territorial life, nor the cosmopolitan tendency of the species, nor the litter of a certain number of young, nor the size and nor the slow gestation, all almost equally contributed to the decrease of the species. As for the rarity of the species, the aforementioned factors except the slow gestation have an influence in the evolutionary trend. Finally, the species called stable, the size and the too slow gestation were not cited as a factor of influence of trend, all the other factors were brought out.

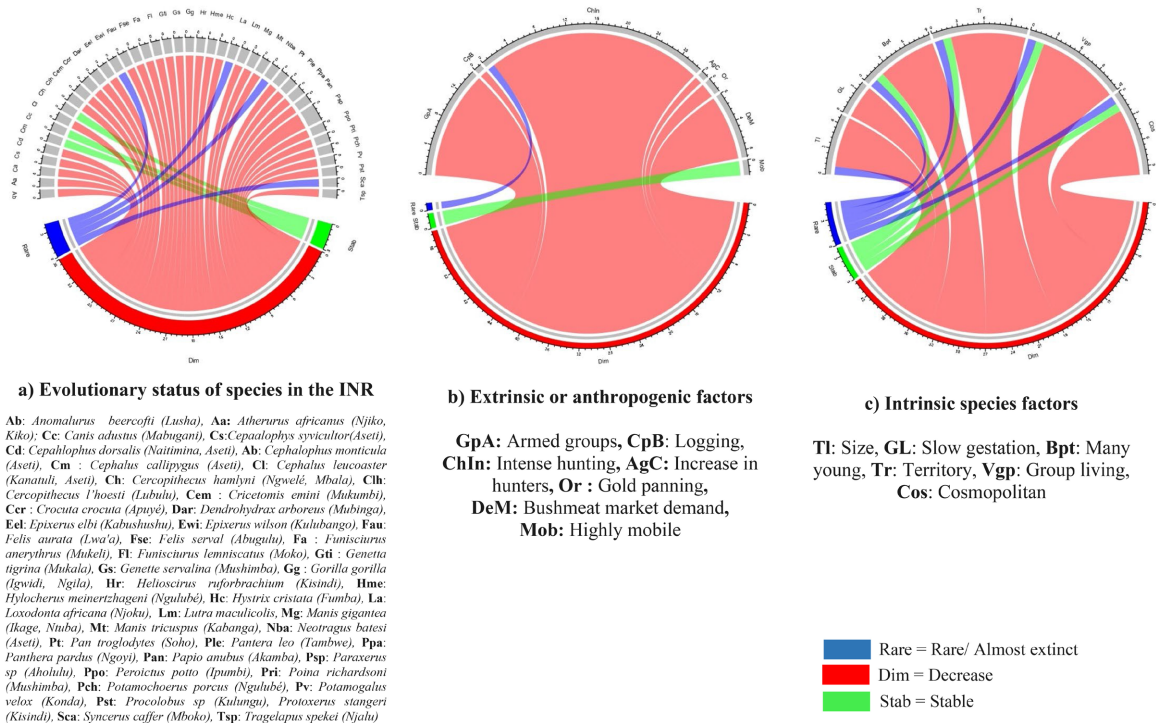


Figure 2. Evolutionary trends observed in fauna in the INR.

3.4. Situation of Emblematic Species by Types of Observation

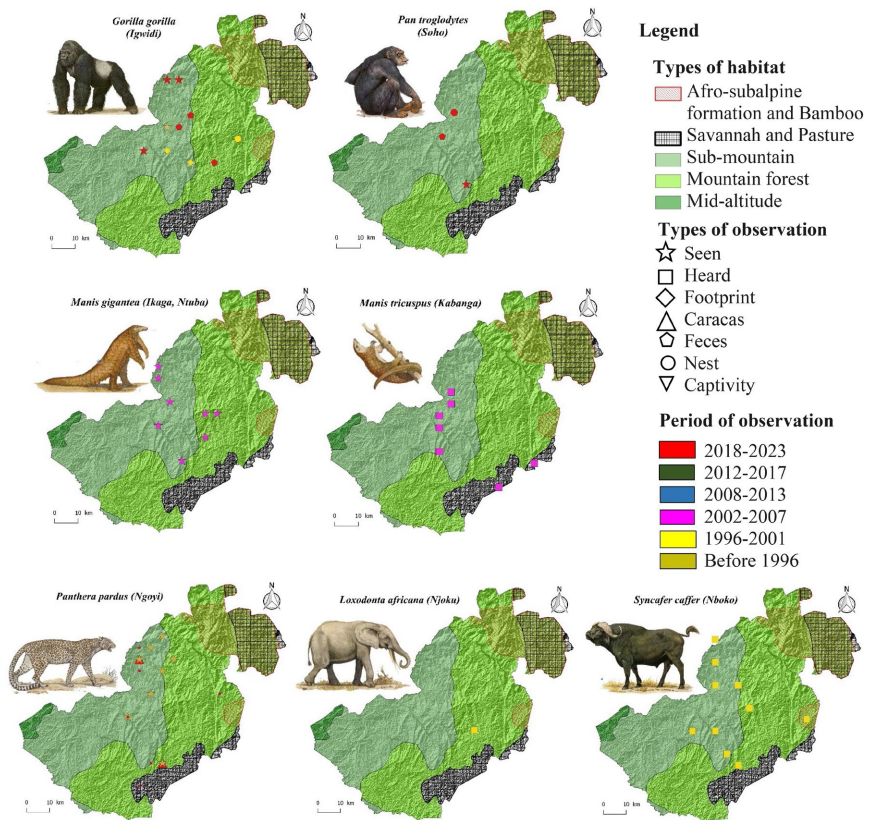


Figure 3. Situation of emblematic species by types of observation.

According to the conservation status of the DRC and ICCN, **Figure 3** shows the type and period of observation of the seven emblematic species of the register (*Gorilla gorilla*, *Loxodonta africana*, *Manis gigantea*, *Manis tricuspis*, *Panthera pardus*, *Pan troglodytes* and *Syncerus caffer*) known, following the evolution of observation for 25 years, that is to say before 1996 to 2023, these species have probably become occasional, rare or disappeared from the INR.

4. Discussions

Multipliers of INR Species Alterations during Evolution

The mammalian wildlife in the INR landscape has been historically altered by various multiplier factors. Based on group discussions with seasoned hunters, key information and existing documentation, it is clearly described that the multiplier alters that have influenced the trends of the species cited in the INR landscape have led significantly to either the decrease or the stability and disappearance of certain species over the last 25 years (1998-2023). The multipliers of alterations are of the order linked to the socio-ecosystem including in a pronounced and explanatory way in this case by the political conflicts, the socio-economic evolution and the increasing influence of the hunts (**Figure 4**). These observations were also observed in different regions such as the Yangambi and Ngazi Reserve in the DRC and Brazil, in the amazonia. [34]-[38].

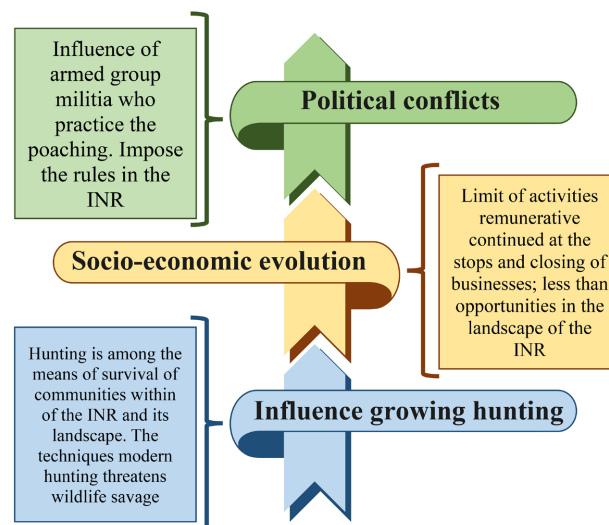


Figure 4. Socio-evolutionary layout in the INR landscape with impacts on wildlife.

➤ Political conflicts:

Since the 1996s, there have been successive rebellions here and there in the DRC, and in the East of the country in particular, which has negatively affected the conservation areas of wild fauna species in the Parks, the Hunting areas as well as the Nature Reserves. The INR, located in the East of the country, has suffered the same effects having caused several collapses which have affected the species in its natural environment as well as its habitat [37] [39]-[41]. In fact, the social, eco-

nomical and ecological system was also particularly affected. This unleashed a considerable loss of perspective on the monitoring and evaluation of wildlife in our environments. During the conflicts, military barracks were set up by armed groups to hide, others passed through the forest in order to pursue the rebel armies. It appears that the management and monitoring of wildlife by agents in charge of conservation became complex within the INR. As a result, the difficulties of reaching certain remote sites in the Reserve, the identification and evaluation of wildlife also became difficult. On the other hand, following the equipment set up by the militias, the small groups of rebels established within the Reserve, imposed their operating rules, this is how they engaged in poaching, to survive but also for illicit trade, logging and gold panning activities were born [37] [42]-[44].

Although the political-conflictual management in this region is gradually being rearranged; the faunal diversity of the species in the environment has undergone significant changes requiring more and more special interest in habitat restoration and the establishment of integrated governance that is complementary to the established, existing and updated state rules.

➤ **Socio-economic developments:**

The decline, following the political-regional instabilities in the DRC for more than two decades, has led to significant economic instability that has affected all the communities living in the Itombwe landscape, including the INR. The companies otherwise known in Itombwe have closed, most of them were assigned to oil milling (palm oil), gold panning, fish farming, etc. Access roads have become impassable, leading to the delay of goods, which has reduced the diversification of activities by limiting the community from thriving economically by blocking contacts that offer more opportunities, as well as limiting communication. As a result, there is a widespread decrease in the flow of goods which is also limited by the movement of people [39] [45]-[48].

In view of the galloping demography, the lack of jobs caused by the lack of opportunity, to ensure its food security, it turns out that the greatest number of families have become dependent on forest resources. During these last twenty-five years, with regard to the demographic growth that is experienced, the landscape of Itombwe stands out for a supply with an unfair and unsatisfactory production to its community. Become, rare and occasional, the animal resources that once contributed equitably within the communities, by the Batwa and Bantu peoples of Itombwe professional hunters for several decades and this people who lived from hunting before the colonial entry which was able to introduce the system of work dependent on private companies, then state. Which gradually led certainly to changes in morals within these indigenous communities otherwise hunters and gatherers, balanced with their forest environment. The supply of domestic animal meat, bushmeat and fish markets has increased over the last twenty years to satisfy and accommodate food needs [9] [49]-[52].

The INR is threatened because the population has become mixed, driven by

exoduses, and is pushing people to enter the established reserve in search of arable land. The increase in arable land and areas of gold panning activities contributes significantly to the deformation of forest habitats where wild species can flourish. According to hunters, the increase in cultivated areas leads to the displacement of species and difficulties in reaching distant forests due to the distance to reach hunting grounds. Some species have become more abundant and cosmopolitan, have adapted although they have become anthropized and have prospered in these agricultural environments [53]-[59].

➤ **Growing influence of hunting:**

Hunting currently in the INR significantly influences the distribution of species and the scarcity that is seen by the galloping growth of hunters. We are witnessing an increase in hunting techniques following the demographic movement that continues to increase, and which presents an incessant demand to the forests in wild animal species for uses in initiation and spiritual rituals, in the manufacture of art objects, in food and for medical purposes [8] [43] [60] [61].

This systematic increase of hunters in the villages surrounding the RNI, is characterized by a lack of activities. It actively includes young people, even under 18 years old who must accompany adults in order to increase the chance of hunting and capture productivity to offer to applicants, at affordable and beneficial commercial prices of bushmeat [37] [44] [62].

Currently, although there is almost no hunting license in our entities, clever possibilities have developed among hunters to increase hunting productivity. [6] [39] [63]-[65]. As hunting is intensified day and night, we are witnessing the manufacture of local rifles and cartridges, although some demobilized hunters from armed militias use normal war rifles of calibers 12, AK-47 and MK14. Today, we can easily find solar flashlights that facilitate the possibility of night hunting, strings and other tools for making traps for captures adapted to each species in the forest, increasingly abandoning the use of hunting with spears and stones which are non-existent even [66]-[69]. To further increase the possibilities of capturing and tracking prey, experienced hunters practice animal calls.

Some hunters end up with camps in the depths of the Reserve, where they spend several weeks, just to expand their fields and chances of hunting in the capture and finally to come out with more game (Animals shot, sometimes already smoked and rarely alive). Hunting combs everything, from the smallest to the largest mammals, hence the rarity of certain species [51] [70]-[75].

➤ **Evolutionary socio-disturbance and repercussions on fauna between 1996-2023 in the INR**

The transformation currently observed leads to crises in terms of species decline and rarity, caused by population movements involving changes in the composition of communities wild mammal [76]-[80].

The damage to wildlife diversity is the result of a growing human population and human activity in full economic expansion, with ever-increasing needs for renewable (hunting) and non-renewable (mineral, energy) resources [40] [81]-

[83]. However, it is difficult to differentiate the modifications resulting from natural constraints (climatic factors) from those induced by human activities in the context of the INR (Figure 5).

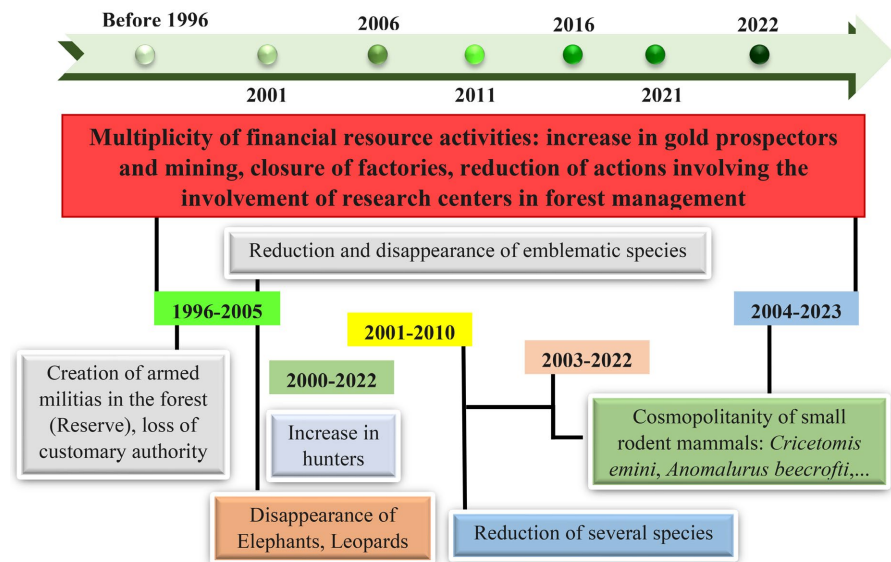


Figure 5. Evolutionary timeline of actions that had an impact on wildlife.

5. Conclusions

The mammalian diversity of wildlife in the Itombwe Nature Reserve (INR) is weakened by human activities in full economic expansion whose needs for renewable (fishing) and non-renewable (mineral, energy) resources continue to increase. However, it is difficult to differentiate the changes resulting from natural constraints (climatic factors) from those induced by human activities. Several causes describe incidents on mammalian wildlife.

The multiplier factors that have contributed to the evolutionary disturbance of wild mammal fauna in the INR, as described, must be limited and abandoned in the following years to allow the stability and increase of wild mammal species and biodiversity in general.

This study highlighted the causes of wildlife disturbance over the past 25 years since 1998, a period characterized by wars and land occupation in the Itombwe Nature Reserve and the Democratic Republic of Congo in general.

By placing communities at the center of wildlife conservation and improving the participatory framework, the latter is encouraged to conservation. By ensuring the increase in social and economic livelihoods, it is possible to strengthen the protection of wild mammals in the INR.

Acknowledgements

We would like to thank firstly the people who agreed to interview us in our investigations, then the head of the ICCN station in Itombwe Seguin B. for welcoming us and allowing us to carry out our work in the proper form. To the Carnegie

Foundation via the RUFORUM-GTA scholarship for supporting his research, the Center for Research in Ecology and Management of Terrestrial Ecosystems (CREGET) of the Official University of Bukavu in the DR Congo for having made available a support team in the field and the Department of Biology of the University of Nairobi in Kenya for having followed the progress of the work via Professor Catherine W. Lukhoba.

Funding

The authors declare to have received the following financial support for the research, writing and/or publication of this article: The authors did not receive any financial support for the research, writing and/or publication of this article.

This work would not have been possible without the institutional support of ICCN, Center for Research in Ecology and Management of Terrestrial Ecosystems (CREGET) of the Official University of Bukavu in DR Congo, and the Department of Biology of the University of Nairobi in Kenya. This work was funded by the Carnegie Foundation Research Initiative via the RUFORUM-GTA grant, which supported her academic research.

Conflicts of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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