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Wildlife Management in Tropics and Subtropics

M.Sc. Thesis

Population dynamics and activity pattern of large herbivores in the Bandia reserve, Senegal

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Declaration

I, Daniel Bada, declare that I have elaborated my thesis independently, only with the expert guidance of my thesis supervisor Mgr. Pavla Hejcmanová, Ph.D.
I further declare that all data and information I have used are stated in the references.

Prague, 30 April 2008

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Abstract

Every reserve management needs reliable data on the numbers, population dynamics and habitat preferences of the animals within its reserve borders. To get these information a research was carried out in the Bandia reserve in Senegal. This research was executed in the frame of Czech – Senegalese cooperation during the end of the dry season from 14.6. to 10.7. 2007.

The main objective of this research was assessment of population dynamics of selected species of herbivores. Three sub-objectives were census of selected species, evaluating population dynamics of selected species and evaluating habitat utilization of selected species. Ten repetitions were chosen because of optimal relation between statistical accuracy of the results and financial and time possibilities.

Ten species of large herbivores were censused their population dynamics and habitat utilisation evaluated. Total ground count from vehicle was chosen for this study. The area of the reserve was divided into four zones according to vegetation densities. This helped evaluate habitat utilization of all ten selected species.

Major increase in population numbers is evident by the Impalas (*Aepyceros melampus),* Roan antelopes (*Hippotragus equinus*), Common elands (*Taurotragus oryx*), Giraffes (*Giraffa camelopardalis giraffa*) and Greater kudus (*Tragelaphus strepsiceros*). These species reproduce well and their population dynamics are increasing.

Minor increase in population is noticeable by African buffaloes (*Syncerus caffer*). Buffaloes are reproducing and their population dynamics is not decreasing or stagnating. The population dynamics of Kob (*Kobus kob*) in Bandia is probably decreasing. Numbers of Waterbucks (*Kobus ellipsiprymnus ellipsiprymnus*) decreased. Population dynamics of Waterbuck in Bandia is decreasing to the point of extinction. Numbers of Gemsboks (*Oryx gazella gazella*) initially increased but then decreased. Their population dynamics stagnates. Numbers of White rhinoceros (*Ceratotherium simum simum*) do not change.

Key words: Senegal, The Bandia reserve, ground count, population dynamics, habitat utilization

Abstrakt

Management každé rezervace potřebuje důvěryhodná data o počtech, populační dynamice a využití habitatů zvířat v rezervaci. Pro získání těchto informací byl prováděn výzkum v rezervaci Bandia v Senegalu. Tento výzkum byl uskutečněn v rámci Česko-Senegalské spolupráce na konci období sucha od 14.6. do 10.7. 2007.

Hlavním cílem výzkumu bylo posouzení populační dynamiky vybraných druhů býložravců. Tři dílčí cíle byly: sčítání vybraných druhů, posouzení populační dynamiky vybraných druhů a posouzení využití habitatu vybraných druhů. Bylo zvoleno deset opakování sčítání kvůli optimálnímu poměru mezi statistickou přesností výsledků a finančními a časovými možnostmi.

Bylo sčítáno deset druhů velkých býložravců. Bylo zvoleno úplné pozemní sčítání z vozidla. Prostor rezervace byl rozdělen na čtyři zóny vzhledem k hustotě vegetace. To pomohlo posoudit využití habitatu všech deseti vybraných druhů.

Výrazný vzrůst velikosti populace je zřetelný u impal (*Aepyceros melampus),* antilop koňských (*Hippotragus equinus*), antilop losích (*Taurotragus oryx*), žiraf (*Giraffa camelopardalis giraffa*) a kudu velkých (*Tragelaphus strepsiceros*). Tyto druhy se dobře množí a jejich populační dynamika je rostoucí.

Mírný vzrůst velikosti populace je patrný u buvolů kaferských (*Syncerus caffer*). Rozmnožují se a jejich populační dynamika neklesá ani nestagnuje.

Populační dynamika kobů (*Kobus kob*) v rezervaci Bandia je pravděpodobně klesající. Počty vodušek (*Kobus ellipsiprymnus ellipsiprymnus*) klesly. Populační dynamika vodušek je klesající a hrozí vyhynutí. Počty přímorožců (*Oryx gazella gazella*) se nejprve zvýšily, ale potom klesly. Jejich populační dynamika je stagnující. Počty nosorožců bílých (*Ceratotherium simum simum*) se nezměnily.

Klíčová slova: Senegal, rezervace Bandia, pozemní sčítání, populační dynamika, využití habitatu

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List of abbreviations

CBD.....Convention on Biological Diversity

CIA.....Central Intelligence Agency

IUCN..... International Union for Conservation of Nature

GEF.....Global Environment Facility

GPS.....Global Positioning System

MFA..... Ministry of Foreign Affaires

OECD .....Organization for Economic Co-operation and Development

PNAE .....National Environmental Action Plan

SPEFS..... Société pour la Protection de l´Environnement et de la Faune au Sénégal

WAPOK .....“W”-Arli-Pendjari-Oti-Mandouri-Keran

MCP.....minimal convex polygon

1 Introduction

1.1 Strategies of nature conservations

1.1.1 Human caused biodiversity threats

All around the world biological communities are under constant and increasing pressure from human activities. Human population is rapidly increasing from one billion in 1850 to six billion in 1998 to predicted ten billion by the year 2050. Human demands and material consumption are simultaneously rising. This means that the devastating impact on biological communities and environments is intensifying exponentially. Habitats are being destroyed, seas and rivers polluted, forests cut down or burned. Loss of forest habitat in some parts of the world is alarming. For instance in Kenya 82% of forest habitat has been lost, in Ghana it is even 91% (Primack, 2000).Since the year 1600 342 extinctions of animal species and 384 of flowering plant species were recorded (Primack, 2000). Populations of many more species have declined dramatically and some of them are at the point of extinction.

The rate of extinctions is accelerating. But there are efforts to reduce these unfortunate tendencies. The diversity of species should be preserved; the extinctions of species due to human activities should be prevented. People do not have the right to destroy species and habitats (Primack, 2000).

1.1.2 *In situ* conservation strategies

There are two major conservation strategies. The first is called *in situ* or on-site preservation which means the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties (CBD, 2008). *In situ* programs include reintroduction programs, introduction programs and augmentation programs. Reintroduction program involves releasing of captive-bred or wild-collected animals into an area of their historic range where the species no longer occurs. The principal objective of this program is to create a new population in the original environment (Primack, 2000). An introduction program involves moving animals and plants to areas outside their historic range in the hope of establishing new populations. This needs to be carefully researched to ensure that the species does not damage

its new ecosystem or harm populations of any local endangered species (Primack, 2000). An augmentation program involves releasing individuals into an existing population to increase its size a gene pool. These released individuals may be wild collected elsewhere or raised in captivity (Primack, 2000).

1.1.3 Protecting habitats

Protecting habitat is the most effective method of preserving biological diversity. Well-selected protected areas can initially protect large number of species, but their long term effectiveness remains in doubt (Primack, 2000). So it is very important to protect and monitor areas outside the protected areas. The loss of biological diversity there will lead to the loss of biological diversity inside the protected areas.

1.1.4 Protected areas

There are several types of protected areas depending on the level of protection and availability of resources and free movement for local people. Some of them allow resident people to use its natural resources in nondestructive and sustainable way.

It seems that from long-term point of view the most effective ways of protection of partially protected areas are those which involve local people in the protection and motivate them by direct and indirect economical benefits. These community-based conservation schemes are still not widely used despite their supposed effectiveness (Caro, 1999). The condition of biological diversity in the partially protected areas influences condition of biodiversity also in the fully protected areas because they are often situated around them, they are often much larger and there are often many or even all species that live in the protected area (Primack, 2000).

Protected areas can be established by government action or land purchases by private individuals and conservation organizations. Very often is cooperation between the government of developing country and international conservation organizations, multinational banks, government of developed countries and private individuals (Primack, 2000).

The International Union for the Conservation of Nature (IUCN) has developed a system of classification for protected areas that covers a range from minimal to intensive use of the habitat by humans. There are six types of protected areas taken from the most protected to the

least protected – strict nature reserves and wilderness areas, national parks, national monuments and landmarks, managed wildlife sanctuaries and nature reserves, protected landscapes and seascapes and managed resource protected areas. Of these categories, the first five can be considered truly protected areas, with the habitat managed primarily for biological diversity, when the areas in the last category are not managed for that, though it may be a secondary management goal (Primack, 2000).

1.1.5 *Ex situ* conservation strategies

Sometimes it is necessary to maintain individuals of rare and endangered species in artificial condition under human supervision because otherwise they would probably become extinct. It is necessary in such cases when there are only few individuals left so the population is too small to survive or all the remaining individuals are found outside of protected areas or the species is threatened by human activities and increasing human disturbances (Primack, 2000).
This strategy is called *ex situ* conservation and means the conservation of components of biological diversity outside their natural habitats (CBD, 2008).
Some of the species already extinct in the wild survive in captivity. *Ex situ* facilities for animal preservation include zoos, game farms, aquariums and captive breeding programs. Plans are maintained in botanical gardens, arboretums and seed banks (Primack, 2000).

1.1.6 Interconnection of *ex situ* and *in situ* conservation strategies

Strategies *in situ* and *ex situ* exist together and they complement each other. Animals from *ex situ* programs could be released in to the wild or protected areas to augment existing populations or to create new populations. Careful consideration and thorough research must be carried out before any releasing introduction or reintroduction to ensure that conditions responsible for extinction or decline of previous populations have changed.
Research and monitoring of populations is carried out in both *ex situ* and *in situ* and their results are complementary.

1.1.7 Conservation laws

No conservation program or habitat protection would be possible without laws which shield and support them. The laws exist on many levels from local national laws to international laws and agreements. These laws concern species and habitat protection, hunting, trade with live animals and their products and parts, logging and pollution limits.

1.1.8 Protection strategies

Each country tries to protect its biodiversity with bigger or smaller success and effort and creates its national protection strategies, which are set and adjusted to local conditions and interests. Every strategy of nature conservation and protection has to come out of specific conditions of each country or area. Before this strategy could be planned and implemented it is necessary to have very thorough knowledge of local conditions and interspecific species relations. Plans and strategies are necessary to be considered in terms of geography, climate, ecosystems, biodiversity and specific local threats. Not less important is the demographic, economical and political situation.

1.2 Senegal

All this is especially true for Africa where political systems are very often unstable and civil wars and local uprising make difficult all efforts for any plans or strategies. In Senegal, where the work on this diploma thesis took place, working system of biodiversity conservation exists. It is derived from local conditions. According to IUCN (1998) Senegal has been a leader in conservation achievements among West African countries.

1.2.1 History

Senegal is a republic; the official name is The Republic of Senegal. The French colonies of Senegal and the French Sudan were merged in 1959 and granted their independence as the Mali Federation on 4 April 1960. The union broke up after only a few months. Complete independence was achieved upon dissolution of federation with Mali on 20 August 1960. Senegal joined with the Gambia to form the nominal confederation of Senegambia in 1982, but the envisaged integration of the two countries was never carried out, and the union was dissolved in 1989. The Movement of Democratic Forces in the Casamance has led a low-level separatist insurgency in southern Senegal since the 1980s, and several peace deals have failed to resolve the conflict. Nevertheless, Senegal remains one of the most stable democracies in Africa. Senegal was ruled by a Socialist Party for 40 years until current President Abdoulaye Wade was elected in 2000. He was reelected in February 2007, but complaints of fraud led opposition parties to boycott June 2007 legislative polls. Senegal has a long history of participating in international peacekeeping (CIA, 2008).

1.2.2 Population

The capital city Dakar lies on the Cap-Vert peninsula, the westernmost point of continental Africa. Estimated population is 12 521 851 (CIA, 2008). About 70 percent of Senegal populations live in rural areas. Density in these areas varies from about 77 inhabitants per square kilometer in the west-central region to 2 inhabitants per square kilometer in the arid eastern section. Around 2 000 000 live in Dakar (CIA, 2008).

1.2.3 Demography

Senegal has a wide variety of ethnic groups and, as in most West African countries, several languages are widely spoken. The Wolof are the largest single ethnic group in Senegal at 43%; the Peul and Toucouleur (also known as Halpulaar, Fulbe or Fula) (24%) are the second biggest group, followed by others that include the Serer (15%), Lebou (10%), Jola (4%), Mandinka (3%), Maures or Naarkajors, Soninke, Bassari and many smaller communities (9%).

About 50,000 Europeans (1%) (mostly French) as well as smaller numbers of Mauritanians and Lebanese reside in Senegal, mainly in the cities.

French is the official language, used regularly by a minority of Senegalese educated in a system styled upon the colonial-era schools of French origin (Koranic schools are even more popular, but Arabic is not widely spoken outside of this context of recitation). Most people also speak their own ethnic language while, especially in Dakar, Wolof is the lingua franca. Pulaar is spoken by the Peuls and Toucouleur. Portuguese Creole is a prominent minority language in Ziguinchor, regional capital of the Casamance, where some residents speak Kriol, primarily spoken in Guinea-Bissau. Cape Verdeans speak their native Creole, Cape Verdean Creole, and standard Portuguese.

Islam is the predominant religion, practiced by approximately 94 percent of the country's population; the Christian community, at 5 percent of the population, includes Roman Catholics and diverse Protestant denominations. There is also a 1% population who maintain animism in their beliefs, particularly in the southeastern region of the country

54% of population live in poverty (CIA, 2008).

1.2.4 Industry and agriculture

The main industries include agricultural and fish processing, phosphate mining, fertilizer production, petroleum refining, construction materials, ship construction and repair. The most important agriculture products are peanuts, millet, corn, sorghum, rice, cotton, tomatoes, green vegetables; cattle, poultry, pigs and fish (CIA, 2008).

1.2.5 Geography

Senegal is westernmost country on the African continent. It belongs to Sahel zone. Senegal is located 14 degrees north of the Equator and 14 degrees west of the Prime Meridian. The country's total area is 196,190 km² of which 192,000 km² is land and 4,190 km² is water (CIA, 2008).

Senegal is bordered to the west by the North Atlantic Ocean. On land, the nation's largest border is Mauritania to the north, an 813 km border along the Senegal River. To the east is the 419 km border with Mali. In the southeast is Guinea (330 km border) and to the south-southwest is Guinea-Bissau (338 km), both borders running along the Casamance River.

Senegal has a near-enclave within its borders—The Gambia in the interior, which has a 740 km border with Senegal. The Gambia penetrates more than 320 km into Senegal, from the Atlantic coast to the center of Senegal along the Gambia River, which bisects Senegal's territory.

In total, Senegal has 2,640 km of land borders, and 531km of coastline and shoreline. Senegal makes maritime claims of a 44 km (24 nautical mile) contiguous zone, a 22 km (12 nautical miles) territorial sea, and a 370 km (200 nautical miles) exclusive economic zone. It also claims a 370 km (200 nautical miles) continental shelf, or to the edge of the continental margin (CIA, 2008).

Senegal is generally flat; most of the country consists of vast plains rising to foothills in southeast. The country is generally low, rolling; average altitude is 40 m (Anonymous, 1999a).

The lowest point in Senegal is the Atlantic Ocean, at sea level. The highest point is an unnamed feature near Nepen Diakha in the Fouta Djallon foothills at 581 m. (CIA, 2008).

1.2.6 Climate

The local climate is tropical with well-defined dry and humid seasons result from northeast winter winds and southwest summer winds (CIA, 2008). Senegal is divided into seven major climatic zones – Southern Canarian, Continental Sahelian, Sahelo-Sudanian, Continental Sudanien, Coastal Sudanian, Continental Sudano-Guinean and Coastal Sudano-Guinean. These zones depend on the proximity to the Atlantic Ocean and the latitude (Lawesson, 1995).

The dry season lasts for seven months from November to May. During the dry season, there are only a few low intensity rainfalls. The rainy season starts at the end of May at the South of the country and moves progressively to the North (Anonymous, 1999a).

Dakar's annual rainfall of about 610 mm occurs between June and October when maximum temperatures average 27 °C; December to February minimum temperatures are about 17 °C. Interior temperatures are higher than along the coast, and rainfall increases substantially farther south, exceeding 1500 mm annually in some areas (CIA, 2008).

1.2.7 Ecosystem diversity

There are four major types of ecosystems in Senegal: lands, rivers and lakes, coastal and marine ecosystems, and a group of specific ecosystems. The land ecosystems include steppes, savannahs, open woodlands, dry closed forests and galleries of palm trees.

The fluvial ecosystems are made up of five major basins: the Senegal River, the Saloum, The Gambia; the Casamance, and the Kayanga. In these ecosystems, the flora is mainly composed of aquatic plants, some of which are invasive. Fauna comprises mainly birds and fish.

The coastal and marine ecosystems are made up of sandy and rocky coastlines, deltas and estuaries, and an exclusive economic zone covering about 200 000 km2. Biodiversity is particularly high in coastal waters. Rare and protected species are mainly found in deep sea and international waters, where the number of species is lower than in coastal areas.

The specific ecosystems are important because of their moisture content, biodiversity, ecological role and fragility. They include mangrove areas, the Niayes and the Djoudj depression.

Although located in the Sahelian zone, Senegal is composed of several ecosystems with a relatively high biodiversity (Anonymous, 1999b).

1.2.8 Species diversity

Because of the diversity of ecosystems, there is also high flora and fauna diversity.

1.2.9 Flora

Total estimated number of plant species is 3150. Fifty of them are endangered (Anonymous, 1999a).

The Phanerogamic flora (plants with flowers) consists of 2 500 species approximately divided into three great floristic zones: a northern zone with approximately 800 species, a central zone with approximately 1000 species, and a southern zone with approximately I 700 species. The main families are *Gramineae (93 genera* and 285 species), *Papilionaceae* (50 genera and 284 species) and *Cyperaceae* (19 *genera* and 188 species). Thirty one species are described as endemic, with a prevalence of herbaceous ones and the absence of typical forest species. Forest biodiversity (national reserves and reserved forests) is better preserved than agricultural biodiversity, because the latter is more difficult to preserve due to the lack of resources to set up or maintain technical facilities (Anonymous, 1999b).

1.2.10 Fauna

Total number of animal species is 4330. 62 of them are endangered – 10 species of fish, 38 species of reptiles and 14 species of mammals (Anonymous, 1999a).

Insects, with approximately 2 000 species for this class only, constitute the most significant group by far. This class is followed by the mollusks (700 species) which, with fish (400 species), illustrate the importance of marine biodiversity, still not well known (Anonymous, 1999b).

Birds also constitute a significant group of 623 species and justify by their importance and diversity the special sites reserved to them (Djoudj, in particular). There are 100 species of reptiles, 192 species of mammals, 2 species of amphibians and 64 species of crustaceans in Senegal.

Endemic animal species in Senegal are found only in the class of fish. They belong to the genera *Protopterus sp., Heterotis, Morinyrus and Gymnarchus.* The loss of at least four large mammals (giraffe, damaliscus, oryx, dama gazelle) was noted.

Several species of primates, antelopes, pachyderms and Canidae are threatened to differing degrees.

Wild fauna is now primarily found in national reserves and consists of large mammals. In the Niokolo Koba national reserve alone, 80 mammals, 330 birds, 2 amphibians, 60 of fish species as well as many invertebrates can be found.

It is therefore important to ensure the sustainable management of natural resources in the Niokolo Koba national reserve, because it is a biodiversity reserve, since it is a habitat for I 700 of the 2 500 Phanerogamic plants (Anonymous, 1999b).

1.2.11 Causes underlying the loss of biodiversity

There are various reasons behind the loss of biodiversity in Senegal. These causes, however, can be grouped in four main categories: natural causes, anthropic causes, legal causes, and institutional or scientific causes (Anonymous, 1999b).

The major natural causes are drought and its consequences, water and soil degradation and salinization and wind and water erosion (Anonymous, 1999b).

The main anthropic causes are bush fires, over-exploitation of biological resources, land clearing, the impact of hydro-agricultural works, the fragmentation and destruction of habitats and poaching and pollution (Anonymous, 1999b).

From the legal standpoint, the main causes for the loss of biodiversity are inadequate regulations concerning domains and activities connected with biodiversity, non-implementation or poor implementation of regulations concerning access to certain biological resources, inconsistencies and insufficiencies in codes and laws governing the exploitation of biological resources, the lack of flexibility in the status of protected areas and the lack of harmonization in regulations concerning resources shared with adjacent countries (Anonymous, 1999b).

From the scientific and institutional standpoints, there are many causes for the loss of biodiversity, especially the lack of programs to combat poverty, gaps in the quantitative and qualitative knowledge of available biological resources, the lack of promotion of research results and an insufficient consideration of traditional knowledge on the utilization of biological resources, a lack of impact assessment studies in development projects likely to affect biodiversity, an inadequate distribution of benefits drawn from the conservation and development of biological resources and finally, the waning of religious practices and beliefs that justify the existence of forests and sacred woodlands (Anonymous, 1999b).

1.2.12 Biodiversity management

The management of biodiversity in Senegal takes place within a legal and institutional framework which deals also with natural resources. Biodiversity is preserved in certain habitats through practices often related to religion or tradition. The Convention on Biological Diversity provides Senegal with a formal framework for strengthening, formalizing, and harmonizing well-established popular traditions and the Government's natural resources conservation and management policies (Anonymous, 1999b).

Those traditions and policies led Senegal to preserve a considerable part of its biodiversity until the three last decades characterized by severe climate conditions with adverse effects on natural resources and biodiversity. Rapid population growth, unmatched by available natural resources to meet population food, energy and medical needs, constituted also an adverse affect on biodiversity conservation (Anonymous, 1999b).

This situation led the Government to setting up a planning system that brings in more stringency in the management of natural resources and biodiversity. In this respect, a National Environmental Action Plan (PNAE) was recently developed and adopted to offset negative trends in the management of natural resources and biodiversity. In the same vein, a National Plan of Action for Desert Control will be implemented.

The Strategy and National Plan of Act ion on the Conservation of Biodiversity are part of the policy measures envisaged by the Government with respect to both macroeconomic policies and the management of natural resources, with a view to restoring conditions for sustainable development in the country (Anonymous, 1999b).

1.2.13 The national legal and Institutional framework

Regulations in force are orders, decrees and laws dealing mainly with vegetal resources, marine and fish resources, pastoral resources and wild fauna.

Concerning vegetal resources, forests were given the greatest attention. Thus the Forest Code into force was developed after long consultations with stakeholders. This explains the legal provisions which confer a right of ownership on the plantations established by local populations on the national domain.

The management of marine and fish resources is organized by several decrees, especially on fishing zones, harpoon fishing, protected species, the Fishing Code, the prohibition of such fishing methods as the use of trawl nets and certain types of fishing gear in rivers, *bolongs,* brooks and lakes, and in some internal waters.

Regulations on pastoral resources deal in particular with the organization of rangelands and conditions for using them. Here, the objectives of the preservation of biodiversity are not sufficiently taken into account in legal provisions. It is important to integrate these concerns in the implementation of a future Pastoral Code. Objectives of policies on hunting and the protection of fauna are to preserve natural resources, wildlife, especially wild fauna, so as to maintain biodiversity and ecological balances. The current legal framework can be considered as exclusively oriented towards the organization of hunting and the management of protected areas. Future orientations should focus on the conservation of the biological diversity of fauna (Anonymous, 1999b).

1.2.14 National strategy for the conservation of biodiversity

An effective national strategy for the preservation of biodiversity should include among its objectives consideration of progress made through appropriate management practices involving populations, i.e. taking into account their production activities (agriculture, cattle rearing and major works of public interest) and sharing with them the benefits drawn from conservation.

The success of such policies will be sustainable only if all actors and beneficiaries are convinced of the importance of biodiversity and the need to preserve it.

On this basis, the national strategy will be developed around four major objectives.

The first objective is conservation of biodiversity in areas of high density. The second important thing is integration of conservation of biodiversity in programs and in production activities. Not less important is equitable distribution of roles, responsibilities and benefits in the conservation of biodiversity. Last but not least come information and sensitization of the importance of biodiversity and the need to preserve it.

To achieve these objectives, the methodological approach adopted includes identification and classification of main components of biodiversity; identification of main causes for the loss of biodiversity in each of these components; definition of strategic options based on the causes underlying the loss of biodiversity and formulation of appropriate actions to achieve the options defined (Anonymous, 1999b).

1.2.15 Strategic Options

The strategic options that constitute the National Strategy can be grouped in two major categories - options that deal with general problems concerning sites, stakeholders and specific options concerning sites of high biodiversity. The general strategic options include capacity-building for the different actors in the conservation of biodiversity; better knowledge of the resource; sensitization or the various categories or actors on the need to preserve biodiversity; promotion of the participation of the populations concerned in the planning of activities relating to the management and conservation of biodiversity; development of a dynamic partnership between the different actors concerned; development of sub-regional and international cooperation in the management of biodiversity and strategic options of a specific character concerning sites of high biodiversity (Anonymous, 1999b).

1.2.16 National plan of actions for the conservation of biodiversity

It is constituted by urgent and important actions to be achieved in a five-year period. Actions are grouped in two categories: those which support in general the implementation of the National Strategy and the National Plan of Action on the one hand, and those which are specific to the main sites of biodiversity on the other hand.

Main actions covering all aspect s of the strategy are the establishment and operation of a unit for the coordination and follow-up of the Strategy and the Plan of Action and the support to the development of regional plans for the conservation of biodiversity.

Main Actions related to a specific aspects of the strategy in national parks, reserves and reserved forests are to involve populations in the control of bush fires; to develop a plan for the management of forests and the control of bush fires; to encourage and support alternative economic activities to poaching in peripheral areas and to carry out ecological studies enabling to determine the most appropriate status for each reserved forest, with a view to sustainable development.

Main Actions related to specific aspects of the strategy in coastal, marine, fluvial and lake ecosystems are to delimit and protect zones, and set periods for the biological dormancy of fish resources; to identify and to protect zones of reproduction of fish resources and to carry out studies on the impact of hydro-agricultural works and pollution on fish resources.

Main Actions related to specific aspects of the strategy in forests in protected and agricultural areas are to involve populations in the management of forests and the control of bush fires; to

identify and preserve wild species related to domestic ones and to assess the impact of leasing land for hunting and promote "faunal fallows".
Main Actions related to specific aspects of the strategy in sites of *ex situ* conservation are to rehabilitate botanical gardens and zoological parks and to rehabilitate and to equip existing gene banks (Anonymous, 1999b).

1.2.17 Implementation of the strategy and the national plan of action

To implement the Strategy and the National Plan, it was proposed to develop an institutional framework and a mechanism of follow-up and evaluation. The institutional framework includes a unit for the coordination and the supervision of all projects and activities related to biodiversity and a national committee on biodiversity that will define the overall orientations and ensure the implementation of the Strategy and the National Plan. It will bring together representatives of all stakeholders, public and private, in the conservation of biodiversity.
The follow-up and evaluation process has two objectives. Firstly it is evaluation of progress made in planned activities by using verifiable progress indicators such as the impact of activities carried out on the development of resources and the extent to which the conservation of biodiversity is taken into account in decisions and activities. The second objective is the possible review of the schedule of activities (Anonymous, 1999b).

1.2.18 Financing of the strategy

In the short and medium terms, financing and implementation of the Strategy and the National Plan will be ensured by the Government and the National Foundation for the Environment on the one hand, and by the Fund for Global Environment Facility (GEF) and external partners in the framework of bilateral and multilateral cooperation on the other.
In the long term, financing could primarily be ensured through income resulting from financial arrangements with public or private bodies (pharmaceutical companies in particular) concerned with the non destructive development of the wealth of biodiversity in Senegal (research on new molecules) (Anonymous, 1999b).

1.2.19 Obstacles and opportunities

In implementation of the Strategy and the National Plan of Action for the conservation of biodiversity, a certain number of obstacles or difficulties will have to be overcome. These

relate mainly to poverty, to the transfer of competencies without prior training of agents in the management of biological resources, to the insufficient integration of biodiversity conservation in major activities such as agriculture and cattle rearing and in economic development strategies and to the problems of communication with communities at the grass roots level.

Furthermore, implementation of the Strategy could benefit from real opportunities including the long tradition of conservation prevailing in Senegal, the wealth of human resources, the existence of a National Plan of Action for the Environment and an overall institutional framework that already takes into account the issue of biodiversity and the transfer of responsibilities to local communities in the management of natural resources and biodiversity (Anonymous, 1999b).

1.2.20 Progress Made

In-situ and *ex-situ* conservation as well as traditional conservation methods should be strengthened so as to enable greater involvement of populations. The considerable wealth of biodiversity has sometimes been gained at the expense of these populations. It will be possible to protect and sustain this wealth of biodiversity, however, only with the active participation of the populations concerned and the sharing of benefits with them (Anonymous, 1999b).

Policies for the management of biological resources made it possible to set up an important system of protected areas including 6 national reserves, 6 bird reserves, 3 biosphere reserves, 3 sites listed as sites of the World Heritage, and 213 reserved forests (Anonymous, 1999b).

1.2.21 Protected areas

There are six national parks in Senegal covering 4% of the country, which is relatively high percentage in an African context. They are in principle to be completely protected from any kind of exploitation and human impact (Lawesson, 1995). These are Niokolo-Koba (9130 km^2), Delta du Saloum (760 km^2), Basse Casamance (50 km^2), Djoudj (160 km^2), Langue de Barbarie (20 km^2) and Iles de la Madeleine (5 km^2). Niokolo Koba national park has long been recognized as one of the most important wildlife refuges in West Africa (IUCN, 1998).

The bird reserves are Kalissaye (less than 1 km^2), Ferlo Nord and Ferlo Sud (11207 km^2), Gueumbeul (8 km^2), Ndiael (466 km^2), Popenguine (10 km^2) and Make–Diama (600 km^2).
The biosphere reserves are Delta du Saloum (1800 km^2), Forêt classée de Samba Dia (8 km^2) and Parc national du Niokolo - Koba.
As sites of the World Heritage were declared Parc national des Oiseaux du Djoudj and Parc national du Niokolo – Koba (Anonymous, 1999a).
Forêts classées (reserved forests) (10557 km^2) are in principle fully protected from any exploitation, and they are managed by government authorities, but grazing and collecting of dead wood may be permitted (Lawesson, 1995). The national parks together with the other protected areas cover more than 11 % of the country (IUCN, 1998).

1.2.22 Private sector

Private reserves and game ranches are on increase in Africa. They are more profitable and create more jobs and income than does cattle ranching if the interest of local population is taken into consideration.
In South Africa, 5,061 ‘exempted’ game farms extend over a total surface of 10.4 million ha with an average range of 821 ha to 4,021 ha. Half of the farms are situated in the Northern Province and a rise of 5.6% was recorded in the size of the game farms between 1993 and 2000.
A total of 9,000 game ranches are registered and 4,000 integrated mixed game and cattle ranches of a total of 13,000 ranches deal with wildlife. The area covered extends over 16 million ha (13.6% of the country or 2.5 times the surface of the National Parks).
Wildlife ranching provides a good demonstration of the contribution of the private sector to conservation. There is more wildlife now in South Africa than a century ago (Chardonnet *et al,* 2002).

In Senegal, private sector and its role is represented by private company Society for the Protection of the Environment and Wildlife in Senegal (Societe pour la Protection de Environnement et de la Faune au Senegal - SPEFS) that manages Bandia and Fathala reserves. According to Nežerková *et al* (2004) SPEFS has directly taken part in preserving large savannah animals and their natural environment in Western Africa.

1.2.23 Cooperation project

There is project cooperation between Senegal and the Czech Republic aimed at biodiversity conservation. This project of Czech development aid is now called: Support to natural reserves and national parks of Senegal.

The leading idea was to use better the natural potential of African antelopes, including the conservation of endangered species, in purpose to improve economic and nutritional conditions of people in the region. The project was designed by the Institute of Tropic and Subtropics at the Czech University of Agriculture in Prague in 1996, and continuously elaborated. In 2000 the project received the funding and agreement of cooperation for next 5 years (2000-2004) by the Ministry of Foreign Affaires (MFA) of the Czech Republic.
Institute of Tropic and Subtropics at the Czech University of Agriculture in Prague decided to implement the project to Senegal where best conditions for cooperation were presented. Moreover there was a possibility to assert the project idea in two lines at the same time: to use Czech experience of antelope breeding and their economic use, and to initiate the conservation action for endangered species. Representatives of the Czech Republic and Senegal (partners from the Directorship of Senegalese National Parks) concluded the agreement of cooperation on the reformulated specific project "Preservation and Breeding of the Western giant eland (*Taurotragus derbianus derbianus*) and other antelopes in Senegal for the purpose of their economic use" (Nežerková *et al*., 2004).

1.2.24 Management of the Bandia Reserve

The Bandia reserve lies at favorable location on the main road connecting the capital of Senegal to the seaside resorts sought by tourists. The reserve offers tourists trips to see the large African animals. The trips are organized for both groups and individuals. At the main entrance all-terrain vehicles are available for hire and the tourists are always accompanied by one of the local professional tour guides, who know the reserve's traits and biotopes off by heart and give a professional commentary about the animals. As a rule the photo-safari ends by sitting in the pleasant restaurant on the banks of the large watering hole **(Figure 1/Annexe)** (Point d'eau) where it is possible to see crocodiles, various water birds and animals that have come to drink, most often Asian water buffalo, warthogs, patas monkeys, and sometimes even common elands. Apart from refreshments and local specialties there are even art objects and traditional Senegalese souvenirs (Nežerková *et al*, 2004).

With regards to the fact that the reserve is for both entertainment and education, the local schools have free access there. In the tourist season there are approx. 100 visitors a day. The visitors are not just from abroad but often residents. The reserve provides employment for the local inhabitants. They work as tourist guides, carry out routine technical work in running the reserve and also get various odd jobs. Directors and managers of the Bandia reserve are Georges Rezk, Christian Dering and Fourzoli Souleih. The company is doing well and so the reserve is gradually being expanded (Nežerková *et al*, 2004).

1.3 Counting methods

No form of wildlife management is possible without reliable information on the numbers, population dynamics and movements of the animals concerned (Norton-Griffiths, 1978).

1.3.1 Objectives of a census

According to Norton-Griffiths (1978) it is best to design a census for one main objective only. Such as a census of total numbers. However, modern technology like GPS changes this. In my research there were two main objectives. Total numbers and distribution of selected animals in the reserve. Use of GPS enabled to do both objectives in one go as described later. The other objective was to establish habitat preferences. To acquire more information, not only number of animals but their exact geographic position and therefore possibility to produce maps are easy with proper equipment. GPS was used to get this information in Aerial Total Count of the "W"-Arli-Pendjari-Oti-Mandouri-Keran (WAPOK) Ecosystem in West Africa (Bouché *et al*, 2004)

1.3.2 Aerial counts

The light aircraft is widely used for wildlife censuses and surveys because it can cover large areas quickly and economically, and it is the only method for censusing in areas where access on the ground is difficult or impossible (Norton-Griffiths, 1978). But according to Jachmann (2002), the estimates from the aerial counts were considerably lower than those from the ground counts for most large herbivore species. The data pointed to undercounting as a major problem of aerial surveys. During the aerial counts, significant numbers of animals were missed out, first due to the low probability of spotting single animals, small groups of animals and less conspicuous ones (sighting probability bias), and secondly because part of the

population was concealed by obstructions and therefore not visible to the observers (visibility bias). Furthermore Bandia reserve is too small for aircraft censusing and vegetation in some areas is too thick. Therefore bias caused by aerial counting would be too high.

1.3.3 Ground counts

Ground counts from vehicles are practicable and give excellent and consistent results in small to medium sized areas where the country allows the use of vehicles and the vegetation is reasonably open and the animals tame to vehicles. But this is not always the case. Along a 200 kilometers long track in south-western Kalahari, Botswana, the track had extremely low traffic intensity the whole year around. But still, ground count from vehicle was used (Bergström and Skarpe, 1999), even if we can say with great probability that because of very low traffic the animals were not tamed to vehicles at all. Counts from vehicles are ideal for detailed studies in small study areas (Norton-Griffiths, 1978). Because of these reasons, ground count from the vehicle was chosen. Despite some areas of thick vegetation, it was possible to drive around this and thus search even these areas.

1.3.4 Road counts

Road counts are adaptation from vehicle ground counts that are widely used, especially when access off the existing road system is difficult. This is true for some parts of the Bandia reserve. This type of count is practical to conduct so it was used in study Biomass density of wild and domestic herbivores and carrying capacity on a working ranch in Laikipia District, Kenya (Mizutani, 1999). However this method is open to many types of bias like preference of road edges for some animals. This was not the case with this research because it was total count. Therefore there was no overestimation of the density due to use of road counts. The other source of bias is that roads tend to pass through “good game viewing areas” and they tend to be placed along contours rather than across contours (Norton-Griffiths, 1978). Again this is not the case for Bandia reserve because the road system here is very dense and the area is small. Every part of the reserve has good road coverage.

1.3.5 Foot counts

Foot counts are only necessary if other methods are impracticable. But if there is opportunity to employ wildlife students or students from another related area of study as observers, then it can supplement other forms of counts. 78 transects in surveys Population trends of antelopes

in Waza National Park (Cameroon) from 1960 to 2001: the interacting effects of rainfall, flooding and human interventions were five to fifteen kilometers long (Scholte *et al*, 2007). For example it is good to use this method to get idea of the density of small resident species and to get information on the proportions of different age/sex classes in a population. The area has to be small so it is difficult to ensure that the data are representative of the whole area or of the whole population (Norton-Griffiths, 1978). Foot counts method was not used because distance traveled every day was too long, around 85 km, which is far too much for walking.

1.3.6 Total counts and sample counts

According to Norton-Griffiths (1978) there are only two ways of censuing animals. Total count where the whole of the designated area is searched and all the animals counted. And Sample count where only part or a sample of the designated area is searched and counted and the number of animals in the whole area is then estimated from the number counted in the sampled area.

First disadvantage of Total counts is price. Sample counts tend to be cheaper than Total counts (Norton-Griffiths, 1978). For small areas like that of Bandia reserve it is only minor disadvantage.

Another disadvantage of Total counts is the difficulties of ensuring that the whole area is searched, all animals are located and to count animals accurately. It is only possible when very good maps are available because then the path of the vehicle (or aircraft) can be mapped as well as the location of every group of animals seen (Norton-Griffiths, 1978). This disadvantage does not apply to this research because the area is very small and it was possible o have very good knowledge of the whole area and to map it precisely. Also use of GPS was great help in orientation and recording of every group and individual animals.

The greatest problem of Total counts is to actually count animals. This has to do with counting rate which is the number of animals to be counted per unit time. If the counting rate is low then accuracy is likely to be high and vice versa. For instance, there is a difference between counting a group of impala while flying above at speed 120 mph at three hundred feet above the ground and having only 8 seconds when the group is in view in order to count them and sitting in a car observing that same group of impala. Second example would bring

very accurate idea of the number of animals in the group (Norton-Griffiths, 1978). This problem was minimized by choosing ground counts from a vehicle. The vehicle could be driven slowly and stop for needed periods of time. This prolonged time necessary for driving through the whole area but in this small area it was possible to manage counting of the whole area in one day. This was the main reason for choosing Total count in preference of Sample count.

1.4 Counted animals

1.4.1 *Aepyceros melampus* (Lichtenstein 1812) – impala

Geographic Range

Impala **(Figure 2/Annexe)** lives in patchy scattering from Kenya south to the Transvaal, Botswana and East Angola (Kingdon, 1997).

Habitat

The impala is found in woodland with little undergrowth and low to medium grassland. Also a close source of water is desired, not needed when there is abundance of grass (Lundrigan and Sproull, 2000).

Food Habits

Impala are ruminants, predominately a grazer. They feed mostly on grass during times of lush growth following the rains and will switch to browse during the dry season (Lundrigan and Sproull, 2000). Acacia, *Combretum* and *Grewia* are important in most areas (Kingdon, 1997).

Conservation Status

Their red list status is lower risk conservation dependent (IUCN, 2007). Impala is one of the most abundant antelopes in Africa (IUCN, 1998).

1.4.2 *Ceratotherium simum* (Burchell 1817) - white rhinoceros

Geographic Range

They **(Figure 3/Annexe)** were formerly abundant all over the better-watered grassland. At the turn of 19th century existed only two small populations (Kingdon, 1997). Current range is a mere fragment of this and restricted to game reserves and national parks (Ellis, 1999).

Habitat

Primarily open woodland with nearby open grassland, thick brush, and water (Ellis, 1999). White rhinos prefer short-grass areas (Kingdon, 1997).

Food Habits

White rhinos are grazers, feeding on grasses that they crop with their wide front lip (Ellis, 1999). They prefer short-grasses (Kingdon, 1997).

Conservation Status

The white rhino is one of the most charismatic, recognizable, and widely studied endangered animals. Poachers have long sought the white rhino for its horn, which in some cultures is thought to have medicinal affects. Habitat destruction and urbanization have also affected white rhino populations. Droughts affect their numbers by killing the plants on which they browse. It is listed by the IUCN (2007) as near threatened.

1.4.3 *Giraffa camelopardalis* (Linnaeus 1758) – giraffe

Geographic Range

Giraffes **(Figure 4/Annexe)** were formerly widespread throughout the drier savannahs of Africa (Kingdon, 1997). Giraffes have disappeared from most of western Africa, except a residual population in Niger. They have been reintroduced in South Africa to game reserves (Maisano and Fraser, 2006).

Habitat

Giraffes inhabit arid, dry land. They seek out areas with Acacia growth (Kingdon, 1997). They are found in savannas, grasslands, or open woodlands. Because they only occasionally drink, giraffes can be found away from a water source (Maisano and Fraser, 2006).

Food Habits

Giraffes feed on leaves, flowers, seed pods, and fruits. In areas where the savanna floor is salty or full of minerals, they eat soil (Maisano and Fraser, 2006). They use many tree species for browse, the major staples are Acacia, *Commiphora* and *Terminalia.* Giraffes eat less than half the intake of typical grazers. They select nutritional rich foliage (Kingdon, 1997).

Conservation Status

Their populations seem to be stable. They are hunted and poached. Populations remain common in east and southern Africa but have drastically fallen in West Africa. (Maisano and Fraser, 2006).The redlist status is lower risk conservation dependent (IUCN, 2007).

1.4.4 *Hippotragus equinus* (Desmarest 1804) - roan antelope

Geographic Range

Roan antelopes **(Figure 5/Annexe)** occur from south Sahara to Botswana (Roe, 2002). They were widespread in northern savannahs and woodlands and in the more westerly parts of the southern savannahs (Kingdon, 1997). In Senegal, they are now restricted to the southeast, where it occurs in good numbers in Niokolo-Koba national park and Faleme (IUCN, 1998).

Habitat

Roan antelope are found in lightly wooded savanna with medium to tall grass and must have access to water (Roe, 2002).

Food Habits

Roan antelope are grazers that prefer leaves over stems. They will browse if grazing forage is poor. The preferred feeding height is 15-150 cm and green shoots are often grazed down to a height of 2 cm. (Roe, 2002).

Conservation Status

Listed by IUCN as lower risk conservation dependent (IUCN, 2007). Declined in recent years as a result of habitat deterioration, hunting, poaching, agricultural encroachment (Roe, 2002).

1.4.5 *Kobus ellipsiprymnus* (Ogilby 1833) – waterbuck

Geographic Range

There are two main groups. The ellipsiprymnus **(Figure 6/Annexe)** is found throughout southeast Africa. The defassa is found in northeastern, central, and western Africa (Newell, 1999b). In Senegal, the defassa occurred widely in the southern savannas. It has been eliminated from most of its former range and today they are restricted to the Niokolo-Koba and Faleme (IUCN, 1998).

Habitat

Waterbuck prefer grassland habitat that is close to water. The best habitats are by draining lines and in valleys. They prefer dry ground but remain close to water (Newell, 1999b).

Food Habits

They are very water dependent. They eat a variety of grasses. Their diet is very rich in protein. When the amount of available grass is low, waterbuck eat other herbs to satisfy their needs (Newell, 1999b), they may even browse leaves or fruits (Kingdon, 1997).

Conservation

Their redlist status is lower risk conservation dependent (IUCN, 2007).

1.4.6 *Kobus kob* (Erxleben 1777) – kob

Geographic range

Kobus kob **(Figure 7/Annexe)** lives from Senegal to West Ethiopia to Victoria littoral (Kingdon, 1997).

Habitat

They prefer low-lying flat country close to permanent water (totally dependent on regular drinking), without seasonal extremes. They favor short swards, cropped and trampled by concentration of large ungulates or fire –induced grasslands (Kingdon, 1997).

Food Habits

Kobs are herbivorous. They eat grasses and reeds, and may migrate great distances to graze along watercourses (DuVal, 2000).

Conservation Status

Kob are still common in national parks. Kob in the Boma grassland ecosystem forms the second largest population of antelope in Africa (DuVal, 2000). Their redlist status is lower risk conservation dependent (IUCN, 2007).

1.4.7 *Oryx gazella* (Linnaeus 1758) – gemsbok

Geographic Range

The range of gemsbok, *Oryx gazella*, **(Figure 8/Annexe)** mostly consists of southern east Africa, though formerly the range included South Africa (Lundrigan and Sanders, 2005).

Habitat

Gemsboks are found in wooded grasslands as well as wetter grasslands. They can survive in areas of low productivity. They prefer stony plains with at least limited water access, but can subsist in areas of dunes, rocky mountainous areas, and arid habitats with little seasonal water (Lundrigan and Sanders, 2005).

Food Habits

Although generally a grazer, they will revert to browsing during droughts or whenever grasses are not available. These animals will also dig up to a meter to find tubers and roots for moisture (Kingdon, 1997). Activity at dawn and dusk allow for the consumption of the condensation present on the grasses (Lundrigan and Sanders, 2005).

Conservation Status

Their red list status is lower risk conservation dependent (IUCN, 2007).

1.4.8 *Syncerus caffer* (Sparrman 1779) - African buffalo

Geographic Range

The African buffalo **(Figure 9/Annexe)** is found in the middle of the African continent. This range stretches from just south of the Sahara to just north of South Africa (Newell, 2000). In Senegal, it was widespread in the southern savannas, but has been eliminated from most of its former range by meat hunting. A major population survives in Niokolo-Koba and Faleme (IUCN, 1998).

Habitat

They are found in arid biomes, including areas with rivers, lakes, and swamps. They like dense cover, but are found in open woodlands as well (Newell, 2000). They depend on low-level browse and an undetermined minimum of grass in their diet (Kingdon, 1997).

Food Habits

They are herbivorous grazers. In the dry season, the pastures diminish and they move toward water or a depression in the ground and feed off of low nutrient grass. Once the rainy season begins, grasses are heavily grazed. African buffalo spend 8 1/2 to 10 1/3 hours a day grazing. They graze slightly more at night than in the day and water once a day (Newell, 2000).

Conservation Status

The population has decreased a little to due an increase in human activities (Newell, 2000). The redlist status is lower risk conservation dependent (IUCN, 2007).

1.4.9 *Taurotragus oryx* (Pallas 1766) – eland

Geographic Range

Eland **(Figure 10/Annexe)** are confined to Africa from Ethiopia and southern Zaire to South Africa (Fahey, 1999).

Habitat

Elands are primarily animals of the woodlands and woodland savannahs (Kingdon, 1997). Elands live in both steppe and sparse forests. They are also found in semi desert areas and at elevations up to 14400 ft. (Fahey, 1999).

Food Habits

The diet of elands consist of grasses, herbs, tree leaves, bushes, and succulent fruits. Elands can tolerate tougher and more aromatic food than other tragelaphines (Kingdon, 1997). They generally forage in open areas. Water is consumed voraciously when available, but elands can abstain from drinking in dry seasons (Fahey, 1999).

Conservation Status

Eland populations have declined or have been extirpated in many parts of their range, but overall are still relatively common. Over hunting has been one cause of the declining numbers (Fahey, 1999). Their redlist status is lower risk conservation dependent (IUCN, 2007).

1.4.10 *Tragelaphus strepsiceros* (Pallas 1776) - greater kudu

Geographic Range

Greater kudus **(Figure 11/Annexe)** are found in southern and eastern Africa. The population has the highest density in the south. In East Africa, the population is broken up (Newell, 1999a).

Habitat

Greater kudus are found in a variety of habitats throughout Africa. They can be found in habitats that provide bush and thicket cover. In the rains, they remain in the deciduous woodlands. During the dry season they can be found along the banks of rivers with rich vegetation (Newell, 1999a).

Food Habits

Greater kudu are herbivores. They eat a wide variety of leaves, herbs, fruits, vines, flowers, succulents and grass (Kingdon 1997). They may water in the dry season but are capable of surviving in a waterless region (Newell, 1999a).

Conservation status

Kudus are rare in some peripheral parts of their range (Kingdon, 1997). Their red list status is lower risk conservation dependent (IUCN, 2007).

2 Objectives

The main objective and the purpose of my research in the Bandia reserve was assessment of population dynamics of selected species of ungulates. These data were needed for reserve management because it is not possible to make correct decisions without reliable information on the numbers, population dynamics and movements of the animals concerned (Norton-Griffiths, 1978).

There are three sub-objectives that result from the main objective.

These are:

1. Census of selected species.
2. Evaluating population dynamics of selected species
3. Evaluating habitat utilization of selected species (habitat preferences of observed groups)

3 Material and methodology

3.1 My field work

In terms of Czech – Senegalese cooperation presented above I worked in Bandia reserve. On my first staying in 2006, I visited the Bandia reserve in the highest rain season. The counting was not possible because vegetation was very dense and the animals were obscured or hidden. On my second staying in 2007, I was working on data collection (counting and observations) for my diploma thesis.

3.2 Study animals

Ten species of large herbivores were counted (**Table 1**). Numbers of White rhinoceroses (*Ceratotherium simum simum*) were previously known because there were only two of them (male and female) in the reserve. Still we recorded them to find out their spatial preferences and home ranges.

These species were chosen because of many interconnected reasons. They are important for management of the reserve. It is important to know their spatial distribution together with habitat preferences. The population dynamics for all ten species can be assessed from the results of the counting. This data bring forward much important information such as prosperity of the animals in the reserve, reproduction success and suitability of sex, social and age structure. Bandia does not have any big predators, elephants, zebras or wildebeest. Because of this, the ten species of large herbivores are very attractive for tourists being the biggest animals in the reserve. However, according to directors and managers of the reserve Georges Rezk and Christian Dering they are considering enriching the reserve's fauna with zebras and wildebeest (Nežerková *et al.*, 2004).

Other animals like fish, reptiles, warthogs, birds, small predators like jackals and monkeys were not counted. Methods which were used for the counting were not suitable for counting of all the species in the reserve. Vegetation in some parts of the reserve is very dense and does not enable precise counting.

Latin name	English name	French name
Aepyceros melampus	Impala	Impala
Ceratotherium simum simum	White rhinoceros	Rhinocéros blanc
Giraffa camelopardalis giraffa	Giraffe	Girafe
Hippotragus equinus	Roan antelope	Hippotrague
Kobus ellipsiprymnus ellipsiprymnus	Defassa waterbuck	Cobe à croissant
Kobus kob	Kob	Cobe de Buffon
Oryx gazella gazella	Gemsbok	Gemsbok
Syncerus caffer	African buffalo	Buffles africains
Taurotragus oryx	Common eland	Eland du Cap
Tragelaphus strepsiceros	Greater kudu	Grand koudou

Table 1: Ten counted species

Nomenclature according to Wilson and Reeder (2005), English names according to Kingdon (1997), French names according to Al Ogoumrabe (2002).

3.3 Date of counts and timing

The research was done during one month at the end of the drought season from 14.6. to 10.7. 2007. Previous experience in 2006 showed that counting in the wet season is all but impossible. Animals were obscured by the dense vegetation **(Figure 12/Annexe)** and visibility was reduced to not more than two meters from the road in some places.

Ten counts were chosen because of optimal relation between statistical accuracy of the results and the limited financial resources that were in our disposal for this field work. Also condition of the car played important part in planning of number of counts. This was important because the road condition was poor in some parts of the reserve. It is understandable taken into consideration harsh environment in the reserve.

Ten repetitions of counting were done according to stated list. The exact dates were 17.6., 18.6., 20.6., 21.6., 23.6., 24.6., 28.6., 29.6., 1.7., 2.7. 2007. The work was done in series of two following days. There were two types of series: in type “A” the “old” part was counted in

the morning (7:15 – 11:30) and the "new" part in the afternoon (14:00 -18:00) in both following days. In type "B" conversely, the "new" part was counted in the morning and the "old" part in the afternoon in both following days. The pattern of series was A-B-A-B-A in total of ten counts (exact timings varied depending on conditions and part of the reserve).

3.4 Study area

3.4.1 The Bandia reserve

The Bandia reserve was the first working enclosed breeding for large animals in Senegal and the adjacent states (Nežerková *et al.*, 2004).

The Bandia reserve lies 65 km east of Dakar **(Figure 13/Annexe)** (14"35' N. 17"00' W) on the main road (N1) to Mbour. It is situated on the south west border of „Forêt classée de Bandia".

The Bandia reserve was established in 1990 as a joint stock company on an economically exploited and markedly degraded baobab grove (Nežerková *et al.*, 2004).

At that time 460 ha were enclosed, in 1999 this was expanded to 651, 04 ha (Al Ogoumrabe, 2002). In 2002 a project of extension begun, current area of the reserve is 1500 ha, final area should reach 3500 ha (Dering 2007, personal communication).
The first stage of conservation was aimed at regenerating the damaged vegetation and after that it was introducing the first animals. Introducing wild animals began slowly in 1991 and reached its peak in January 1997 with the arrival of ungulates from South Africa (Al Ogoumrabe, 2002).

The Bandia reserve lies in flat area which is intersected by the temporary water flow called Somone. Somone has two branches; the northern branch of the Somone is in Bandia.

3.4.2 Vegetation

More than 100 plant species in 30 families were recorded in the Bandia reserve. Phytogeographically the reserve belongs to the Sudan-Sahelian area and the original vegetation is made up of *Acacia ataxacantha* - *Acacia seyal* bushland (Lawesson, 1995). When the reserve was established the vegetation was in much degraded state. Today, it is

possible to observe 3 varying stages of succession according to how the reserve was gradually expanded and enclosed (Nežerková *et al.*, 2004).

The first stage of succession still has the character of open grassy savannah with a high representation of annual species. The dominant grass species are *Brachiaria distichophylla, Brachiaria lata, Digitaria velutina, Pupalea lappacea, Penisetum violaceum, Digitaria abyssinica*. Of the herbs there are for example *Blainvillea gayana, Cassia tora, Corchorus sp., Indigofera sp., Sesbania sesban* and others.

In the course of the short rains and in the second part of the dry season (from the end of January) the herbs are not abundant and their nutritional value is low. For this development stage one of the characteristic species is *Calotropis procera*, which quickly colonizes newly created biotopes, however in later stages it recedes.

The second stage is the transitional phase of bushy savannah, where the regeneration of species such as *Acacia ataxacantha* can be found. Then it is pushed out by shade of *Acacia macrostachya*, *Acacia seyal* and *Tamarindus indica*.

The oldest part of the reserve involves a tree and bush savannah that is the original vegetation structure dominated by the baobab *Adansonia digitata* **(Figure 14/Annexe)**, making up 52 % of the storey. Other dominant species of the tree and bush layer are *Acacia seyal, Balanites aegyptiaca, Boscia senegalense, Combretum micrantum, Grewia bicotor, Feretia apodanthera, Ziziphus mauritiana* and others. *Azadirachta indica* and *Eucalyptus alba* are not original species. They show signs of antelope grazing, although they are not well received by livestock. In the surroundings of the northern branch of the Somone River we can find *Khaya seneqelensis, Lonchocarpus sericeus, Lonchocarpus laxiflorus, Celtis toka* and *Cordia senegalensis*. The river corridor of the Somone is colonized by *Tamarix senegalensis* demonstrating a certain amount of salt in the soil (Nežerková *et al.*, 2004).

3.4.3 Fauna

No big mammals lived initially in the area. Introduction of wild animals from various areas in Senegal began in 1991 and continued year by year up to 2000. The same pattern was followed with foreign animal import that began also in 1991 and continued up to 2000. Very important was the year 1997 when eight species of ungulates from South Africa (including giraffes, impalas, kudus and common elands) arrived (Al Ogoumrabe, 2002).

Wild animals were once common in the area. Such as Golden jackal (*Canis aureus*), Spotted hyena (*Crocuta crocuta*), Common genette (*Genetta genetta*), Bushbuck (*Tragelaphus*

scriptus), Velvet monkey (*Cercopithecus aethiops*), Side-striped jackal (*Canis adustus*), warthog (*Phacochoerus africanus*), Aardvark (*Orycteropus afer*), Patas monkey (*Erythrocebus patas*). The African elephant (*Loxodonta africana*) was extinct by the end of the 19th century. The West African giraffe (*Giraffa cameleopardalis peralta*) was extinct before the announcement of the Forêt classée de Bandia´ in 1933. Nile crocodile (*Crocodylus niloticus*) was present in river Somone up until 1968 according to local hunters, villagers and Europeans. Pythons (*Python sebae*) and cobras (*Naja nigricolis*) were recorded here in 1975. One specimen of python (*Python sebae*) was observed inside Bandia reserve between the main gate and a restaurant in 2007 (personal observation). Also this area is described as the southern most border of distribution of tortoise (*Geochelone sulcata*) in the year 2000 which was found here (Nežerková *et al.*, 2004).

Avifauna of the reserve is abundant and 90 bird species have been recorded here.

Francolins, glossy starlings, doves, hornbills, weaver birds from the *Quelea* genus and oxpeckers were observed (Nežerková *et al.* 2004, personal observation, 2007).

From 1991-1999 the following animals were imported from various areas of Senegal: African buffalo (*Syncerus caffer*), Kob (*Kobus kob*), Defassa waterbuck (*Kobus ellipsiprymnus defassa*) and the Roan antelope, (*Hippotragus equines*) obtained from game catches in the Niokolo-Koba national park; Red-fronted gazelle (*Gazella rufifrons*), Dama gazelle (*Gazella dama mhorr*) coming from northern Senegal, Bushbuck (*Tragelaphus scriptus*), warthog (*Phacochoerus africanus*), Nile crocodile (*Crocodylus niloticus*) and the tortoise (*Geochelone sulcata*) were introduced or regenerated from the original population or even moved themselves into the safety of the reserve.

In 2000 a group of western Giant elands (*Taurotragus derbianus derbianus*) was caught in the Niokolo-Koba national park. Asian water buffalo (*Buballus buballis*) also coming from Senegal, from the Asian animal breeding station near St. Louis in northern Senegal (Nežerková *et al.,* 2004).

Foreign animal imports began in 1994, apart from the 6 day-old ostrich chicks (*Struthio camelus*) From Holland in 1991. Other ostriches were also imported, also Caama hartebeest (*Alcephafus buselaphus caama*), Blesbok (*Damaliscus dorcas phillipsi),* Defassa waterbuck (*Kobus ellipsiprymnus ellipsiprymnus*), Common eland (*Taurotragus oryx*), Greater kudu (*Tragefaphus strepsiceros*), Impala (*Aepyceros melampus*). giraffes (*Giraffa camelopardalis giraffa*), Gemsbok (Oryx *gazella gazella*) and the southern white rhinoceros (*Ceratotherium*

simum simum) (Nežerková *et al.*, 2004). Giraffes, roan antelopes, elands, impalas and warthogs are reproducing very well and their numbers are still increasing.

3.4.4 Area

Current area of the reserve is 1500 ha (Dering 2007, personal communication). The area was divided into two parts, because it was too large to be counted in one trip. Towards the end of the study the time needed to finish counting of both parts got shorter. But still it would be too difficult to count them in one go. Harsh weather conditions (heat, dust and bright sun) would mean tired observers and that would transform into increased counting bias. For the work purposes two parts were designated as "old" and "new" part as the reserve was expanded. For evaluating of the habitat utilization the area of the reserve was divided into four zones according to vegetation densities from the least dense to the densest (**Figure 15).**

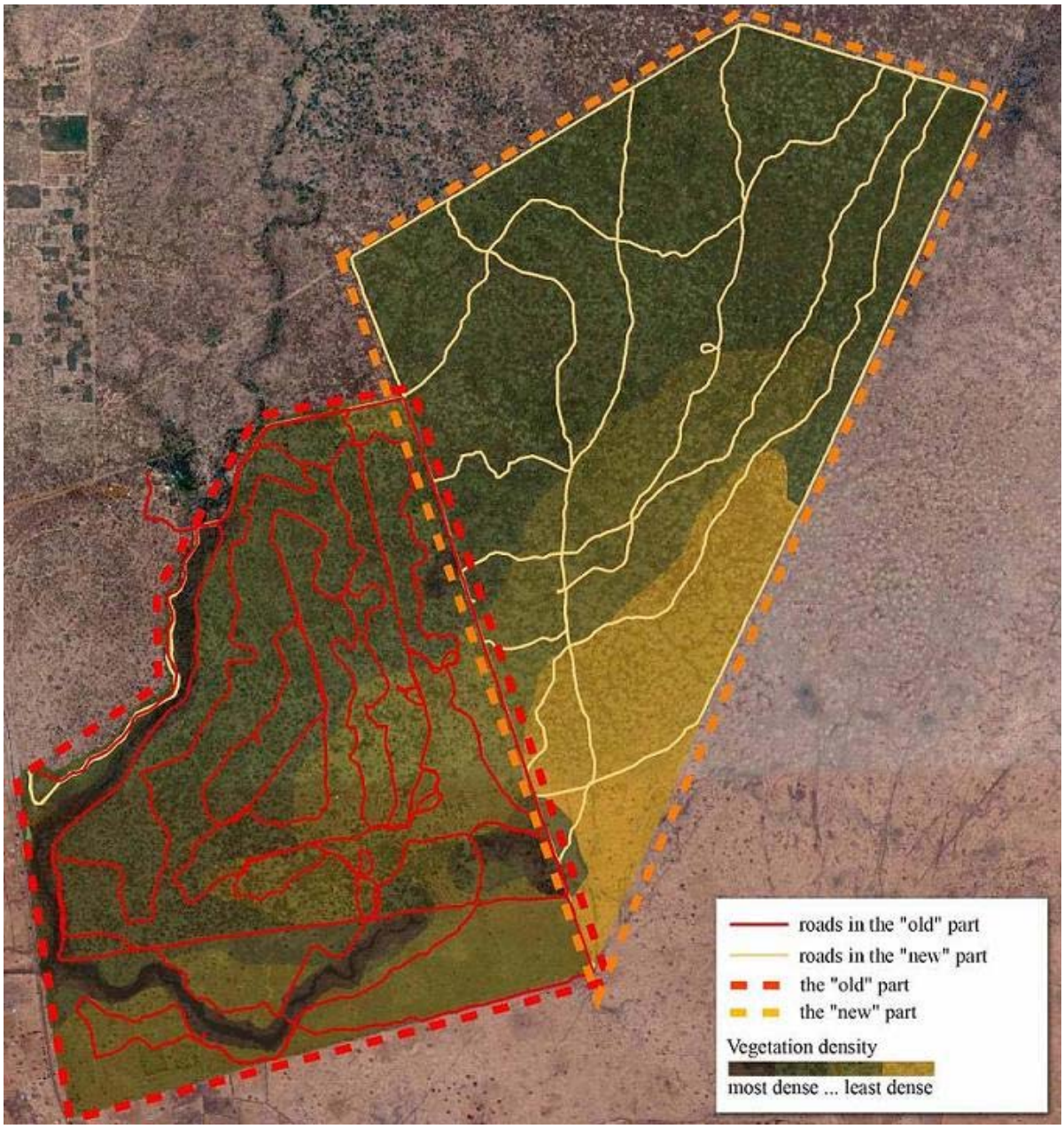

Figure 15: Division into old and new part with road layout and vegetation densities in the Bandia reserve

There is very dense road network in the “old” part, which had been already mapped, so the map was used for route planning in this part.

The road network in the “new” part is not very dense since it is a latter part of the reserve and it had not been mapped before, it was necessary to map it first to enable planning the route. Each route in both parts took approximately 45km to come through which gave about 90km for one counting in one day in the whole reserve.

3.5 Counting method

There were two observers in the car each of them observing one side. One of the observers was also a driver. For to record all animals possible, the driving speed was approximately 10 km/h. In areas of very dense vegetation in the "old" part, the speed decreased to 5 km/h or even less in areas of particularly broken road. Higher speed would mean big counting bias due to overlooking of many animals. In big part of the "new" part of the reserve **(Figure 16/Annexe)** where the visibility was very good (visibility was approximately 500 meters) and the road was not broken, it was possible to drive 17 km/h. Visibility was good because there was not any vegetation apart of some solitaire baobab tree *Adansonia digitata.* Lack of vegetation was caused by fire (Dering 2007, personal communication).

The GPS was set to draw tracks when following ideal planned routes **(Figure 17/Annexe)**. In the "new" part it was possible to follow planned routes exactly because there was not dense net of roads and terrain was open. In the "old" part the situation was very different. The road net was very dense and some of the roads changed their position slightly every season. Also the vegetation in some parts very thick. Therefore the path was slightly different each counting run. It was possible to follow exact planned route for approximately 70% of length of the counting run from the fifth counting on. Firstly the borders of the counted part was driven around, so its shape and size were marked in the GPS. The remaining part of the counted area was driven trough according to GPS so as all the counted area was covered as evenly as possible. The GPS was used to make waypoints on each observed group or individual so accurate track from every observation was made. Gradually it was possible to remember the location of the roads and the planed way through. The time needed for counting went shorter step by step. First counting took 7,23h and the tenth counting took 5,97h.

The car was brought to stop every time a group or an individual animal was spotted.

These data were filled in for each group or individual: time, GPS waypoint number, distance and angle, species, number of individuals and general activity **(Figure 18/Annexe)**. The angle numbers are not complete due to problems and malfunctioning of GPS because it mostly did not show the angle. Presumption is that GPS was malfunctioning because of heat. But this was the only problem with GPS, the other measurements were correct. Where possible, also the number of males and females in the group and their age in categories of adult, sub-adult and young were added. For the most part it was difficult to find out this because animals were obscured, only partly visible, too far, lying down, too many of them in one place or moving

around. To acquire these data it would be necessary to stop and observe the animals for much longer time. But it was not desirable to spend too much time monitoring one group of animals because it would devalue the counting. It would not be possible to count whole reserve in one day and also if the counting was too long then the animals would move around and therefore the counting would be more biased.

We tried to minimize duplicate counting bias as much as possible by comparing every new group with previous groups of the same species already counted in the same day. Comparison was done on numbers (males, females, young where possible), location and the line of travel at the time of previous observing. Sometimes it was possible to recognize an animal and therefore whole group by its specific feature (for instance a missing ear on one kob female or limping impala young).

3.6 Material and tools

Main tool for the counting was a four-wheel drive car Mitsubishi Pajero, and GPS Garmin GPSmap 60CSx. Next important material was paper pad with pencil. Notebook was used to transfer data from the GPS and to work with them in the field. Digital camera Olympus μ 750 was used to document the work and to photo any groups of animals that were difficult to count for later counting after return to base from notebook screen. Also good knowledge of animals was necessary as there was not enough time to consult literature or wonder about what kind of animal it is. It was planned to use binoculars for close ups on animals for better view and thereby to lover counting bias. But it was not possible to use them because they were severely damaged by dust and sun as they were kept behind the windshield for quick reach. ArcMap 9.1 and Photoshop CS3 10.0.1 was used to evaluate habitat utilization and creating the maps.

3.7 Population dynamics and habitat preferences metodology

Maximum numbers gained by this censuing in 2007 were compared to the numbers of animals when introduced and the numbers of animals from counting in 2002 mentioned by Al Ogoumrabe (2002). Differences between these numbers showed tendencies of population dynamics. According to personal observation of the vegetation densities of the reserve a map of vegetation densities was created. The vegetation density was described in four steps according to subjective evaluation from the least dense to the densesest. Location of the

animals recorded by GPS and projected by Arc Map was compared to the map of vegetation density. The outcome of this comparison showed the habitat preferences of all the chosen animals in the reserve.

4 Results

4.1 Census of selected species

Ten counts were done in ten days (**Table 2**). The area of the reserve was divided into two parts – the "old" part and the "new" part. Both parts were counted on the same day; this was to assure the best possible accuracy of the results.

837, 3 kilometers were driven during all ten counts which makes 83,73 km per one count on the average.

Nine species of large herbivores were chosen for counting in advance. One species, White rhinoceros (*Ceratotherium simum simum*) was observed because of habitat preferences. All of them were successfully observed and counted.

Latin name	17.6.2007	18.6.2007	20.6.2007	21.6.2007	23.6.2007	24.6.2007	28.6.2007	29.6.2007	1.7.2007	2.7.2007	max	min
Aepyceros melampus	43	78	67	55	87	77	81	81	82	53	**87**	43
Ceratotherium simum simum	2	2	0	2	2	2	2	0	2	2	**2**	0
Giraffa camelopardalis giraffa	18	15	12	3	12	8	14	10	11	12	**18**	3
Hippotragus equinus	73	144	97	72	85	45	58	69	89	70	**144**	45
Kobus ellipsiprymnus ellipsiprymnus	0	1	1	0	2	0	0	0	0	3	**3**	0
Kobus kob	8	3	6	4	5	5	8	7	14	7	**14**	3
Oryx gazella gazella	4	5	5	3	5	5	4	5	0	0	**5**	0
Syncerus caffer	11	16	12	16	0	14	16	15	12	16	**16**	0
Taurotragus oryx	41	59	61	34	38	51	28	44	56	28	**61**	28
Tragelaphus strepsiceros	18	13	11	12	9	6	12	3	6	13	**18**	3

Table 2: Ten counted species of animals, dates of counts and achieved numbers

4.2 Population dynamics of selected species

New counts compared to numbers of animals when introduced and counts from 2002 (Al Ogoumrabe, 2002) show, that the population of some species is increasing, population of

some species stagnates and some species seem to be decreasing in numbers (**Table 3**), (**Figure 19)**.

Distinct increase in population is evident by the Impalas (*Aepyceros melampus),* Roan antelopes (*Hippotragus equinus*), Common elands (*Taurotragus oryx*) and Giraffes (*Giraffa camelopardalis giraffa*).

Minor increase in population is noticeable by Greater kudus (*Tragelaphus strepsiceros*) and African buffalos (*Syncerus caffer*).

Population of Kob (*Kobus kob*), Defassa waterbucks (*Kobus ellipsiprymnus ellipsiprymnus*) and Gemsboks (*Oryx gazella gazella*) decreased.

Name	**Date of introduction**	**Total numbers when introduced**	**Total numbers in 2002**	**Maximal numbers in 2007**
Aepyceros melampus	31.12.1996	10	33	**87**
Ceratotherium simum simum	July 2000	4	4	**2**
Giraffa camelopardalis giraffa	31.12.1996	4	9	**18**
Hippotragus equinus	June 1999	24	63	**144**
Kobus ellipsiprymnus ellipsiprymnus	31.12.1996	7	14	**3**
Kobus kob	30.4.1994 26.2.1995 25.5.1997 7.5.1998 1.5.1999	3 3 4 6 22 total: 38	15	**14**
Oryx gazella gazella	31.12.1996	5	9	**5**
Syncerus caffer	18.7.1999	10	10	**16**
Taurotragus oryx	31.12.1996	8	26	**61**
Tragelaphus strepsiceros	31.12.1996	5	14	**18**

Table 3: Numbers of animals when introduced and in 2002 from Al Ogoumrabe (2002), numbers of animals in 2007 new counts

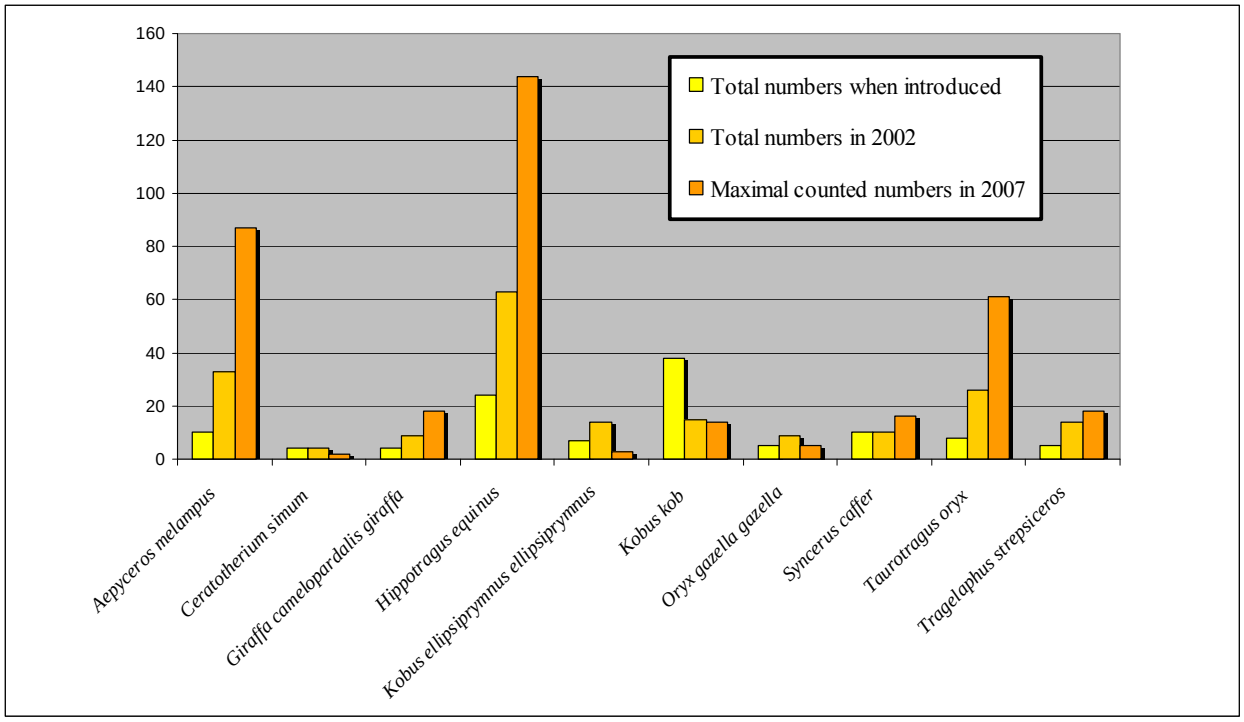

Figure 19: Graph of numbers of animals when introduced and in 2002 from Al Ogoumrabe (2002), numbers of animals in 2007 new counts

4.3 Habitat utilization of selected species

Most of the animals occurred in the old part of the reserve (**Figure 20**).

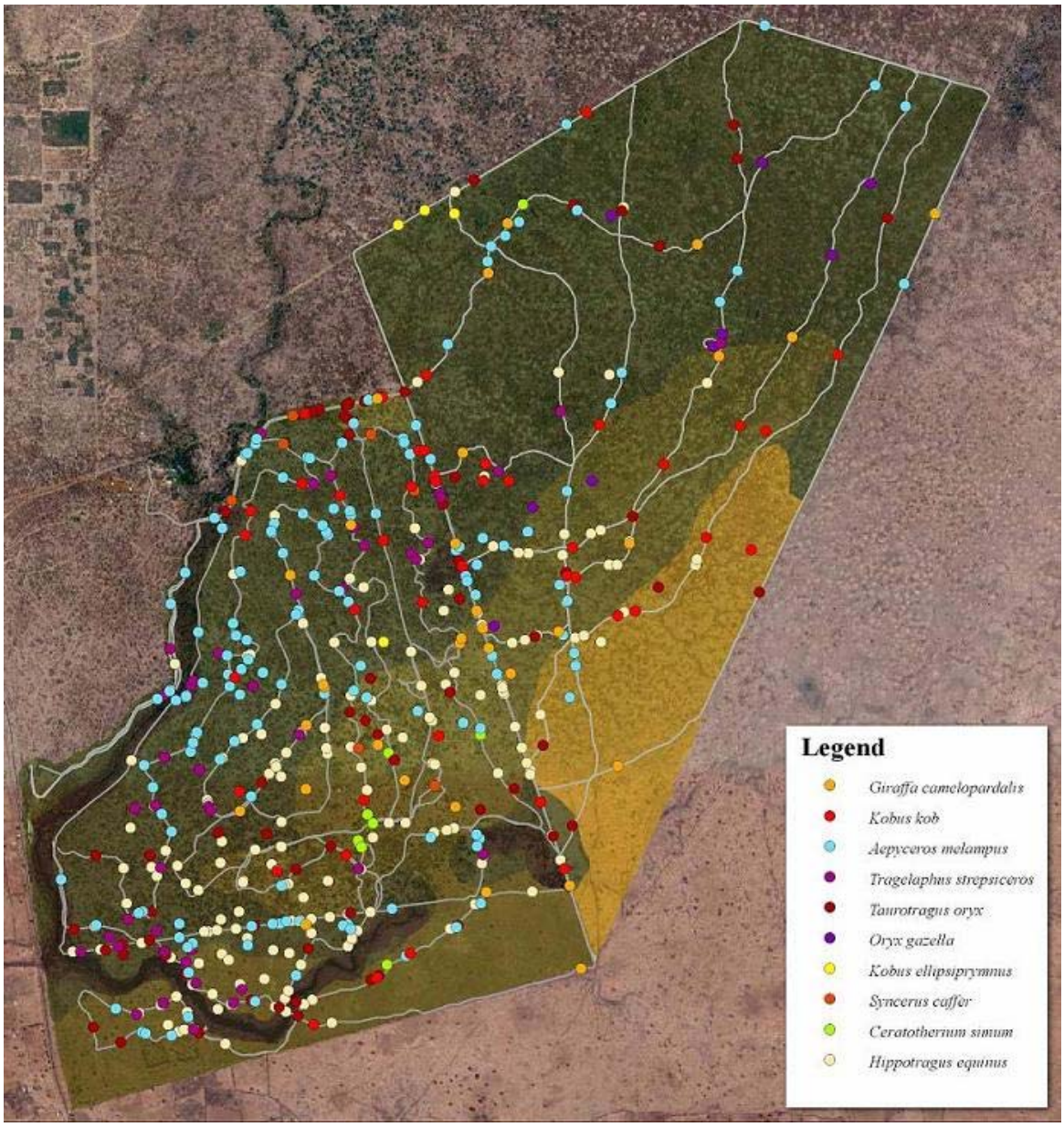

Figure 20: Habitat utilization of all counted species during all census time

4.3.1 Impala (*Aepyceros melampus*)

Impalas occurred in the old part more than in the new part where almost only males or group of males were found. Only one group of females was observed well inside the new part. Two times group of male and females were observed close to border between new and old parts

inside the new part. One group of male, females and young ones was observed on the border as well. Impalas were never observed in the big open area in the new part. All groups of females with young ones were found in the old part in the sections of densest vegetation with very heavy undergrowth (**Figure 21**).

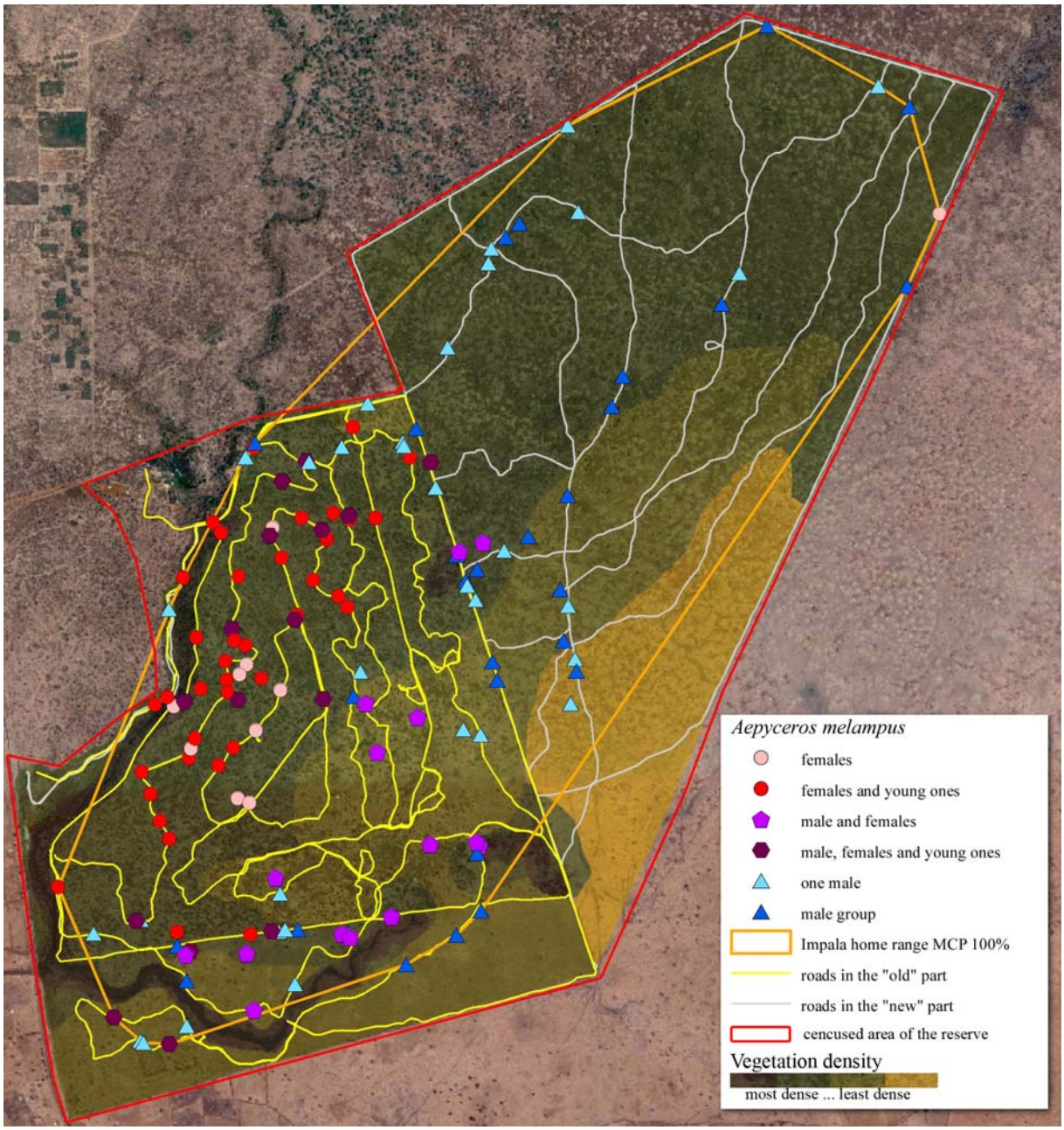

Figure 21: Habitat utilization of Impala

4.3.2 White rhinoceros (*Caratotherium simum simum*)

There are only two rhinos in the reserve, male and female. They were always observed together. They were mostly observed in the old part in the semi-open areas with acacia trees but not many shrubs. Only once they were observed in the new part (**Figure 22**).

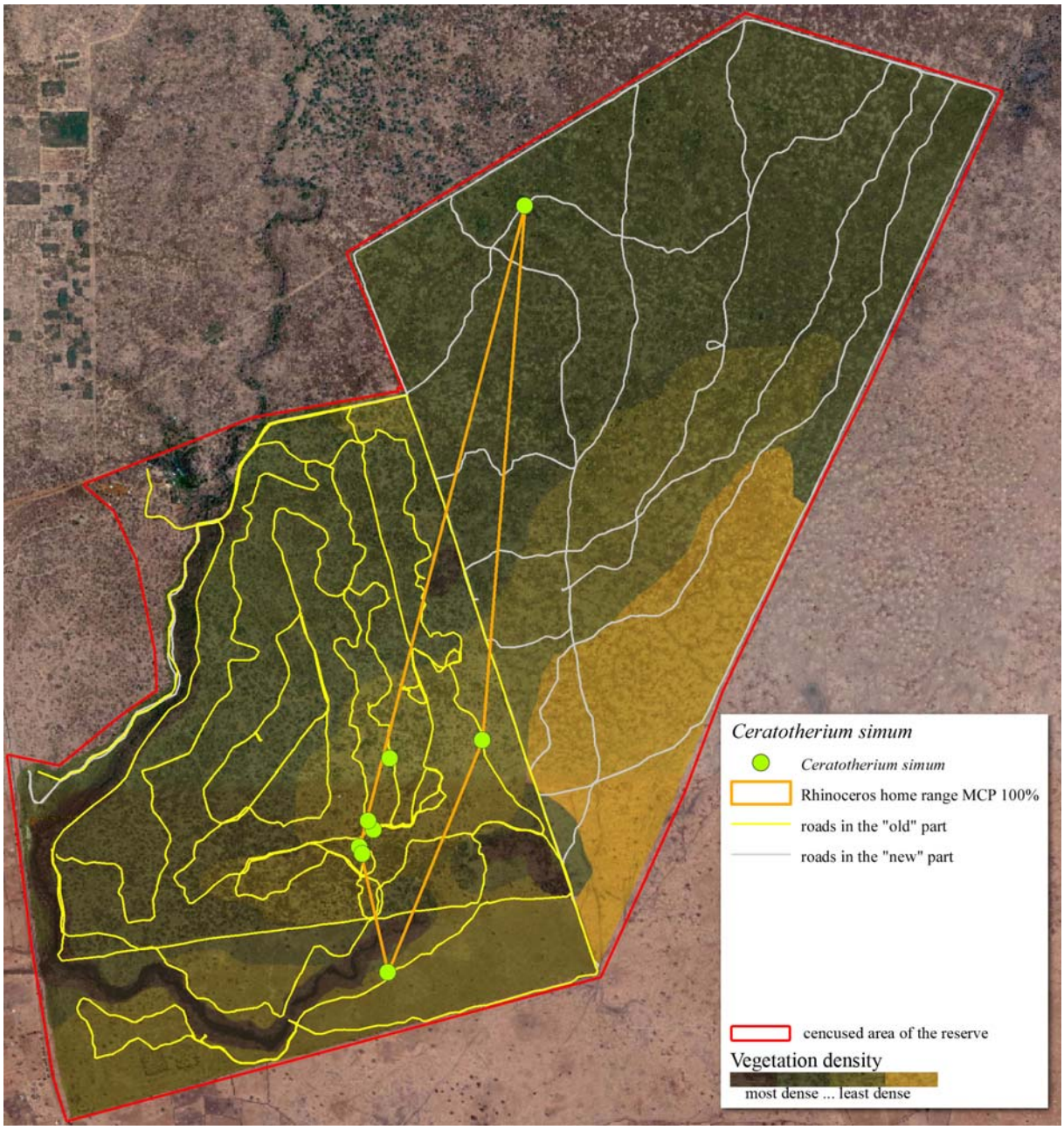

Figure 22: Habitat utilization of White rhinoceros

4.3.3 Giraffe (*Giraffa camelopardalis giraffa*)

Groups of giraffes and solitary males occurred in both parts. No habitat preference was observed, it seems that giraffes use whole reserve and move around (**Figure 23**).

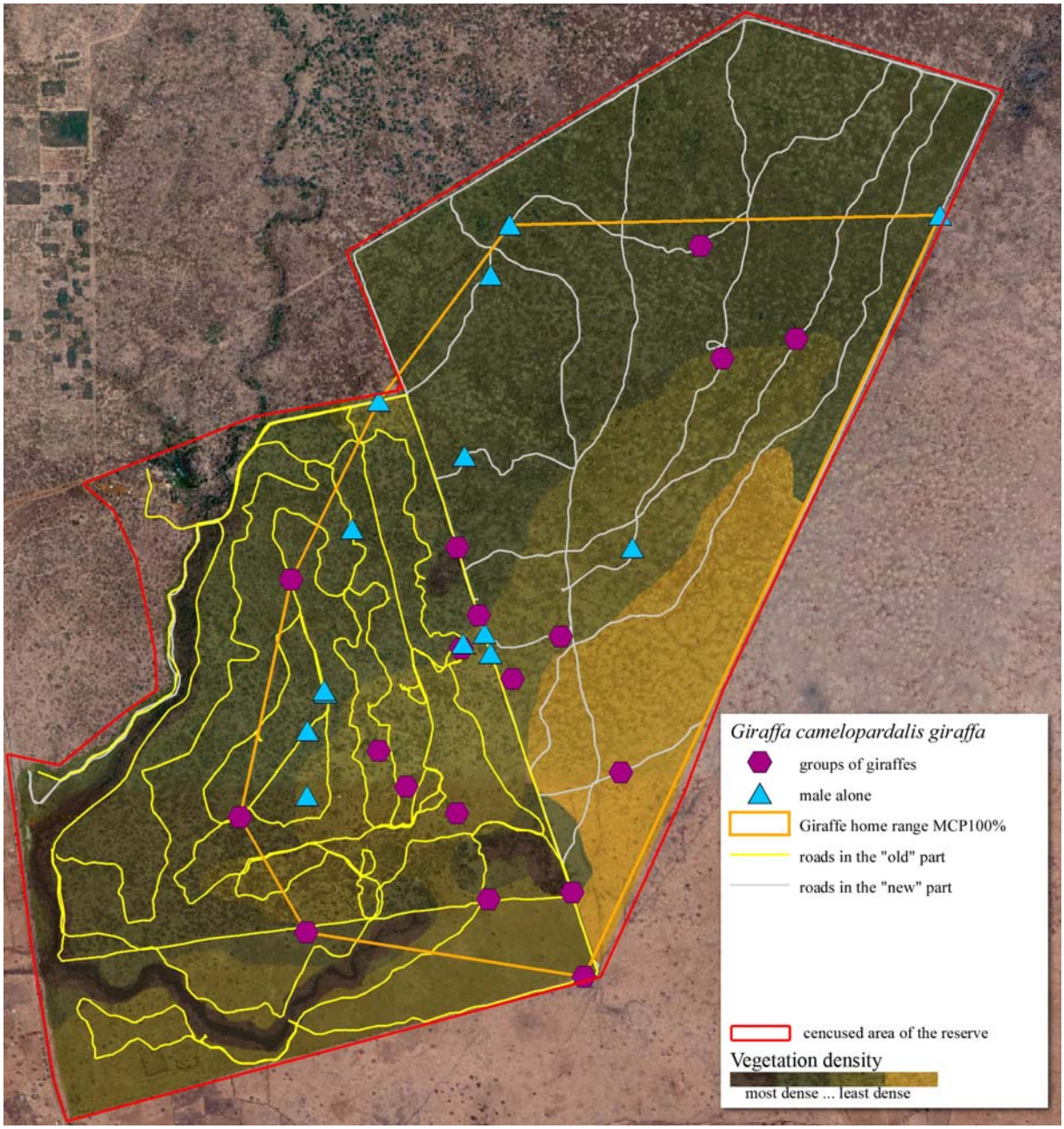

Figure 23: Habitat utilization of Giraffes

4.3.4 Roan antelope (*Hippotragus equinus*)

Roan occurred mostly in the old part in the south area. Vegetation there was scarce and old grass was abundant with not many trees. Some of them were observed in the new part but mostly close to the border with the old area (**Figure 24**).

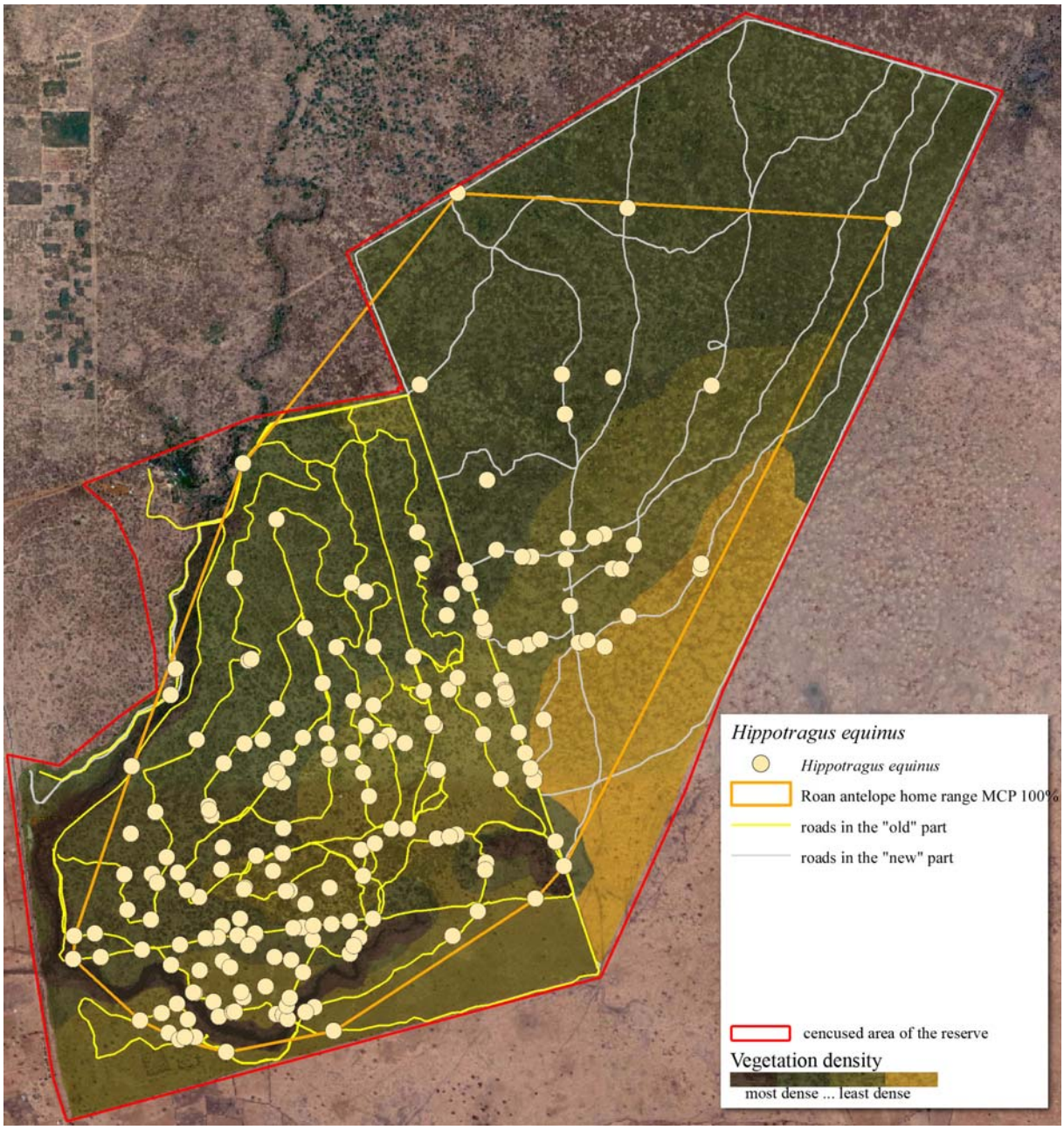

Figure 24: Habitat utilization of Roan antelope

4.3.5 Defassa waterbuck *(Kobus ellipsiprymnus ellipsiprymnus)*

Defassa were observed only four times. They were observed three times in the new part and only once in the old part. All observations in the new part were very close to each other by the northern fence. Vegetation was dense there and old grass abundant (**Figure 25**).

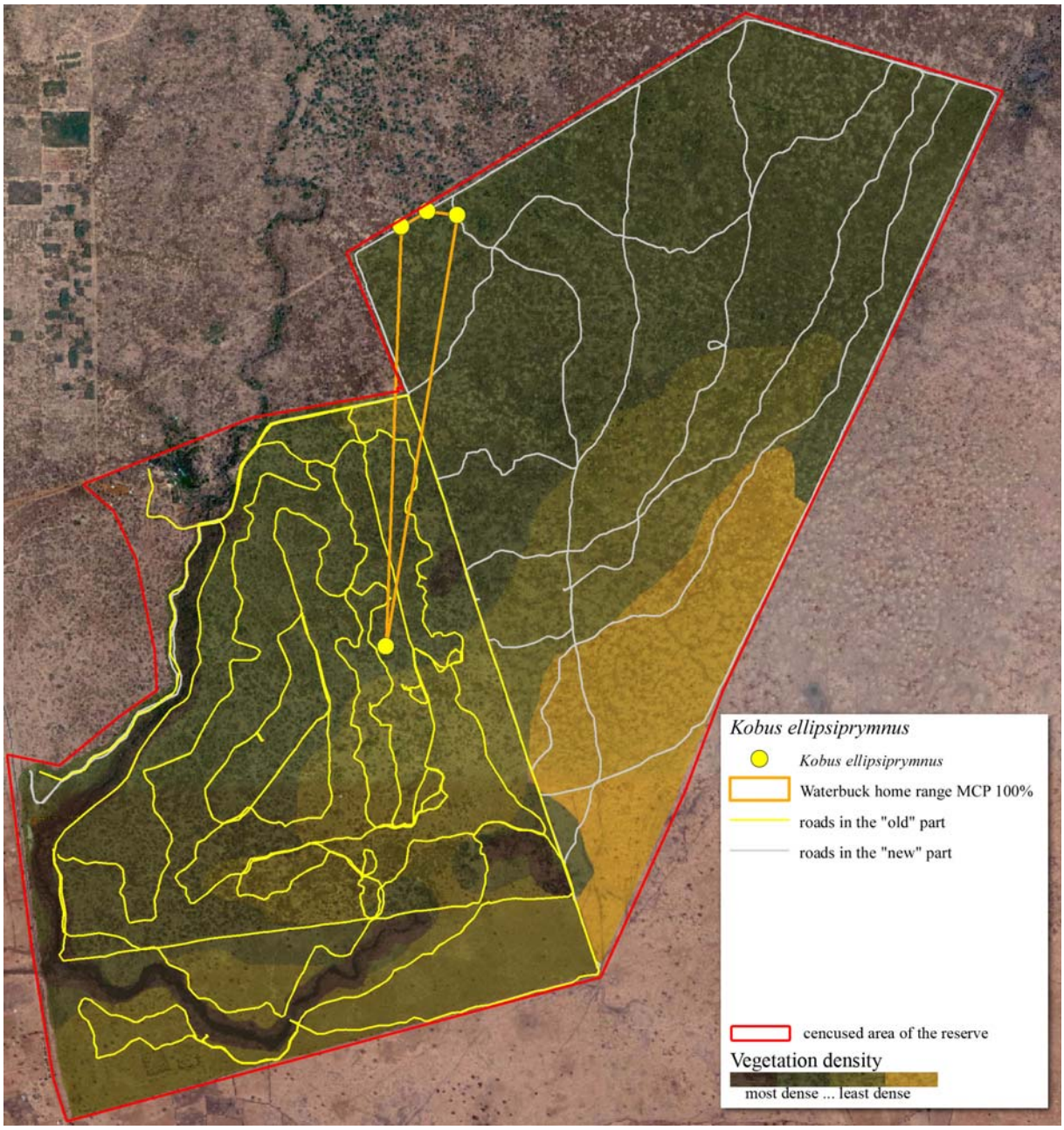

Figure 25: Habitat utilization of Waterbuck

4.3.6 Kob (*Kobus kob*)

Kob were observed in both parts of the reserve equally. They were observed in different parts of the reserve in different habitats. Groups of females, solitary females, solitary males and male with female were observed (**Figure 26**).

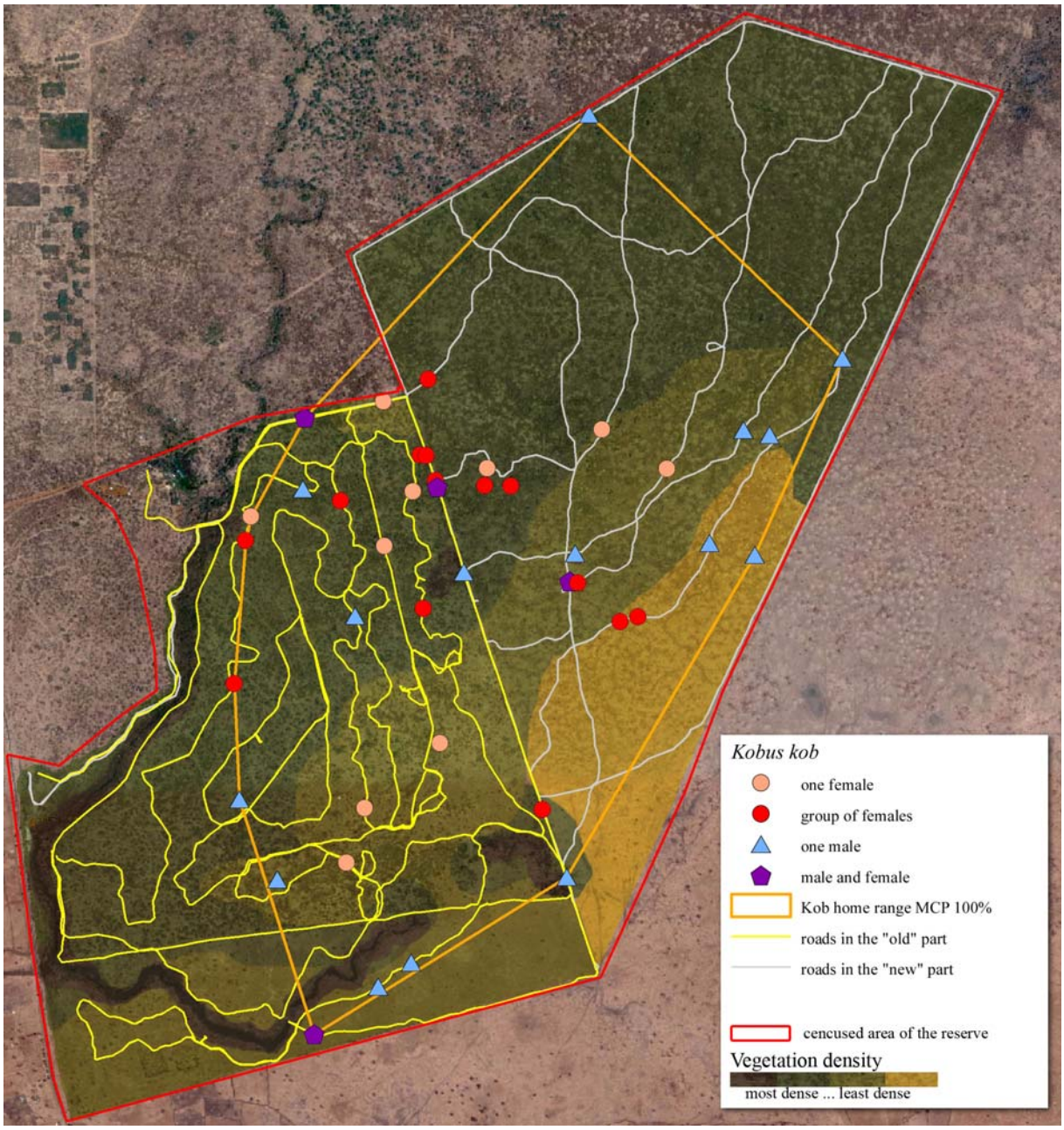

Figure 26: Habitat utilization of Kob

4.3.7 Gemsbok (*Oryx gazella gazella*)

Gemsbok were observed only in the new part. They inhabited areas with dense acacia shrubs but also areas with not so dense vegetation and without any old grass. There were areas where old grass was burned by fire (**Figure 27**).

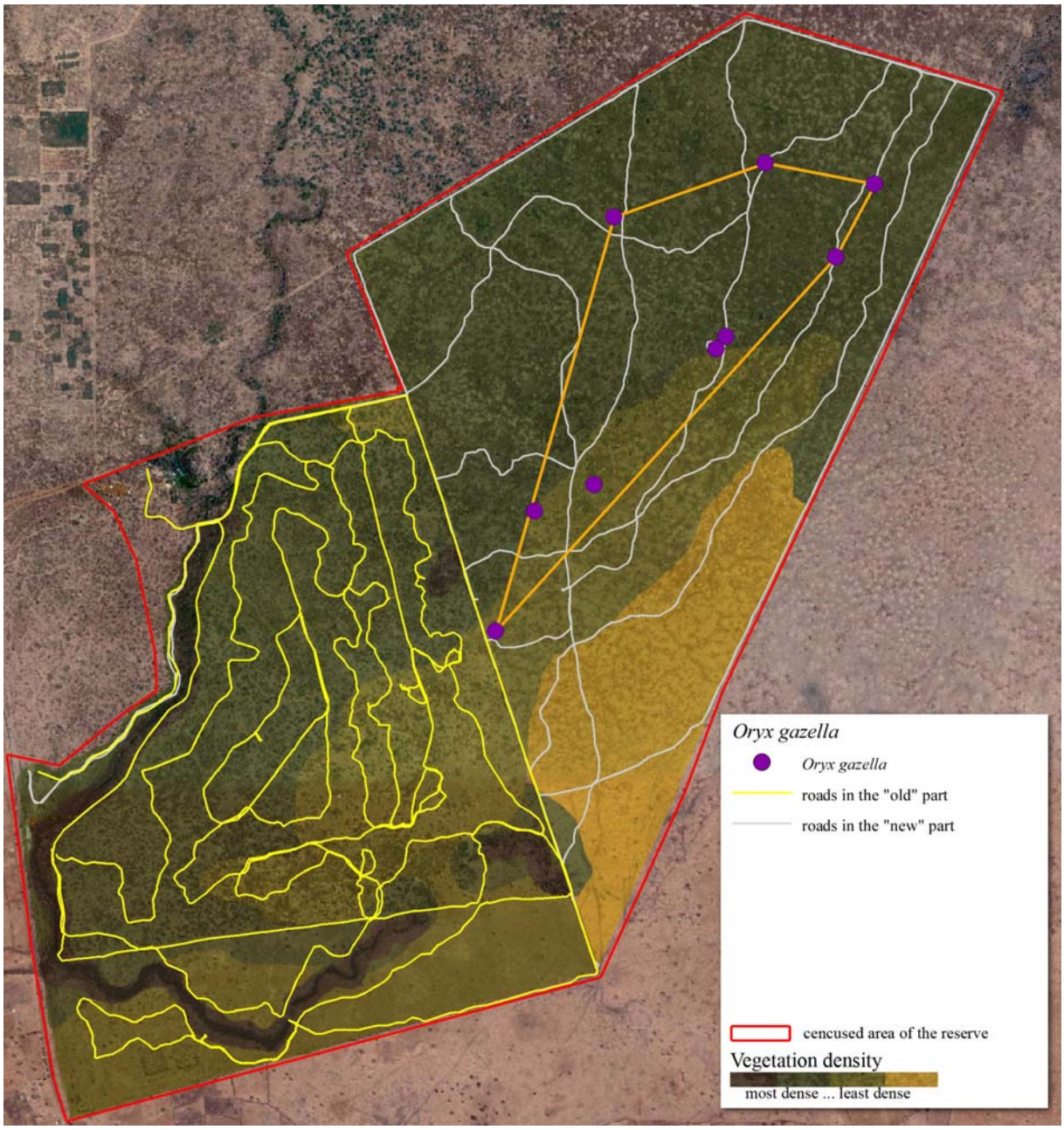

Figure 27: Habitat utilization of Gemsbok

4.3.8 African buffalo (*Syncerus caffer*)

Buffalos were observed only in the old part. All but two observations were made in the northern part by the fence. Feeding area is situated there. Most of the time buffalos were encountered not far from that. Habitat is partly opened with dense shrubs and undergrowth there (**Figure 28**).

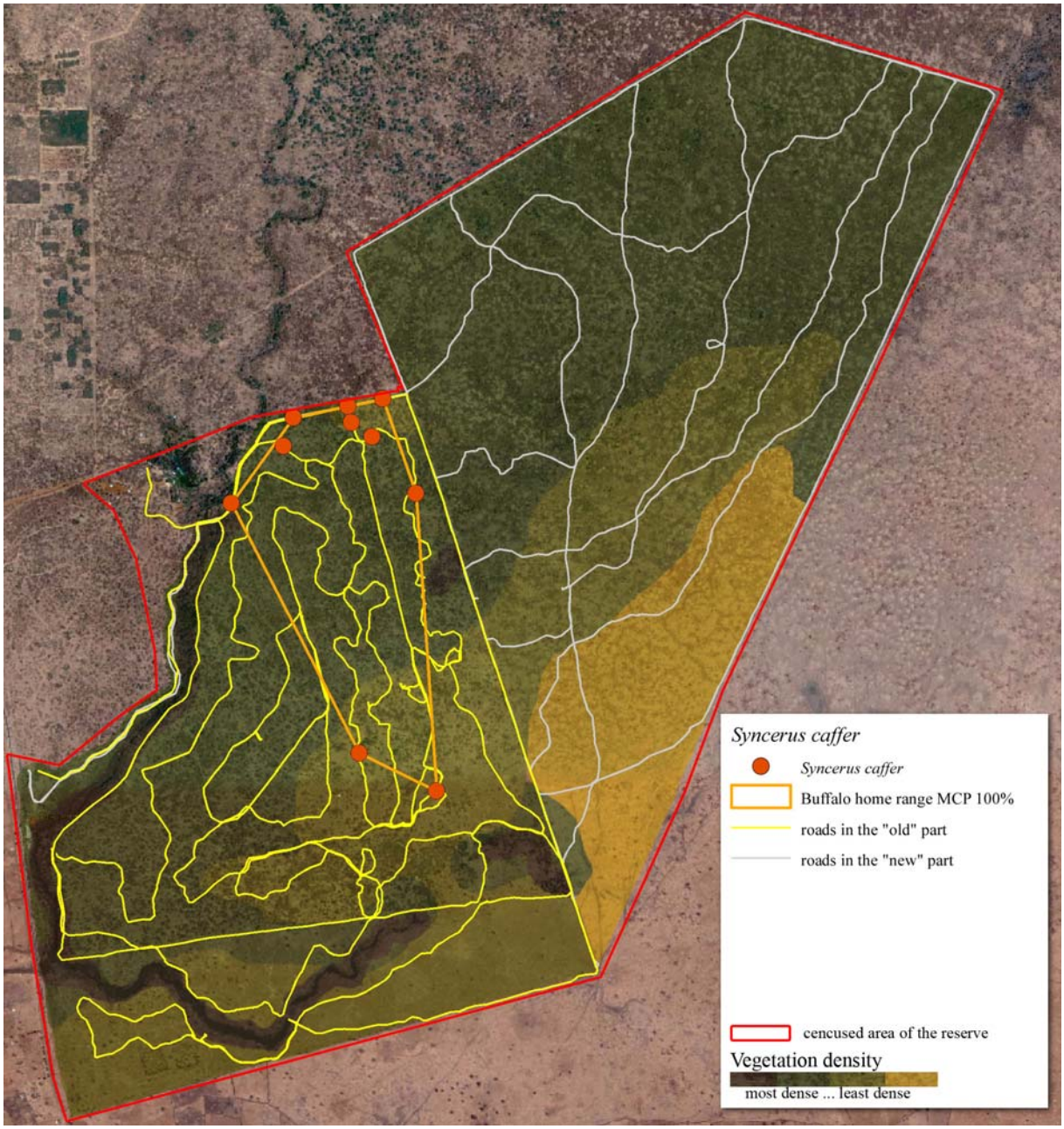

Figure 28: Habitat utilization of African buffalo

4.3.9 Common eland (*Taurotragus oryx*)

Common elands were observed in both parts of the reserve but they occurred mostly in the old part. They were observed in every habitat of the reserve except of the densest vegetation section of the old part. Groups of males were often noted at the feeding area by the northern fence (**Figure 29**).

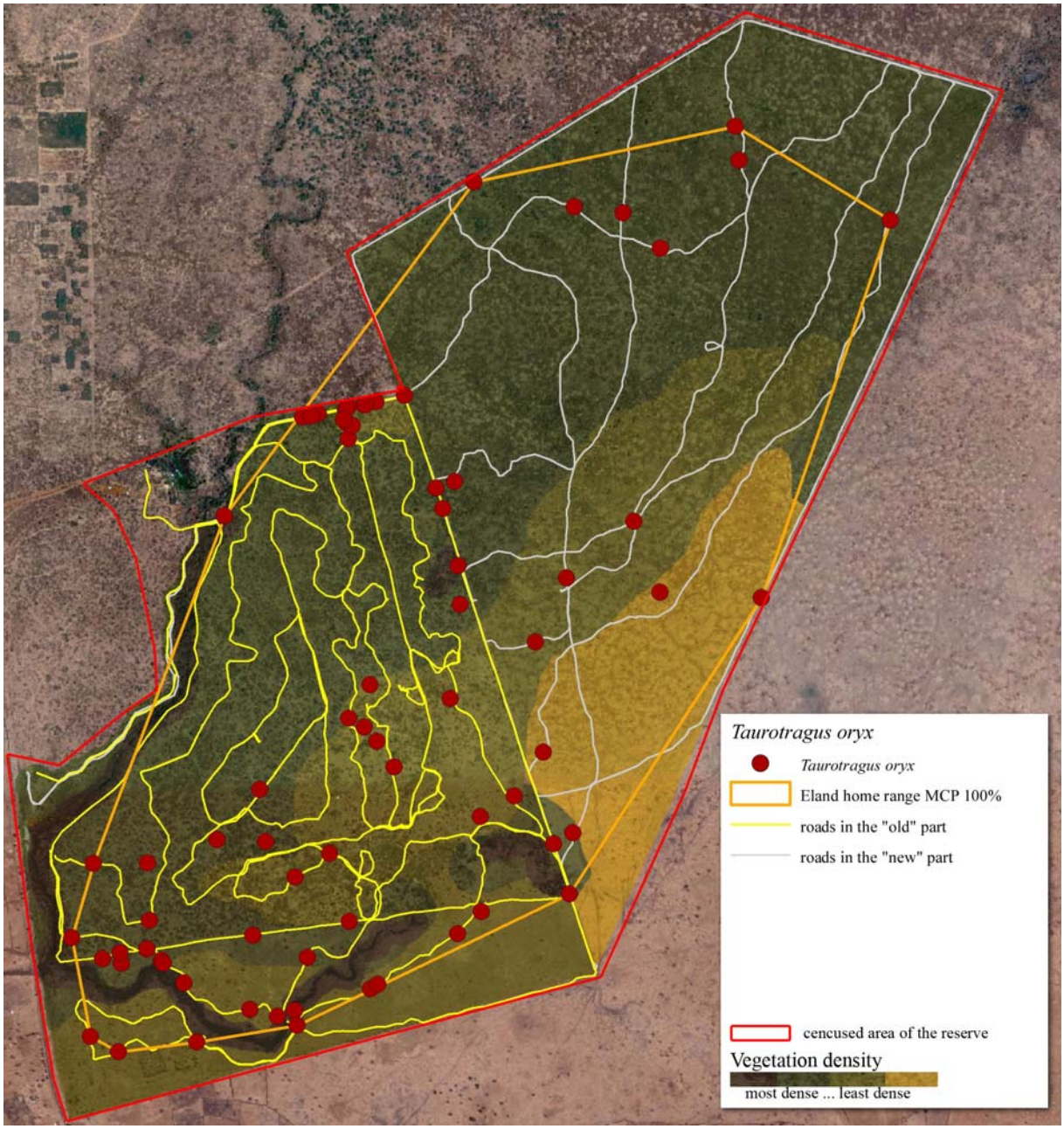

Figure 29: Habitat utilization of Common eland

4.3.10 Greater kudu (*Tragelaphus strepsiceros*)

Kudu were found mostly in the old part. In the new part were observed only females, group of females or females with young ones but not very often. Males and group of males were observed primarily in the south of the old part from open areas to very dense areas. Young ones, females, group of females and females with young ones were found mainly in the densest vegetation areas of the old part (**Figure 30**).

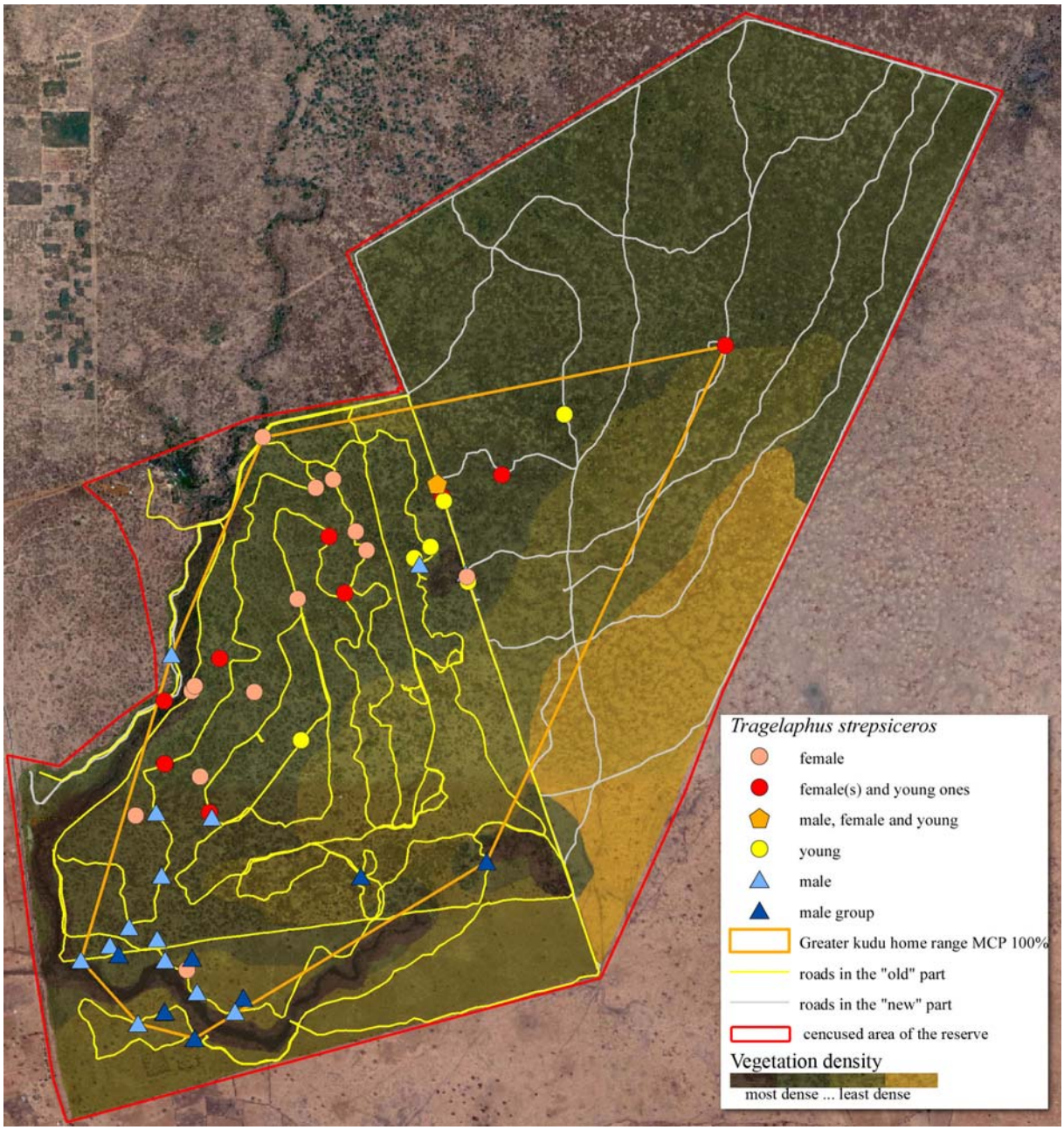

Figure 30: Habitat utilization of Greater kudu

5 Discussion

5.1 Methodology discussion

5.1.1 Why total count from vehicle

Total ground count form vehicle was used in preference of aerial counts and foot counts because this way of counting is least biased in Bandia conditions. Aerial counts tend to be undercounted due to sighting probability bias and because some individuals and groups of animals would be concealed by dense vegetation or obstructions (Jachmann, 2002). What is more, aerial counts are expensive and technically demanding and there was not access to the aircraft or helicopter. Distance traveled every day was around 85 km, therefore foot count was not possible because there was only one group of two observers so it would be too much walking for one group. On the other hand, counts from vehicles are ideal for detailed studies in small study areas (Norton-Griffiths, 1978), and ground counts from vehicles are practicable and give excellent and consistent results in small to medium sized areas where the country allows the use of vehicles and the vegetation is reasonably open and the animals tame to vehicles (Bergström and Skarpe, 1999). Total count was used because the Bandia reserve is too small for transect or sample count.

5.1.2 Problems of the chosen methodology

It was planned to get more information than just numbers of animals. The plan was to write down sex and age structure of every group of animals encountered. But in the end it was possible to get this information only for impala, grater kudu and kob. For whine rhinos it was not needed to find out sex and age structure because there are only two of them in Bandia and this information was already known. For the rest of the animals it was not possible to find out sex and age structure. This was because animals were partly obscured, lying down, too far away or moving around all the time. It would require too much time to get this information anyway. Consequently it would mean that it would not be possible to census whole reserve in one day and therefore census would be biased. It was decided to focus primarilly to get as accurate numbers of the animals as possible in preference of herds sex and age structure information.

5.1.3 Methodology bias and results

I think that the chosen methodology and outcome of this research is not biased overly. Whole reserve was driven through in one day and we tried to cover every part of the reserve and count every animal. But still, vegetation in some parts of the Bandia reserve is very dense and so animals in that parts at the time of counting were in fact uncountable.

We tried to minimize double counting bias. We compared groups of animals of the same species observed close together on the same day. Comparison was done on estimated numbers, sex and age structure where possible, location and line of travel.

5.2 Evaluation of population dynamics and habitat utilization

5.2.1 *Aepyceros melampus* – impala

Population of impalas has increased considerably since releasing of the original population into the reserve. Legros (2004) mentions that this species seems to be very prolific in the reserve and the animals are well adapted to the biotope in the reserve. New census from 2007 confirms this. Edges between grassland and denser woodlands, notably *Acacia* are preferred. Grassland is occupied during the rains, woodland more in the dry season (Kingdon, 1997). This was confirmed by the censuing 2007 because habitat preferences of observed impalas were woodlands and shrubs in the denser parts of the reserve. Despite being predominantly a grazer in the rain season, impalas will switch to browse during the dry season (Lundrigan and Sproull, 2000). In dry season they browse on shrubs, herbs, pods, and seeds; *Acacia, Combretum* and *Grewia* are important for impala's dietary requirements (Kingdon, 1997). All these plants are present in the Bandia reserve and *Acacia* is abundant (Nežerková et al., 2004). So they can find enough nutrition in the reserve throughout the whole year. Because of these conditions the population dynamics of impalas seems to be increasing. Herds of females and young ones without male were observed as well as females without male. This was probably due to sighting probability bias as we were not able to find male because of very dense vegetation cover. Presumption is that male was present but not visible.

5.2.2 *Ceratotherium simum* - white rhinoceros

Two males and two females were released after adaptation in quarantine enclosure. None of the animals died but during the year 2002 males started to fight. It was a hormonal effect, a result of the fact that they reached sexual maturity. One couple was therefore transported to

Fathala (Legros, 2004). White rhinos prefer areas of short grass (Kingdon, 1997). They are grazers feeding on grass. Their anatomy and feeding behavior is adapted for efficient short grass feeding (Ellis, 1999). According to Kingdon (1997) long grass is grazed more clumsily. Conditions in the Bandia reserve are very different from habitat preferred by White rhinos. In the dry season almost no grass is present only old dry low nutrition long grass. In the wet season green grass is abundant but it is long grass generally not preferred by White rhinos. This means that the Bandia reserve habitat and vegetation structure is not very suitable for White rhinos. This could be the reason they do not breed. The management of the reserve tries to help them by feeding them additional supplementary food (Dering, 2007 personal communication).

5.2.3 *Giraffa camelopardalis* – giraffe

Giraffes are especially associated with savannas where *Acacias* are abundant trees. They are known to feed from over 100 species of plants but *Acacia, Commiphora* and *Terminalia* species are mayor staples (Kingdon, 1997). They are browsers and feed on leaves, flowers, seed pods and fruits. Their main food is the leaves from *Acacia* trees. Their anatomy and feeding behavior is adapted for efficient browsing including *Acacia* thorns (Maisano and Fraser, 2006). The Bandia reserve is rich with *Acacia* so giraffes find enough fodder here. The Bandia reserve is suitable for giraffes in terms of habitat and vegetation composition as well. Numbers gained by censuing confirm the increase of population. Population dynamics of giraffes in the Bandia reserve seems to be increasing.

5.2.4 *Hippotragus equinus* - roan antelope

According to Roe (2002) Roan antelopes are found in lightly wooded savanna with medium to tall grass and must have access to water. Roans occasionally browse shrubs or herbs and pick up *Acacia* pods in the dry season. They prefer mosaics with clumps of trees or woodland margins with shades for resting (Kingdon, 1997). The Bandia reserve provides them with enough food in both rain and dry seasons and they have access to water as well. Roan are the most numerous species of large herbivores in the reserve. Their habitat preference corresponds to their spatial distribution in Bandia. Population dynamics of Roan antelopes in the Bandia reserve is increasing.

5.2.5 *Kobus ellipsiprymnus* – waterbuck

Waterbuck prefer well-watered valley grasslands with permanent water mainly in tropical Africa (Kingdon, 1997). They remain close to water for food and as an escape from predators. Waterbucks are very water dependent. They eat variety of grasses, both medium and short in length. When there is not enough grass they eat other herbs (Newell, 1999b) and they may browse leaves or even fruits (Kingdon, 1997). Though they numbers at first increased (Al Ogoumrabe, 2002), the censuing in 2007 showed that only three individuals remained in the reserve. Remaining individuals are all females (Dering, 2007 personal communication). This means that population dynamics of Waterbuck in Bandia is decreasing to the point of extinction unless new animals are brought in. I would not recommend new imports because it seems that the Bandia reserve is not suitable for Waterbuck. Habitat and vegetation structure seems to be unsatisfactory especially in the dry season.

5.2.6 *Kobus kob* – kob

According to DuVal (2000) kob are usually found near permanent water sources. They frequent moist savannah, floodplain, and the margins of adjacent woodlands. Areas with short grass are preferred habitat. Bandia environment is very dry in the dry season and there is no short grass. Kob are grazers and eat common grasses. They prefer short sward and are totally dependent on regular drinking. Kob do not prefer habitat with seasonal extremes (Kingdon, 1997). It seems that the Bandia reserve is not suitable for kob as habitat and vegetation structure seems to be unsatisfactory especially in the dry season. From the total number of 38 introduced animals 23 died from stress after releasing so only 15 individuals remained (Legros, 2004). In this case maximum numbers gain by census seem to be biased because average result is 5 to 8 individuals. High number was probably caused by double counting. Therefore the population dynamics of kob in Bandia is probably decreasing.

5.2.7 *Oryx gazella* – gemsbok

Gemsbok prefer wooded grasslands and *Acacia* bush of the central Kalahari. Its distribution includes areas of very variable fertility and rain fall (Kingdon, 1997). Although generally a grazer, they will browse during droughts or when grasses are not available. As dessert dwellers they can eat dry grass but prefer green grasses (Lundrigan and Sanders, 2005). Habitat and vegetation structure in the reserve agree with needs of gemsbok. So it would seem that gemsbok should thrive well in the Bandia reserve but their population dynamics

stagnates. But for small populations like this there can be many reasons for stagnation and without research aimed at gemsbok it is difficult to come up with answers.

5.2.8 *Syncerus caffer* - African buffalo

African buffaloes like dense cover but are found in open woodlands as well (Newell, 2000). This corresponds with habitat preferences of buffaloes in the Bandia reserve as was observed in this study. They favor mosaics and savannahs with patches of thicket reeds or forests and they need water. They are grazers and eat wide choice of grasses and swamp vegetation but depend on low-level browse too. They prefer grassy glades, watercourses and waterlogged basins (Kingdon, 1997). It seems that vegetation structure is unsatisfactory especially in the dry season for African buffaloes in the Bandia reserve. They do not have enough grass and there are no waterlogged areas. In spite of this the population dynamics of African buffaloes in the reserve shows minor increase.

5.2.9 *Taurotragus oryx* – eland

Eland live in both steppe and sparse savanna forests. They are also found in semi desert areas (Fahey, 1999). This corresponds with habitat preferences of elands in the Bandia reserve as was observed in this study. They preferred more opened part to the densest parts. According to Kingdon (1997) they are browsers and eat foliage and herbs. Eland can tolerate tougher and more aromatic food. In the dry season they eat *Combretum* and *Acacia* seeds and pods. Their diet includes also grasses and succulent fruits (Fahey, 1999). The Bandia reserve provides them with enough food in both rain and dry season and because of that their population dynamics is increasing.

5.2.10 *Tragelaphus strepsiceros* - greater kudu

Greater kudu are found in variety of habitats throughout Africa that provide bush and thicket cover (Newell, 1999a). This corresponds with habitat preferences of greater kudu in Bandia as was observed in this study. They prefer densest parts to the more opened parts. Greater kudus eat very wide range of foliage, herbs, vines, flowers, fruits, succulents and grasses. They have great seasonal changes in their diet. In the dry season their diet include *Acacias* and *Combretum* (Kingdon, 1997) which can be found in Bandia. The reserve is suitable for greater kudu in terms of habitat and vegetation composition as well. Numbers gained by censuing

confirm the increase of population. Population dynamics of greater kudu in the Bandia reserve seems to be increasing.

To better evaluate population dynamics and habitat utilization of those species, other studies must be carried out. These studies should concentrate on ecology of selected species depending on climate and vegetation conditions in the Bandia reserve. This should bring clear results as to what species are not suitable to the Bandia reserve and what species fit well into the reserve environment. But not for all species at once. Better option would be to focus on one species at a time as this approach would mean that there will be enough time for more detailed study.

I would recommend to enrich animal species of the reserve with some new species that are well adapted to the environment of the Bandia reserve. Of course detailed studies would have to be done to evaluate suitability of the new species according to habitat and food preferences. Some of these new species could be for instance Sable antelope (*Hippotragus niger)*, Addax *(Addax nasomaculatus)*, Springbuck *(Antidorcas marsupialis)* or Grant´s gazelle *(Gazella granti)* whose habitat and food requirements (Kingdon, 1997) might be similar as encountered in the Bandia reserve. But it is only a guess without extensive study to prove it or to refuse it.

6 Conclusion

A research was carried out in the Bandia reserve in Senegal. This research was executed in the frame of Czech – Senegalese cooperation during the end of the dry season from 14.6. to 10.7. 2007.

Ten species of large herbivores were censused, their population dynamics and habitat preferences evaluated. Total ground count from vehicle was chosen for this study. The area of the reserve was divided into four zones according to vegetation densities. This helped evaluate habitat utilization of all ten selected species.

Major increase in population is evident by the Impalas (*Aepyceros melampus),* Roan antelopes (*Hippotragus equinus*), Common elands (*Taurotragus oryx*), Giraffes (*Giraffa camelopardalis giraffa*) and Greater kudus (*Tragelaphus strepsiceros*). The reserve meets the requirements for these species and is suitable for them in terms of habitat and vegetation composition as well. Climate seems to be acceptable too. These species reproduce well and their population dynamics are increasing.

Minor increase in population is noticeable by African buffaloes (*Syncerus caffer*). The Bandia reserve does not meets all the requirements for African buffaloes. But in spite of this buffaloes are reproducing and their population dynamics is not decreasing or stagnating.

The population dynamics of Kob (*Kobus kob*) in Bandia is probably decreasing. It seems that the Bandia reserve is not suitable for Kob as habitat and vegetation structure seems to be unsatisfactory especially in the dry season.

Numbers of Waterbucks (*Kobus ellipsiprymnus ellipsiprymnus*) decreased. The Bandia reserve is not suitable for Waterbuck. Habitat and vegetation structure seems to be unsatisfactory especially in the dry season. Population dynamics of Waterbuck in Bandia is decreasing to the point of extinction.

Numbers of Gemsboks (*Oryx gazella gazella*) initially increased but then decreased. Habitat and vegetation structure in the reserve correspond with needs of gemsbok. Climate should be acceptable as well. In spite of this their population dynamics stagnates. But for small populations like this there can be many reasons for stagnation and without research aimed at gemsbok it is difficult to come up with answers.

Numbers of White rhinoceros (*Ceratotherium simum simum*) do not change. Conditions in the Bandia reserve are very different from those demanded by White rhinos. This applies for the

dry season and for the wet season too. The Bandia reserve habitat and vegetation structure is not very suitable for White rhinos. This could be the reason they do not breed.

To better evaluate population dynamics and habitat utilization of those species, other studies must be carried out. But not for all species at once. Better option would be to focus on one species at a time as this approach would mean that there will be enough time for more detailed study.

7 References

AL OGOUMRABE, N., 2002: Les aires protégées au Senégal: étude du cas de la Réserve de faune de Bandia: adaptation des animaux sauvages introduits et aspect socio-économique. Thèse UCAD EISMV Dakar, N°7,193 pp.

ANONYMOUS, (1999a): Monographie Nationale sur la Biodiversité au Sénégal, Ministère de l´Environnement et de la Protection de la Nature

ANONYMOUS, (1999b): Strategie nationale et plan national d´actions pour la conservation de la biodiversite, Ministère de l´Environnement et de la Protection de la Nature

BERGSTRŐM, R., SKARPE, C., 1999: The abundance of large herbivores is a semiarid savanna in relation to seasons, pans and livestock, Afr. J. Ecol. 1999, Vol. 37, pages 12 - 26

BOUCHÉ, P., LUNGREN, C.G., HIEN, B., OMONDI, P.,2004: Aerial Total Count of the "W"-Arli-Pendjari-Oti-Mandouri-Keran (WAPOK) Ecosystem in West Africa , 108 pp.

CARO, T.M., 1999: Densities of Mammals in Partially Protected Areas: The Katavi Ecosystems of Western Tanzania, The Journal of Applied Ecology, Vol. 36, No. 2, pages 205 – 217

CBD – CONVENTION ON BIOLOGICAL DIVERSITY [online], last actualization 19.4.2008 [cit. 13.2.2008], available from: <http://www.cbd.int>

CHARDONNET, P., DES CLERS, B., FISCHER J., GERHOLD, R., JORI, F., LAMARQUE, F.:2002: The value of wildlife, Rev, sci. Tech. Off. Int. Epiz., 2002, 21 (1), pages 15- 51

CIA: The World Factbook – Senegal [online], last actualization 15.4.2008 [cit. 3.4.2008], available from: <http://www.cia.gov/library/publications/the-world-factbook/geos/sg.html >

DUVAL, E., 2000: *Kobus kob*, Animal Diversity Web [online], [cit. 16.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Kobus_kob.html. >

ELLIS, E., 1999: *Ceratotherium simum*, Animal Diversity Web [online], [cit. 21.4.2008], available from: http://animaldiversity.ummz.umich.edu/site/accounts /information/Ceratotherium_simum.html.

FAHEY, B., 1999: *Taurotragus oryx*, Animal Diversity Web, [online], [cit. 16.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Taurotragus_oryx.html. >

IUCN, 1998: African antelope database, IUCN/SSC Antelope Specialist Group Report

IUCN, 2007: 2007 IUCN Red List of Threatened Species, [cit. 23.4.2008], available from: <www.iucnredlist.org>

JACHMANN, H., 2002: Comparison of aerial counts with ground counts for large African herbivores, Journal of Applied Ecology 2002, 39, pages 841 – 852

KINGDON, J., 1997: The Kingdon Guide to African Mammals, A&C Black Publishers Ltd., London, 476 pp.

LAWESSON, J.E., 1995: Study of woody flora and vegetation in Senegal. Opera Botanica, 125, Kopenhagen, 172 pp.

LEGROS, M, 2004.: Réserve privée de Bandia (Sénégal), Analyse des possibilités d´introduction du zébre et du gnou: Diploma thesis, Haute Ecole Provinciale du Hainaut Occidental, 52 pp.

LUNDRIGAN,B., SANDERS, S., 2005: *Oryx gazella*, Animal Diversity Web[online],[cit. 19.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Oryx_gazella.html>

LUNDRIGAN,B., SPROULL, K., 2000: *Aepyceros melampus*, Animal Diversity Web [online],[cit. 20.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Aepyceros_melampus.html. >

MAISANO, S., Fraser, A, 2006: *Giraffa camelopardalis*, Animal Diversity Web [online] [cit. 21.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Giraffa_camelopardalis.html. >

MITUZANI, F., 1999: Biomass density of wild and domestic herbivores and caryying on working ranch in Laikipia District, Kenya, Afr. J. Ecol. 1999, Vol. 37, pages 226-240

NEWELL, T., 1999a: *Tragelaphus strepsiceros*, Animal Diversity Web [online], [cit. 18.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Tragelaphus_strepsiceros.html. >

NEWELL, T., 1999b: *Kobus ellipsiprymnus*, Animal Diversity Web [online], [cit. 20.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Kobus_ellipsiprymnus.html>

NEWELL, T., 2000: *Syncerus caffer*, Animal Diversity Web [online], [cit. 19.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/Syncerus_caffer.html.>

NEŽERKOVÁ, P.,VERNER P.H., ANTONÍNOVÁ M., 2004: The conservation programme of the Western giant eland (*Taurotragus derbianus derbianus*) in Senegal – Czech Aid Development Project, Gazella 31, Zoo Praha.

NORTON-GRIFFITHS, M., 1978: Counting animals, second edition, Handbooks on techniques currently used in African wildlife ecology 139pp, Handbook n°1. Page 139. African Wildlife Leadership Foundation., Nairobi

PRIMACK, R.B., 2000: A primer of Conservation Biology, Boston University, Sinauer, 319 pp.

ROE, B., 2002: *Hippotragus equinus*, Animal Diversity Web [online], [cit. 18.4.2008], available from: <http://animaldiversity.ummz.umich.edu/site/accounts/information/ Hippotragus_equinus.html. >

SCHOLTE, P., ADAM, S., SERGE, B.K., 2007: Population trends of antelopes in Waza National Park (Cameroon) from 1960 to 2001: the interacting effects of rainfall, flooding and human interventions, Journal compilation 2007 Blackwell Publishing Ltd, Afr. J. Ecol.

WILSON, D. E., REEDER, D. M. (eds)., 2005: Mammal Species of the World, Johns Hopkins University Press [online], 2,142 pp., available from: Johns Hopkins University Press,1-800-537-5487 or (410) 516-6900 <http://www.press.jhu.edu>

Annexes

Figure 1: Watering hole Point d´eau. Photo by D. Bada

Figure 2: Herd of impalas (*Aepyceros melampus).* Photo by D. Bada

Figure 3: Resting rhinoceroses (*Ceratotherium simum simum*). Photo by D. Bada

Figure 4: Herd of giraffes (*Ceratotheriu simum simum*). Photo by O. Scheuerová

Figure 5: Resting roan antelope (*Hippotragus equinus*). Photo by D. Bada

Figure 6: Waterbucks (*Kobus ellipsiprymnus ellipsiprymnus*) masked in dense vegetation. Photo by D. Bada

Figure 7: Kob male (*Kobus kob*). Photo by O. Scheuerová

Figure 8: Gemsboks (*Oryx gazella gazella*). Photo by D. Bada

Figure 9: African buffalos (*Synceros caffer*). Photo by O. Scheuerová

Figure 10: Eland male (*Taurotragus Oryx*). Photo by O. Scheuerová

Figure 11: Greater kudu (*Tragelaphus strepsiceros*). Photo by D. Bada

Figure 12: Dense vegetation in the old part of the reserve. Photo by O. Scheuerová

Figure 13: Position of the Bandia reserve

Figure 14: Baobabs (*Adansonia digitata)* in the Bandia reserve. Photo by D. Bada

Figure 16: Sparse vegetation in the south-eastern corner of the new part. Photo by O. Scheuerová

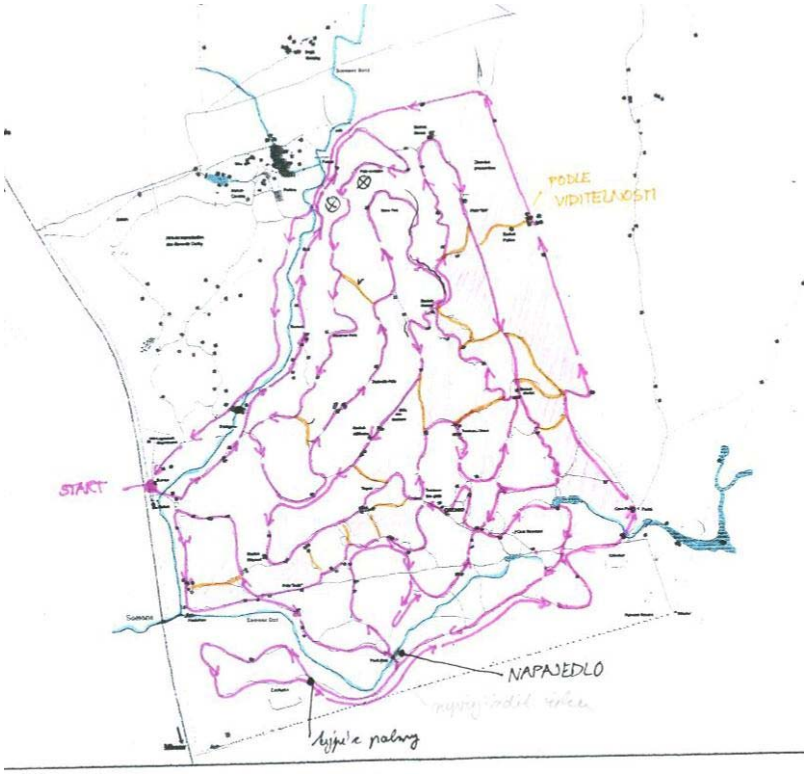

Figure 17: First planned track of going through the reserve

14 IC STARÁ ČÁST

Date: 21.6.07 Observer: Olga Scheuerová, Daniel Bada Timming: ODPOLEDNE 14:00 - 18:10

Page: 9/12 Observed from car Weather: JASNO, OPAR

GROUP					INDIVIDUAL					
N°g	time	g.s.	gen. activ.	ph.	N°i	species	sex	age	activity	note
001	14:11	1	SDN		1	KUDU	M	A	SDN	za plotem u dubíků
002	14:17	6	SDN, L		6	AL	2M	A		5m
003	14:21	1	SDN		1	ŽIRAFA	M	A		240° 60m
004	14:24	5	L, W		3	AK		A		240° 30m
					2	-11-		SA		
005	14:35	1	F		1	IMP	M	A		140° 10m
006	14:39	4	L		2	AK		A		10m
					1	-11-		Y		
007	14:40	4	L		2	AK		A		10m
					2	-11-		Y		
008	14:45	2	SDN		2	IMP	M	A		6m
009	14:52	3	L, SDN		3	AK				110° 60m
010	14:54	8	F		7	IMP	F	A		přes ulici
					1	-11-	M	A		
011	14:56	2	F		2	IMP	M	A		
012	14:57	3	F, W		2	IMP	F	A		250° 10m
[illegible]					1	-11-	M	A		
013	14:59	1	F		1	IMP	M	A		20m
014	15:01	3	W		3	AK		A		340m
015	15:05	1	L		1	KUDU	F	A		7m
016	15:07	1	SDN		2	AL	M	A		leží
017	15:12	1	F		1	AK				10m
018	15:14	2	F		2	IMP	F	A		290° 6m
019	15:15	1	F		1	KUDU	F	A(SA)		290° 7m
020	15:26	5	L		3	AK	F	A		250° 7m

Figure 18: Filled in printed form used for counting.