GAME RANCHING BEST PRACTICES FOR MOZAMBIQUE

Supporting the Policy Environment for Economic Development (SPEED+)

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ACRONYMS

AEC	Animal Ethics Committee
ANAC	National Conservation Areas Agency
CA	Conservation Areas
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
CoAE	Certificate of Adequate Enclosure
GIS	Geographic Information System
GPS	Global Positioning System
GRM	Government of the Republic of Mozambique
HCGW	Health Care General Waste
HCRW	Health Care Risk Waste
HCW	Health Care Waste
OIE	Office of International des Epizooties
SADC	Southern Africa Development Community

I. INTRODUCTION

Like its neighbours in the SADC region, Mozambique has the habitat and species presence that can support a robust game ranching sector - game ranching, when managed properly, provides the co-benefits of species conservation that supports livelihoods and nutrition (increasing available meat for protein) for surrounding communities. Economic activities of a game ranch include trophy hunting, safari tourism, and wild game meat production and processing. When situated adjacent to national conservation areas (CAs), game ranches can provide the service of restocking parks with critical species.

With these benefits in mind, ANAC seeks to formalize a game ranching regulation under Mozambique's landmark Conservation Law 5/2017 that clearly sets the enabling environment for interested private sector investors. This best practice guideline, for Mozambique, was adapted from the book *Game Ranch Management (6th Edition)*, whose co-author JG du Toit, is working under the SPEED+ program to guide the drafting of Mozambique's first Game Ranching Regulation.

Game ranching can be an attractive investment providing diverse income streams to the private sector, while also resulting in co-benefits to the natural habitat and communities. Studies demonstrate that the returns on game ranching far exceed those of cattle ranching and can positively contribute to the biodiversity of surrounding areas.

Economic Potential. Most species of wild ungulates have a high reproductive potential, grow more rapidly than their domesticated counterparts, can gain nutrients from broad range of vegetation, and are able to convert that vegetation into protein more efficiently than cattle. Fewer inputs are required for population growth and the time horizon for population growth is advantageous to investors designing a business plan around the income streams of meat production, wildlife tourism, and a limited number of trophy hunting licenses for popular range animals, such as the water buffalo. Studies indicate that per hectare of land, game ranching generates 2-3 times the financial returns as cattle.

Benefits to Habitat and Wildlife. Wild ungulates such as oryx, impala, wildebeest and eland require considerably less water than cattle, and in general wild animals are less dependent upon surface water for their survival. Since they can utilize semi-arid and arid range to obtain adequate hydration, wild ungulates are able to disperse over greater areas of land and thus avoid the overgrazing and consequent land deterioration characteristic of cattle farming. When game farms release a set percentage of their species population into nearby conservation areas, where hunting is prohibited, this restocking service can help park managers to support species that have been in decline due to poaching, disease, etc.

Benefits to Local Communities. Game farm investments often bring new infrastructure that communities can benefit from (roads, water service, electricity), as well as jobs in construction and longer-term positions in wildlife management and tourism related jobs including hospitality, guiding, and food production. Women are often seen as central to meat processing operations and often see increased income-generating opportunities, which, in turn, has positive effects on nutrition, food security, education, and health of entire families in communities near game farms. Communities can also rent their land to game ranchers in exchange for income and a percentage of the wildlife produced, providing them access to game meat for their own consumption.

In Mozambique, research and data on existing game ranch operations is sparse - it is thought that around twenty enterprises exist that produce either a mix of mammals or crocodiles (for meat and hides). Investors in the region have expressed interest in Mozambique for game ranching, however clarity in the regulatory environment is a critical next step to unlock this interest.

Mozambique's Conservation Law 5/2017 (Article 18 1.f and Article 24) provides a foundation for development of game farming for fresh/dried bush meat production and sport hunting activities, but regulations are required to define procedures for wildlife management, breeding in captivity, domestic trade in wildlife for game farms, and transportation and hunting of captive populations. With support from SPEED+, ANAC seeks to finalize a Game Ranch Regulation that focuses on herbivores such as kudu, impala or any other endemic species (endangered species, such as lions, will not be included in the regulation). It is recommended that only animals that occur naturally in Mozambique be introduced on game ranches; the focal game species are in **Table 1** below.

Table 1: Focus Game Ranch Species Endemic to Mozambique

Common Name	**Scientific Name**
Impala	*Aepyceros melampus*
Lichtenstein hartebeest	*Alcelaphus lichtensteinii*
Blue duiker	*Cephalophus natalensis*
Bluewildebeest	*Connochaetes taurinus*
Roan antelope	*Hippotragus equinus*
Sable antelope	*Hippotragus niger*
Waterbuck	*Kobus ellipsiprymnus*
Suni	*Neotragus moschatus*
Klipspringer	*Oreotragus oreotragus*
Oribi	*Ourebia ourebi*
Blue duiker	*Philantomba monticola*
Steenbok	*Raphicerus campestris*
Sharpe's grysbok	*Raphicerus sharpie*
Common reedbuck	*Redunca arundinum*
Mountain reedbuck	*Redunca fulvorufula*
Grey duiker	*Sylvicapra grimmia*
African buffalo	*Syncerus caffer*
Eland	*Taurotragus oryx*
Nyala	*Tragelaphus angasii*
Bushbuck	*Tragelaphus scriptus*
Greater kudu	*Taurotragus strepsiceros*
Giraffe	*Giraffa camelopardalis*
Warthog	*Phacochoerus africanus*

Contents of the Code of Best Practice

This report is written for an audience of wildlife managers and veterinarians who seek to operate game ranches in Mozambique. It is structured as follows:

I. Key Terms & Definitions
II. Game Ranch Management & Conservation
    a. Management Plans
    b. Monitoring Systems
    c. Physical Infrastructure
    d. Wildlife and Their Habitat
    e. Animal Selection
    f. Animal Census Methods
III. Animal Management & Veterinary Science
    a. The Wildlife Manager & Research
    b. The Wildlife Manager & Game Capture
    c. Holding Facilities
    d. Transporting Wild Animals
    e. Techniques Used the Manage Wild Animals
    f. Disease Management

All best practices consider Mozambique's commitments under the Convention of Biological Diversity (CBD), Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on Migratory Species (CMS), the World Heritage Convention (WHC), Convention on Wetlands of International Importance especially as Waterfowl Habitat (RAMSAR) and the World Organization for Animal Health (OIE).

I. KEY TERMS & DEFINITIONS

Wildlife Production Systems

Extensive wildlife production unit: a large fenced or unfenced, privately owned or communal area on which wildlife is extensively managed for the direct utilization of wildlife-related products, such as by hunting and live animal sales, and for indirect utilization such as ecotourism. Such an area is also commonly ***known as a wildlife ranch.***

Intensive wildlife production unit: a small, fenced area on which wild animals are managed intensively for the production and harvesting of marketable products, such as meat, hides, other products and live animals. Such an area is also ***commonly known as a wildlife farm.***

Wildlife Management Types

Active management: involves the manipulation of animals and their habitat. Active management should only be applied on a game ranch that has been fenced, meaning usually relatively small areas with intensive breeding programs. The managers that members will employ must have an in-depth knowledge of the area, the nature of management and the vision to make adaptations when new facts and trends emerge. Key aspects of the ecology of the animals and their habitat should therefore be constantly monitored so that trends will be noted in good time and management adjustments can be made accordingly.

Passive management: involves the prevention of any human influence.

Conservation Area Classification System in Mozambique

National Park

A *National Park* is a delimited total conservation area under the public domain of the State, destined for the propagation, protection, conservation, preservation and management of vegetal and animal wildlife, as well as for the protection of sites, landscapes or geological formations of particular scientific, cultural or aesthetic value in the interest of public recreation and representative of the national heritage.

Transfrontier Park

A *Transfrontier Park* is a protected area that crosses the international boundaries of two or more states. It is also known as an international peace park.

Integral Natural Reserve

An *Integral Natural Reserve* is a delimited total conservation area under the public domain of the State, destined to the preservation of nature, the maintenance of ecological processes, and the functioning of ecosystems and rare or endangered species.

Conservancy

A *Conservancy* is a conservation area that is legally owned and/or occupied by one or more landowners, but which is managed as an ecological unit to achieve a common conservation goal.

Natural Heritage Site

A *Natural Heritage Site* is an important large or small conservation area or site which is either owned privately, or by a corporation, a company or a government institution, and which is administered nationally under a relevant programme by the Department Environmental Affairs.

World Heritage Site

A *World Heritage Site* is an important international area or site, the importance of which is based on natural or cultural values.

Cultural and Natural Monument

The *Monuments* are total conservation areas under the public domain of the State, of a local authority, community or privately-owned, containing one or more elements with exceptional or unique natural, aesthetic, geological, religious, historical or cultural value in an area smaller than 100 hectares that because of its uniqueness and rarity requires to be preserved and maintained in its entirety.

Special Reserve

A *Special Reserve* is a delimited conservation area of sustainable use under the public domain of the State, destined for the protection of a rare, endemic, endangered or dwindling vegetal or animal species or of a species of recognised cultural or economic value.

Environmental Protection Area

An *Environmental Protection Area* is a delimited conservation area of sustainable use under the public domain of the State and managed in an integrated manner, where the interaction between human activity and nature shapes the landscape with specific and exceptional aesthetic, ecological or cultural qualities, producing important ecological services for its residents and their neighbours.

Official Game Reserve

An *Official Game Reserve* is a delimited conservation area of sustainable use under the public domain of the State, intended for hunting activities and the protection of species and ecosystems in which the right to hunt is only awarded through a concession contract between the State and an operator.

Community Conservation Area

A *Community Conservation Area* is a delimited conservation area of sustainable use under the public domain of a community and under the management of one or more local communities holding the right of use and enjoyment of the land, destined for the conservation of the flora and fauna and the sustainable use of its natural resources.

Sanctuary

A *Sanctuary* is an area under the public domain of the State or privately-owned, intended for the breeding, shelter, feeding and research of certain vegetal and animal species.

Wildlife Farm

A *Wildlife Farm* is a private area intended for the conservation of the fauna and flora in which the right to hunt is limited to the holder of the right of use and enjoyment of the land or to those duly authorised, all of them subject to a permit issued by the relevant authority.

Municipal Ecological Park

A *Municipal Ecological Park* is a conservation area of sustainable use under a municipal, public domain, intended for the conservation of sensitive ecosystems in the urban context.

Image 1: Zambian sable antelope

II. GAME RANCH MANAGEMENT & CONSERVATION

Investors interested in starting a game ranch must first acquire land of adequate size for aimed activity, within or outside the sustainable use conservation area, in accordance with the legal framework of Mozambique (Land Law and the Law of protection, conservation and sustainable use of biological diversity), subsequently must-assemble a management plan and a monitoring system to create the framework for operations. She must also align animal selection with the identified habitat and calculate stocking rates to ensure a proper balance of species in and around the managed property. To ensure access, appropriate fencing, and watering holes, an infrastructure plan is critical to the investment; likewise, taking accurate animal census on the ranch is important for population control and, when in a restocking agreement with park authorities, accounting for the number of species released into a conservation area. Best practices in each of these themes follows below.

A. MANAGEMENT PLANS

The management plan of the production unit (**game ranch**) is the product of a management process and broadly consists of the following series of steps, many of which can be carried out simultaneously:

- A comprehensive description of the ecosystem(s) involved.
- Determination of the available manpower, expertise and finances.
- Determination of land-use patterns in the surrounding areas.
- A definition of the permissible limits of any change.
- Prediction of future trends and the needs of the area and its users.
- The compilation of a timetable for implementing the management plan based on production principles.
- A description of all the realistic options that may exist for helping to achieve the manpower, finances and available expertise.
- A choice of preferred options and a description of the management plan based on production principles.
- A comprehensive monitoring plan for determining and limiting the impact of the production actions on the ecosystem.
- A constant re-evaluation and readjustment of the management plan and the set of new objectives to meet the production principles if necessary.

Management decisions for a natural area (**nature reserve**) include one or more of the following nine broad objectives:

- Total or ecosystem conservation.
- Conservation of natural plant and animal communities within demarcated limits.
- Conservation of specific landscape characteristics, such as a river valley or a mountain range.
- Conservation of rare plants or animals.
- Conservation of specific genetic characteristics and integrity.
- Conservation for utilization by man, but especially for recreation, education and research.
- Conservation of the catchment areas for erosion control and for the sustained production of fresh water.
- Conservation for the production of usable products such as venison and trophies.
- Conservation as a nature reserve for later decisions on the type of land use.

B. MONITORING SYSTEMS

There are two systems to be monitored; the ecological components of the individual game ranch and the collective monitoring of the wildlife industry (National database). The frequency of ecological monitoring depends on the rate of the ecological changes that are being measured, and the size of the area. Some aspects, such as the productivity of animals and rainfall, should be monitored annually while others may be measured over a longer interval. Although monitoring will take place every year, each facet will not necessarily be monitored each year. The ultimate aim of monitoring is the determination of useful trends. Monitoring is therefore often aimed at precise measurements that repeatedly give the same results, rather than accurate measurements.

Components to be Monitored

There are numerous components of the environment that can be measured on a game ranch of average size. Many of these, however, apply only to intensive ecological studies. For practical management purposes at least, the following components should be monitored regularly:

Rainfall

The long-term rainfall data would be obtained by the member from the closest official weather station to area for comparative purposes and for determining long-term trends. In addition, the rainfall received should be monitored daily if possible. The reliable standard rain gauge on a grid pattern of 2 × 2 km would be used, with one rain gauge in each block. The member will attempt to distribute the rain gauges that it will represent different habitat types on the ranch. Should daily measurements not be possible from a management point of view, a more expensive type of rain gauge, which collects rain over a period of days or weeks and stores it beneath an oil layer, can be used. Automatically recording rain gauges are also available. Rainfall figures over at least 20 years are needed to make reliable deductions for a specific area. The data recorded must be kept in a hardcover book.

Temperature

The occurrence of extremes such as the dates of the first frost, cold fronts, and the influence that it may have of plant and animal life.

Soil erosion

Soil erosion is influenced mainly by the vegetation cover, vegetation root structure, rainfall intensity, soil type and slope of the land. Erosion will be monitored using fixed-point photographs taken annually at the same time from the same point and in the same direction. This technique also applies to the rehabilitation of an area where soil erosion is controlled. The point of photography will be marked with a permanent marker or post and protected against larger animals such as elephant by placing rocks around the markers.

Habitat

The influence of the following on the habitat on at least the following would be monitored regularly:

- The veld condition in terms of composition of plant species, frequency of species, density and/or cover, and plant biomass production.
- Ecologic and economic grazing and browsing capacity for grazers, mixed feeders and browsers.
- The effects of fire.
- The effects of water provision.
- The effects of bush encroachment and its control.
- The effects of habitat reclamation measures, such as soil erosion control.

Vegetation

Fixed-point photography is an essential component of vegetation monitoring. By retaking a series of photographs from the same point at regular intervals, a visual record is obtained which can later be subjected to objective analysis. The advantages derived from fixed-point photographs include the following:

- They provide a rapid means for assessing short- and medium-term trends in the vegetation. Therefore, they can have a predictive value.
- They provide additional evidence for evaluating and interpreting the impact of various external influences on the vegetation, such as fire and elephant damage.
- The method is cheap, easily applicable and provides a permanent record for re-examination when required.

Fire

All areas that are burned should be recorded annually on a map of the ranch, together with the date and the reasons why the fire occurred. This is particularly important in the case of intense fires that occur after periods of high rainfall, and a high plant biomass accumulating during these periods. Aerial reconnaissance assists in the mapping of fires. When a burning program is used, a survey of the field condition and available fuel load of each habitat or plant community would be done before deciding which areas to burn. A disc pasture meter or a harvesting technique can be used to determine the fuel load in kilogram per hectare.

Animals

The seasonal distribution and numbers of animals should be recorded continually, and population growth rates calculated. Rare animal species will be counted accurately so that a record of all the individuals can be kept. The age and sex structure of the various herds and populations would be monitored annually to determine trends. Calving and lambing percentages would be recorded annually. The natural rate of mortality would also be determined annually, and the occurrence of and reason for any deaths should be recorded. The condition of all animals can be determined visually or by internal examination at the end of the wet and dry season.

Water

The quantity and quality of water provided must be monitored from boreholes that may contain toxic minerals for consumption. Monitoring the water quality will provide the information required by the member to manage the water sources utilized in an area. The information required includes knowledge of potential hazards, trends regarding aquifer recharge rates, deteriorating water quality, and possible pollution sources. Drastic changes in concentration can occur between seasons. Monitoring the water quality allows the members to allocate water during periods of poor quality to less sensitive population cohorts or species, and to make the best water available to the more valuable ones. Key watering points would be identified within a wildlife enterprise and be monitored on a quarterly basis. A full analysis, including a semi-quantitative scan, should be obtained from the nearest water laboratory.

National Databases – Collective Monitoring

The aim of sounds databases of wildlife information is:

- To collect reliable data for the management of wildlife populations on a National basis.
- To prevent disease outbreaks and disasters.
- To integrate and analyze data collectively on a National basis between different government databases.
- To assist with forensic investigations.
- To promote science – presentations to OIE and CITES are done on a sound scientific bases.

The fact that there are nine provinces that govern nature conservation that did not have a tool in place to coordinate the wildlife industry leads to fragmentation. Departments involved in wildlife management include veterinarians, rangers, and law enforcement - when spread over nine provinces gives a total of 27 bodies that must communicate with the private sector. The shortage of information because of fragmentation leads to following questions that must be answered on a National level to manage National assets:

- What is the size of land utilized by game ranching and wildlife reserves?
- What is the size of the different veld types utilized by game in Mozambique?
- What is the distribution of different game species (GIS) in Mozambique?
- What is the distribution of diseases (GIS) in Mozambique?
- What is the number of the different animal species in Mozambique?
- How many animals of which species are sold alive every year?
- How many animals of which species are hunted every year?
- How many domestic animals are in Mozambique and their distribution?
- Where is the contact zone between game and domestic animals in Mozambique?
- How many animals of which species are culled for meat every year?
- How many people (men and women) work in the game ranch industry?

The national database also creates a neutral instrument represented by government and the private sector. Key features include:

- Data on an integrated system available to all stakeholders.
- Standardized data available that could be used for research purposes.
- Avoid duplication and save money through innovative use of technology and self-administration.
- Such a database can be expanded to include domestic animals and identify important wildlife-livestock interfaces for risk of disease outbreaks.

C. PHYSICAL INFRASTRUCTURE

Traditional Fencing

Requirements

- The fence would be straight and vertical.
- All the straining posts would be firmly and vertically anchored.
- All the posts would extend to the same height above ground level by corresponding to the terrain form.
- The straining posts and droppers would not be too far apart - the closer the droppers are, the firmer the fence. However, the number of droppers been used influences the costs of a fence.

- Each wire strand would be firmly attached to the standards or line posts at a specific height above ground level and should be a certain distance apart from each other.
- The droppers would be neatly and evenly spaced between the standards. The wire strands should be firmly attached to maintain the proper space between the strands and to prevent vertical movement.
- Fences should never be constructed of inferior quality material.

Fence Height

The height of the fence on a game ranch depends on the type of animals kept. Wild animals can be grouped into various categories on the basis of their potential to move over, under or through fences. It should, however, be noted that most wild animals will only resort to crossing fences when they are under some kind of stress or duress. The following fence-crossing groups can be categorized as:

- **Animals that jump over fences:** Kudu, impala, mountain reedbuck, grey rhebok, eland and waterbuck.
- **Animals that crawl underneath or through fences:** Ungulates like the warthog, bushpig, duiker, steenbok, klipspringer, gemsbok, springbok, sable antelope, red hartebeest and tsessebe, and predators such as jackals, caracal, cheetah, leopard and lion.
- **Animals that break fences:** Buffalo, white and black rhinoceroses, giraffe and waterbuck, and also eland, blue wildebeest and sable antelope bulls.
- **Animals that usually do not jump over fences:** Springbok, blesbok, steenbok, duiker and oribi.

Animals that jump fences can be fenced in effectively by erecting a 2.25 to 2.4 m high fence consisting of 17 to 21 strands of wire. In areas where there are no animals that dig holes underneath fences, such as warthogs, it may be advantageous to attach diamond, pig or jackal wire mesh or netting to the bottom section of the fence. This may prevent stray dogs or predators from moving freely through the fence. A standard 1.5 m wire mesh fence with a strand of wire 150 mm above the mesh and another one 150 mm above this, should keep most non-jumping animals within the ranch.

Electric Fencing

Requirements

To be effective, an electrified fence should meet at least the following requirements:

- The fence should be planned and designed for the specific animal species that it must control.
- Therefore, the power of the energizer and the placement of the wire strands and other posts should be suitable for the target animal species.
- The cost of the fence should be as low as possible, but inferior quality material should not be used.
- The fence should be neat and permanent and require minimum maintenance. It should allow faults to be traced as quickly as possible.
- The after-sales service by the manufacturers should be of a high standard.
- The fence should be safe for contact by humans.

Electric Fence design for Animals

The design of an electrified game ranch fence is determined mainly by the size of the ranch and the types of animal that are to be controlled by the fence. A powerful energizer is used when dealing with

large animals. The more powerful the shock, the sooner the animal will learn to respect the fence. Do not try to improve on long-distance records in terms of the energizer and the length of fence that it supplies with power. One energizer for a maximum of 10 km of fencing should be used. This will ensure a powerful and reliable power supply at all times, and an effective electrified fence.

Some animals have the capacity to cover long distances, while others keep to a more limited range. The size of the range is often determined by the availability of water and food. When fences are erected in wilderness areas, they may cut off migration routes or cut across the ranges of certain animals. Animals will then tend to test certain parts of the fence regularly. Therefore, it is desirable to have a minimum of 4000 volts available at all points for effective control. For elephants a minimum of 6000 volts is an absolute requirement.

The position of the wire strands depends on which animals are to be controlled by the fence. In the Lowveld it is recommended that an electrified fence be combined with a conventional wire fence of 2.4 m with 17 strands. A conventional electrified fence consists of three wire strands, but the position of the strands depends on the types of animal that have to be controlled.

The following rule can be applied as a general guideline: When an animal is shocked in front of the shoulders it will move backwards, but when it is shocked behind the shoulders it will move forwards. Therefore, an electrified wire strand should be placed at nose height of the target animal(s). For some animals an additional single electrified wire strand can be placed some 150 mm above the ground level and 500 mm away from the rest of the fence, whether it is electrified or of wire. It will be sufficient to deter most movements through the fence. This additional electrified wire strand is affixed with insulators to iron droppers that are cut short and hammered into the ground.

As most animals move rapidly, it is important that all fences on a game ranch are visible and resilient. This can be achieved as follows:

- Use a wire strand thickness of at least 2.5 mm.
- Improve visibility by attaching strange objects such as tin cans or pieces of sheet material to the fence in such a way that they do not short-circuit the system.
- Achieve resilience by using high-tensile steel wire strands in sections of no longer than 500 m.

Ecological Principles to Consider When Erecting Fences

- Plan the fence that it does not cut off the migration routes of animals, especially when bordering a river – split the river boundary with the neighboring ranch.
- Try to avoid cutting off big trees to achieve a straight fence.
- Cattle fences in the ranch/reserve must be removed to avoid giraffe calves getting entangled.
- The lower strand of electrified fences electrocutes small mammals, such as the pangolin.
- Fences limit the flow of genetic material between free-living populations.
- Fence material can be used by poachers to set snares.

Image 2: Rinderpest fence in 1900's in Tanzania to prevent cattle and wildlife contact

Water Provisioning

Requirements for an Ideal Watering Hole

The design and location of a waterhole are as important as the provision of the water itself and the following requirements apply:

- Sufficient water should be economically exploitable.
- The design should satisfy the drinking preferences of different animal species.
- The water supply should be controllable so that it can be opened or closed to encourage animals to utilize other areas of the ranch with an alternative water supply.
- The design should limit losses if competition for water occurs between different animal species.
- The distance between adjacent waterholes should be considered so as to limit over- or under-grazing.
- The water supply should be permanent and reliable, especially during times of drought.
- There should be sufficient shade in the area around the waterhole where those animals that require it can rest after drinking.
- The waterhole should be constructed in such a manner that it allows maximum game-viewing, coupled with minimum disturbance to animal movements by tourists.
- Waterholes should not be placed on watersheds or on highly erodible soils because this encourages soil erosion.
- Waterholes should be designed in such a way that they provide minimum cover for predators.
- The water quality should be suitable. For example, high salt concentrations have a detrimental effect on the nutritional metabolism of most ungulates.
- The waterhole should look as natural as possible.

Placing Waterholes

With the exception of storage dams, all waterholes should be constructed on level areas. The maximum slope allowed on a site is 5 degrees. When this gradient is exceeded, erosion and trampling may follow. Clay soils will limit the loss of water by drainage from natural pans. When possible, no waterhole should be placed in sweet veld areas, particularly on or near brackish areas where the naturally sparse grass cover increases the danger of trampling and erosion.

Busy roads and rest camps may have a disturbing effect on animals. Waterholes should preferably be constructed at least 100 m away and upwind from such places. When an observation point is

constructed at a waterhole, a screened walkway of at least 100 m from the parking area to the observation point is needed so as to limit disturbance by the visitors.

When too many animals drink from a trough, a second one may be constructed 40 to 100 m away. The movement patterns of animals lead to excessive veld utilization in a given area defined by the maximum critical distance that a given species will move away from the nearest water. Waterholes that are too far apart may result in gaps of unutilized veld, whereas waterholes that are too close to each other may cause severe overutilization and trampling of the veld. The nature of the veld and the animal species involved will serve as guidelines for the correct placement of waterholes.

In the Lowveld the badly disturbed area around waterholes generally does not extend beyond 300 m away from the waterhole. This disturbed area usually has high animal concentrations. Grazing around artificial waterholes is not affected more than that around natural waterholes. For animals such as the roan and sable antelope, which prefer tall grass areas in the Lowveld as a habitat, it is desirable to place waterholes in such a way that at least certain grazing areas in large ranches or conservancies are further than 10 km from the water. A group of waterholes in an area of up to 20 km2, placed in a radius of 500 m and alternated with a 20 km2 waterless area whenever this is possible, is optimal for wild herbivore species diversity in the Lowveld.

Control of Grazing, Diseases and Parasites at Watering Holes

During the winter, animals congregate in greater numbers around drinking places, creating ideal conditions for the spread of contagious diseases. Diseases that are spread by water include rabies, anthrax, foot-rot and parasitic infections. Owing to the concentration of animals' large numbers of parasite eggs are left behind in the feces and they hatch after the first spring rains. However, many of the larvae die before finding a suitable animal host. In practice it is difficult to treat the diseases that affect wild animals. Once a disease has broken out at a waterhole, the area should be fenced off. The waterholes surrounding the infected area are then drained to form a safe and waterless zone free of parasite host species. In this way the disease may be isolated effectively.

The most notable causes of local over- and under-grazing are ineffective water provision and control, and the injudicious use of fire. The available quantity of winter grazing in the immediate area surrounding a waterhole determines the population density of the herbivores around it, while the distribution of permanent waterholes in a particular veld type will partly determine the grazing or browsing capacity of that veld. Controlled closing and opening of waterholes, in combination with a burning program, can be used to encourage the movement of wild herbivores.

Ecological Aspects to Consider with Watering Holes

- Waterholes play an important role in regulating animal behavior and they influence the functioning of ecosystems.
- Most conflicts between different species and between members of the same species occur when waterholes, water supplies or drinking space are limited. Aggressive animals such as the elephant, rhinoceros and buffalo have been known to injure and even kill each other or other animals at waterholes.
- The number and location of waterholes may control animal populations to some degree, but the opposite is also true.

- Mortalities and injuries may result from the congregation of animals at a waterhole during peak drinking times when limited drinking space is available. Young animals may also fall into troughs and drown. Giraffe may slip on wet or smooth cement slabs and break their legs.
- Waterholes are focal points for animals in the dry season, and predators will lie in wait at such strategic places to obtain their prey more easily.
- Diseases such as anthrax are spread by animals that contaminate waterholes after scavenging from diseased carcasses. Vultures, in particular, bathe in shallow waterholes. Consequently, when they have fed on the carcass of an animal that died of anthrax, they will contaminate the waterhole.
- High concentrations of salt in the drinking water may lead to chronic kidney damage. When animals in such areas are herded for capture, capture myopathy occurs more easily. A high fluorine content in boreholes north of Pretoria has also led to fractured legs in young buffalo bulls.
- Veld pans fulfill a thermoregulatory function for animals such as the elephant, warthog and buffalo, which enjoy rolling in mud. Mud pans that form as a result of such wallowing may increase in size with time and serve as temporary waterholes in the rainy season, easing the grazing pressure around the permanent waterholes.
- The incorrect location or placement of waterholes can result in either over- or under-utilization of grazing areas. This may lead to management problems such as erosion and bush encroachment. Another problem is a species-specific effect that could lead to undesirable ecological results. For example, when new waterholes were opened up in parts of the prime roan antelope habitat in the Kruger National Park, it also opened up those areas to large herds of plains ungulates like the zebra and blue wildebeest. Roan antelope are shy animals and will not drink in the presence of other animals. In this case, the new waterholes probably contributed to a decline in the roan antelope population. Closing such waterholes therefore yields better ecological results than establishing them.

Image 3: Natural pan in Etosha National Park

Roads

A road is a disturbance of the natural environment. On a game ranch, roads should therefore be positioned with care, with the effect and primary goal of each road being considered carefully. There are three types of roads on a game ranch:

Tourist roads aim to provide the tourist with the opportunity for viewing and experiencing the scenery and other natural resources on the game ranch. These roads should never include long straight stretches but should preferably twist through the bush along a contour line or an ecotone. An ecotone is a zone of transition between two types of vegetation. The ideal road for game-viewing will follow an ecotone, be situated in open veld types and be about 100 m from the border of more dense areas. Tourist roads usually link waterholes, traverse as many veld types as possible, and are also used for patrolling and for capturing animals.

Firebreak roads should be wide enough - at least 8m wide - to prevent accidental fires from crossing them. They should be planned and built in such a way that they separate the major veld types on the ranch. This will enable the game rancher to combine veld management with a burning program. A firebreak road can also serve as a tourist road or vice versa, as long as the road complies with the necessary specifications.

Hunting roads are often twisting, dual-track roads. They should be easily negotiable while disturbing the veld as little as possible. Hunting roads should enable the hunter or cropping team to deliver any hunted or captured animal to the skinning or holding facilities with the minimum delay. Hunting roads are usually used mainly during the hunting season.

Ecological Effects

Depending on their construction and location, roads can have various ecological effects on a game ranch. The following are some examples:

- Construction work destroys plants, especially trees, and small animals.
- Poorly planned roads may create erosion problems and lead to habitat deterioration.
- Firebreaks are escape routes for most animals during veld fires.
- Roads are used by animals as routes between watering points and grazing areas.
- Animals such as the impala and blue wildebeest sleep on roads during rainy or moonless nights, especially in areas where predators occur.
- Culverts or storm water drains serve as burrows for warthogs, jackals and spotted hyenas.
- Baboons and monkeys learn to beg along roadsides when fed by tourists. Pioneer plants along roads attract hares and steenbok.
- Snakes bask in the sun on roads when the daytime temperature is low ground-nesting birds often breed next to roads.
- Tarred road surfaces become smooth with time and animals running across such a road may slip and injure themselves.
- Nocturnal animals are blinded by vehicle headlights at night and may be run over.
- Quarries near roads provide water for animals out of season, which can lead to over-utilization of certain areas. These quarries can also become a source of disease, such as anthrax in the Etosha National Park.
- Roads affect the movement of skittish animals such as the sable antelope and eland. This can prevent such animals from reaching vital feeding and breeding areas.

- Excessive water run-off creates vegetation thicket galleries next to roads, which can reduce the available grazing and be detrimental to tourism because it limited visibility.

Image 4: Tourist road in Kruger National Park

D. WILDLIFE AND THEIR HABITAT

Land Carrying Capacity

The ability of a game rancher to apply wildlife management principles depends directly on the knowledge available to him. In the same way, browsing and grazing have their own links of knowledge that have to be considered before approximations of grazing and browsing capacity can be made. Factors such as range use, adequate shelter for the young, climate, predators, feeding habits, availability of water, fencing, herd composition and disturbances all influence the normal feeding and reproduction of wild animals.

"Grazing capacity" and "browsing capacity" are terms that were derived from the field of veld management. More specifically, these terms describe the number of animals that the veld can support at maximum constant tempo of production. Such a definition makes allowance for the fact that the veld can carry more unproductive than productive animals. Grazing and browsing capacity may therefore be expressed as the number of grazing or browsing animals that can be supported by a given habitat. Provision is also made for a specific, but not progressively increasing, impact on the natural plant resources by these herbivores.

Ideal grazing and browsing capacities rest on balance between plant and animal production. Because plant communities consist of diverse plant species, and domestic animals do not use all the plant species that are available to them, it follows that wild herbivores with their utilization of a greater diversity of species are capable of more thorough plant resource utilization than domestic herbivores. A wide variety of factors and variables are involved in the estimation of grazing and browsing capacity. These factors are the reaction of the veld to use pressure, the fact that grazing capacity and browsing capacity fluctuate seasonally, and predictions of the effect of the current biological and climatological conditions on the future veld condition all make it difficult to determine grazing or browsing capacity exactly.

To determine the grazing or browsing capacity of an area for a variety of herbivores, three main nutritional approaches can be followed. These approaches are the estimate method, energy method and the large animal unit method.

When calculating stocking rates, it should always be remembered that nature is so dynamic and reacts to so many factors, that no simple stocking rate of animals per hectare can be given for different animals on all the possible habitats that they will use. Therefore, the ecological condition of a specific habitat type should be monitored continually to check and adapt the stocking rates on a game ranch based on active, adaptive wildlife management. Only the nutritional aspects of stocking rate calculation will now be discussed briefly.

Carrying Capacity and Stocking Rate in Relation to Large Animal Units

One of the basic questions relating to game ranch management is how many animals of what species the veld can carry. Although the concept of an ecological capacity for a given piece of land is a nebulous one, the rancher needs to have some guidelines on how to stock a given game ranch.

The stocking rate refers to the number of animals or animal units that the game ranch manager allots to a specific surface unit of land for a specified period (usually a year), so that the most beneficial

return will occur in terms of a given management objective. The stocking rate is therefore given as animal units per hectare per year. The stocking rate is generally accepted as one of the most important factors affecting animal production and veld condition. Therefore, it should be conservative to cope with the variable and inconsistent rainfall and the consequent variable range quality and quantity during the dry season, which is characteristic of most savannas of southern Africa.

The grazing capacity or grazer stocking density of the veld is related to the productivity of the grazeable vegetation. This productivity potential is expressed as the area of grazing land required to maintain a specified animal unit in a good condition over an extended number of years without deterioration of the grazing or the soil. It is designated either as the number of animal units per hectare, or as hectares per animal unit. The method uses the metabolizable energy requirements of the specific type of animal and its probable food intake. Comparisons are then generated and expressed as large animal units. Large animal unit equivalents or replacement values are calculated by using the metabolic weight (W0.75) and a reference norm of a steer weighing 450 kg.

The difference between stocking rate and grazing capacity is that the former is a production decision whereas the latter is a habitat characteristic. Therefore, grazing capacity is primarily a function of the vegetation condition, whereas the stocking rate is the range manager's estimate of which land-to-animal relationship will be the most beneficial. Although grazing capacity norms are usually laid down for the long term, the production and grazing capacity of the veld varies over the short term between years and even between seasons in the same year. Nevertheless, it is possible (and wise) to adjust the animal numbers in a given area to the seasonal variation in the available grazing through an active, adaptive management approach.

For each type of animal in a given grazing area there is a certain maximum sustainable stocking rate that may vary according to fluctuations in the environmental conditions. At low stocking rates, animal production per hectare is also low but it increases with an increase in stocking rate until it reaches a maximum. After reaching the maximum, the animal performance decreases to zero as the stocking rate increases. Conversely, at a low stocking rate the production per animal unit is maximal but, after reaching the point where competition for forage starts to occur, the production per animal unit decreases to zero. The optimal stocking rate depends on the aims of management. For example, when quality is desired, such as for trophy hunting, a low stocking rate should be maintained because it yields maximum production per animal. However, to produce a large quantity of a product such as venison, the stocking rate should be increased to yield the maximum production per hectare. When animal production is not a priority, but the population size is important to allow good hunting for venison (sport hunting) and game viewing, then the stocking rate should be increased towards that of the ecological capacity. This stocking rate is higher than that used for venison production.

In practice, it is commonly found that game ranch managers overestimate the grazing capacity of a ranch. This causes a situation where periodic droughts cannot be bridged, and consequently, the veld condition deteriorates because of continual overgrazing. It is conservatively recommended that the grazing capacity on a single-camp game ranch should be 20 to 30% lower than that for livestock. This is so mainly because wild herbivores cannot be manipulated as easily as livestock. Therefore, rotational grazing usually cannot be done with wild herbivores, resulting in continuous grazing pressure.

Calculating Stocking Rates

The calculation of grazing capacity is based on the conversion of animal species to metabolic weight

equivalents. This method assumes a homogeneous system that tends to some point of equilibrium or stable state, and a land-use objective of maximal animal production. Different equations have been proposed to calculate the grazing capacity of an area. Some are based on the weight of an animal only and do not consider its feeding habits. However, by combining the ecological index value, grass production or cover, rainfall, incidence of fire, accessibility of the terrain, and feeding habits and social behavior of the herbivores involved, it is possible to calculate a more reliable and scientific grazing capacity for a particular plant community on a game ranch. This grazing capacity value is useful for management purposes. The following methods can be used to calculate short- and long-term estimates of the grazing capacity from vegetation analysis data in the savanna regions of southern Africa.

Rainfall Method

This method was developed by Coe during 1976. It is based on a significant relationship between rainfall in a range from 165 to 650 mm and large herbivore biomass in a range from 405 to 4848 kg/km2. The equation was calculated for wildlife areas that receive less than 700 mm of rain annually. The formula can be used to calculate the carrying capacity of larger areas by using the average rainfall of the area;

Log Biomass (kg) Large Herbivores = 1,685 × log Average Rainfall (mm) – 1,098

The herbivore biomass data used included animal counts from eastern and southern Africa that were done on a wide range of the most common large African grazers and browsers. The wild herbivore biomass estimates were obtained by using the above equation and are a first approximation of the ecological capacity of an area for herbivores. It includes both grazers and browsers. A major deficiency of this approach is that the broad relationship between biomass and rainfall does not take local temporal and spatial variations in the habitats into consideration. Furthermore, the model was based on animal numbers obtained by using a wide variety of counting methods. Therefore, they are not really comparable.

Example: Calculating the Carrying Capacity for a ranch with an annual average rainfall of 550 mm.
Carrying Capacity = Large herbivore biomass in kg/km2
= 1.685 × log (mean annual rainfall) mm – 1.098
= [1.685 × log (550 mm)] – 1.098
= 3.520 [antilog]
= 3 308 kg/100 ha [1 km2 = 100 ha]
= 33.08 kg/ha [1 large animal unit = 450 kg]
= 13.6 ha/Large Animal Unit

Large Animal Unit Approach

The grazing capacity of a specified area for domestic herbivores is given either in large animal units per hectare or in hectares per large animal unit. The use of the former is recommended because it shows a linear relationship with a change in animal numbers. In contrast, the hectares needed per large animal unit are not related linearly to the number of animal units on an area of land. Another method of expressing an animal stocking rate is to use animal biomass or kilogram of biomass per hectare (kg/ha). Here one large animal unit is regarded as a steer of 450 kg whose weight increases by 500 g per day on veld with a mean energy digestibility of 55%.

Table 2: Conversion factors to convert large animal units to wild herbivore numbers

Common Name	Scientific Name	Number wild herbivore/LAU
Impala	*Aepyceros melampus*	6.03
Lichtenstein hartebeest	*Alcelaphus lichtensteinii*	2.5
Bluewildebeest	*Connochaetes taurinus*	1.99
Roan antelope	*Hippotragus equinus*	1.65
Sable antelope	*Hippotragus niger*	1.65
Waterbuck	*Kobus ellipsiprymnus*	1.8
Klipspringer	*Oreotragus oreotragus*	14.27
Oribi	*Ourebia ourebi*	13.5
Steenbok	*Raphicerus campestris*	17.37
Common reedbuck	*Redunca arundinum*	4.84
Burchell's zebra	*Zebra burchellii*	1.51
Grey duiker	*Sylvicapra grimmia*	10.74
African buffalo	*Syncerus caffer*	0.9
Eland	*Taurotragus oryx*	0.98
Nyala	*Tragelaphus angasii*	3.91
Bushbuck	*Tragelaphus scriptus*	7.62
Greater kudu	*Taurotragus strepsiceros*	2.4
Giraffe	*Giraffa camelopardalis*	0.63
Warthog	*Phacochoerus africanus*	4.71

They are based on the metabolizable energy requirements and probable food intake of the animals, and conversions are then made to large animal units. For example, a conversion value of 6.03 impalas is given in some tables as the equivalent of one large animal unit. When the agricultural grazing capacity of a given area is 8 ha per large animal unit, it means that the area can carry 75 impalas on every 100 ha of land. The stocking rate for each of the other wild animals is then calculated on the same basis. These conversion factors do not, however, take the following differences into account: the feeding and habitat preferences of the different wild herbivores; diversity in the vegetation types, their condition and production; availability and quality of the browse and grazing, social behavior; and accessibility of the terrain. These factors should therefore be used with great circumspection. ***They can never be more than a broad, general guideline.*** Nevertheless, it is a practical way of comparing the different habitat types on a game ranch to obtain a broad index of its potential ecological capacity.

Veld Types & Grazing

Veld Types and their Nutritional Value

One of the aspects of natural grazing that influences the condition of herbivores is the nutritional value of the veld during different seasons of the year. From a grazing point of view, the vegetation or habitat types in the grasslands and savannas of southern Africa can be classified broadly as sweet veld, mixed veld or sour veld.

Sweet veld occurs in the lower-lying, semi-arid savannas that receive from 200 to 500 mm of rain per year. This type of veld is usually associated with more clayey soils with a high base status. Species of the genus Acacia (Vachellia) are dominant in the woody layer of the vegetation. In this type of veld, the dominant grazing plants maintain their palatability and nutritional value throughout the year and

for their entire life cycle. These plants can be utilized throughout the year and the animals on veld of this kind remain in a good condition and reproductive state. Only a minimal translocation of nutrients from the leaves to the roots occurs during the winter.

Sour veld occurs in the high-lying and usually montane regions of southern Africa where the rainfall is 650 mm per year or higher. This type of veld is usually associated with well-drained, sandy soils with a low base status. Tall grasslands or broadleaf savannas dominated by species of the genus Combretum are typical of sour veld. In this type of veld, the dominant grazing plants lose their palatability and nutritional value at maturity. A translocation of nutrients to the roots occurs towards the end of the growing season, usually late in the summer and in the autumn. Sour veld is thus palatable and nutritious only during the growing season. Therefore, it can maintain animals in a good condition and reproductive state only for about six to eight months of the year. Because of the high rainfall and consequent leaching of the soils in the sour veld regions, the soil pH is lower than in the sweet veld regions. Moreover, protein, calcium and phosphate deficiencies often occur in the grasses of the sour veld. A phosphate supplement is therefore essential for animals in these regions, although wild herbivores tend to survive successfully in sour veld areas through their ability to utilize natural licks and their selection of plant parts that are high in nutritional value.

Mixed veld usually occurs in the transitional area between the sweet and sour veld. It is suitable for grazing for periods of six to ten months of the year. Knowledge of seasonal changes in the nutritional value of grazing is important when determining the suitability and grazing capacity of a specific area for wild herbivores. The nutritional value of grazing depends on the degree to which the animal eats the plant material voluntarily, and the efficiency with which these nutrients are utilized. A characteristic of savanna vegetation of great significance to game ranching is the natural variation in the phenology of various woody and grass plant species. Woody species generally break vegetative dormancy well in advance of the grasses. In southern Africa, the flush of woody species begins in August, some two months before the rains set in. This early flush provides an invaluable, high source of protein food during that time of the year when grass quality is a limiting factor in sustaining the proper herbivore biomass. In contrast to other areas, however, the availability of browse in mopane veld is at its lowest from September to November.

The nutritional value of grass species in sour veld is maximal in the early growing stages. Although the quantity of food increases as the season progresses, its quality decreases towards the end of the growing season. The nutritional value of the leaves of shrubs and trees is also highest in the early growth stages, but the rate at which the quality decreases thereafter is not as rapid as in some grass species. The crude protein content of the leaves of trees and shrubs is higher than in grasses, especially towards the end of the growing season. The new growth of shrubs and trees has a crude protein content of 12 to 20% on a dry weight basis, and 7 to 14% towards the end of the growing season. For example, the mopane tree has the following growth stage-related values for crude protein: budding young leaves: 13.3%; young green leaves: 17.6%; mature green leaves: 9.7%; and senescent leaves: 3.6%. The crude protein content of grasses varies from 12 to 15% at the beginning of the growing season, to 3 to 6% at the end of it. Twigs and bark are also often utilized by herbivores. They have a crude protein content varying from 4 to 8%. Wild flowers and fruit, such as the pods of species of the genus Acacia, have a crude protein content of 11 to 18%.

The decrease in the nutritional value of sour veld grazing as the summer progresses is associated with a concurrent decrease in the physical condition of the animals on a game ranch. The main objective of

supplementary winter and spring feeding is to remedy the deficiencies and to stimulate the appetite of the grazing animal to increase its utilization of natural veld. Appetite-stimulating licks with urea or protein bases are preferred to supplementary energy-rich feeds. The licks must not contain more than 5% urea for wild herbivores. As grass species in the sweet veld areas largely retain their palatability and nutritional value throughout the year, nutrient deficiencies are not as pronounced in sweet veld areas as in the sour veld ones. Browse food such as leaves, and fruits also have a higher and less variable protein content than grasses, therefore they are an important food source in the savannas.

Grazing can take one of three basic forms: continuous grazing, rotational grazing and zero grazing. Most of our current knowledge on the different grazing systems applies to livestock. Moreover, it is not always directly applicable to wild animal production systems because wild herbivores cannot be manipulated easily. Therefore, a whole spectrum of wild herbivores with different feeding habits will occur together on a game ranch in what is essentially a single-camp system. However, it is still necessary to indicate briefly the most important differences between the three basic grazing systems, especially when wild and domestic herbivores are being kept together.

Veld Utilization Systems

Continuous grazing

In a continuous grazing system, the animals are kept in one camp, or on a single-camp game ranch for at least a full, uninterrupted year. High stocking rates in sour veld will result in an increase in sour and unpalatable grass species. On mixed veld high stocking rates will cause regional selection and an invasion by weeds and toxic plants, with subsequent veld deterioration in the heavily used areas. On sweet veld retrogressive succession will occur, followed by soil erosion. The problem with continuous grazing systems is their inability to adapt to varying climatic conditions. When combined with rotational grazing, a continuous light grazing pressure, or a stocking rate that varies depending on plant production and climatic conditions, is apparently the only way in which to maintain the veld in a reasonable condition under a continuous grazing system. There is no reason yet to believe that wild herbivores graze differently from or less destructively than domestic ones.

Rotational grazing

Some form of rotational grazing is actually promoted on game ranches where a continuous grazing system is in operation. The use of burns, licks and water to induce the animals on a game ranch to move about contributes to a more even utilization of the different vegetation types by minimizing area or patch selection. In a single-camp system, a better dispersion of wild herbivores can be partially accomplished in the following ways:

- Burning sections of a game ranch, especially in the mixed veld and sour veld areas, is one of the most effective methods of encouraging some form of slow annual rotational grazing and of attracting animals away from any localized sweet veld areas. The frequency of burning will depend on the rainfall received, the accumulation of fuel and the degree of utilization by the grazers. Over-utilization of the burned areas must be prevented by ensuring that the surface area that is burned is large enough to exceed the short-term forage requirements of the wild herbivores that will be attracted to it, so that no over-utilization of the veld occurs. A well-planned mosaic of veld that is burned in rotation generally yields the best results.

- Using salt and other licks, especially in the dry season, will encourage rotational grazing. However, these licks should not be placed in the sweet veld areas or in areas with soils that are susceptible to erosion.
- Planting pastures may ease the grazing pressure on over-utilized veld.
- Closing certain waterholes on large game ranches or in large conservation areas may accomplish some form of rotational grazing. However, this is effective only for water- dependent animals occurring on large tracts of land.
- Allowing the natural migration of wild herbivores plays a limited role in fenced game ranches because most of these ranches are comparatively small. Nevertheless, it can play a role in large conservancies.
- Wild herbivores can sometimes be herded from one camp to another by helicopter, ground vehicles or men on horseback or on foot. On a game ranch in the grasslands of the Free State, wild herbivores have been rotated successfully between three camps by six to seven men forming a line and calmly herding the animals from one camp to another. However, the animals were not moved during the mating or lambing season, and all the gates in the fences were opened three weeks before the move.

The movement of animals from one camp to another can also be done with the passive system. The animals are allowed to drink water undisturbed in a central camp of approximately 20 ha. Salt licks can help lure the animals to the waterhole.

A form of intermittent grazing of natural veld is recommended for the following reasons:
- The frequency of grazing of the preferred food plants is controlled. A camp system ensures a degree of control over the quality of the grazing and allows a recovery period for the plants to complete their essential physiological growth and reproductive processes.
- The intensity of the grazing of the preferred food plants is controlled by regulating the number of animals and their period of occupation of a given area.

Studies comparing continuous and rotational grazing by livestock, and multi-camp with few-camp systems, have shown that the difference in defoliation patterns is minor. Continuous grazing therefore did not cause the expected frequent severe defoliation of the preferred food plant species. Moreover, individual animal production performance under continuous grazing is as high, or higher, than with rotational grazing. These results indicate that the manipulation of defoliation patterns by rotational grazing is limited unless the overall grazing intensity is raised to the point where animal performance is affected adversely. Although there is little economic or ecological justification for applying multi-camp grazing systems, the importance of long periods of rest for the veld would nevertheless suggest an advantage in using some form of camp grazing system.

Resting

The policy of resting a camp for at least a full growing season is primarily aimed at giving the plants a chance to produce and disperse seed, allowing new plants and seedlings to establish themselves, promoting plant vigour and an abundant food supply, and ensuring a dense vegetation cover to protect the soil. The duration and frequency of the rest period depend on the vegetation type, rainfall and veld condition. The sensitivity of the vegetation to severe grazing depends on both the season and the growth stage of the plants. The grazing of young plants in the spring retards the growth process and weakens the root system. Excessive and regular defoliation deplete the nutrient reserves of a plant, retard the root growth, and increase drought sensitivity in plants. A rest period in the spring is also

necessary for the plants to germinate and establish themselves. Therefore, sufficient growth must be allowed to take place in the spring before the plants are allowed to be grazed.

During the summer, when the growth and reproductive activities of grasses reach a peak, severe grazing can be detrimental to forage production and to flower and seed formation. During the autumn, a translocation of nutrients to the roots of grass plants occurs. Grazing then will inhibit this process and lead to a weakening of the root system. It is therefore essential that there are sufficient leaves on the plants during the summer and the autumn to build up adequate nutrient reserves for the following growing season¬ in the spring. It is usually accepted that grazing during the winter after the grasses have become dormant will not do them much harm.

Zero grazing

Zero grazing refers to feeding animals in enclosures or bomas where the animals never have access to natural grazing, such as when wild herbivores are kept in a boma to prepare them for auction. On game ranches where wild animals are husbanded extensively, this option is not relevant. In intensive game ranching practices, however, it is highly relevant.

Selective use

Selective use and over-utilization are the two most important causes of deterioration of the natural veld. Selective use occurs because certain animals prefer specific plant species, vegetation strata or feeding areas. Eventually they over-utilize and trample these plants or patches as a result of their feeding preferences and habits, the differences in the palatability of the plants and the effect of veld management practices. In a continuous grazing system such as that found on most game ranches, the grazing capacity has to be adjusted to the production capacity of the preferred grazing areas. If this is not done, overgrazing, veld deterioration and soil erosion result.

The following types of selective use can be distinguished:

- Selection for the following plant parts: leaves, flowers and fruits.
- Selection for plant species caused by morphological and chemical differences between various plant species, which includes deciduousness, spinosity and tannin content.
- Area or patch selection caused by small-scale differences in the soil properties, and a preference for plants at waterholes, termite mounds, old fields, gates and old kraals.
- Habitat selection that is influenced by vegetation composition, shelter, terrain morphology and feeding habits.

Different wild herbivore species also prefer different height levels when grazing or browsing. Moreover, the phenological differences between plants contribute to changes in the preference for certain plant species between the seasons. The main consequence of selective use is over-utilization of the vegetation in question. The continual selection of the flowers, fruits or seeds of a plant will affect the reproduction of the species in the long term and can eventually lead to local extinction. Palatable species will then gradually be replaced by undesirable and less palatable ones, and consequently the veld quality will be affected adversely. Bush encroachment will cause a decrease in veld productivity. Sweet veld areas that contain Acacia/Vachellia karroo or Acacia/Vachellia tortilis are often selected and overgrazed by herbivores. The habitat requirements (**Annexure A**) and plant preference (**Annexure B**) of southern African herbivores are reflected for suitable game ranch species.

The soil found under trees is more fertile and richer in nitrogen, phosphate and calcium than that found in the open areas between trees. A good grazing grass such as Panicum maximum usually grows only under trees. Moreover, palatable grasses growing on the soils of old termite mounds will be selected by grazers. This contributes to the creation of a sub-habitat or a patch-selective grazing pattern, especially in the mixed veld and sour veld areas.

Rangeland Management

Competition between Grass and Trees

The classical view of the co-dominance of trees and grasses in savannas is that it represents a system in a competitive equilibrium in which the trees use the deep soil water and the grasses use the surface soil water. The savannas are not a stable mixture of trees and grasses but rather an inherently unstable mixture that persists because of disturbances such as fire, herbivory and fluctuating rainfall. The competitive interaction between the mature trees and the grass layer is strongly asymmetrical, with the trees having a much greater effect on the grasses than the reverse. A view currently being suggested is that this inherently unstable tree-grass mixture in the savannas is in disequilibrium. In the absence of disturbances such as fire and herbivory that control woody plants in particular, the savannas will increase in woodiness until further tree growth becomes limited by competition with other trees. Trees have a suppressive effect on grass production, whereas grasses have a suppressive effect on tree recruitment, both through competition with tree seedlings and the effect of fire on small trees. When the grass layer is reduced by heavy and continuous grazing, the tree seedlings are allowed to grow beyond the control of grass competition and fire. Consequently, this leads to bush encroachment.

Bush Encroachment Control

Plants that become encroachers or weeds are usually vigorous growers. They are also strong competitors for water, light, space and nutrients. They can be indigenous or exotic, are adaptable and invade a wide range of ecological niches. In rangelands, woody encroachers compete with the grasses and therefore cause lower forage production. Moreover, some weeds may be toxic to animals, while others may upset the indigenous ecology. Encroachment can sometimes be controlled by introducing browsing animals, provided the browse is acceptable and within reach of these animals. Fire can sometimes be used to reduce the height of the foliage, as explained in Section 4 below. However, the ratio of grazers to browsers on a game ranch must be correct so that the vegetation can meet the requirements of both in the long term. The four basic methods for controlling bush encroachers or weeds on a game ranch are discussed below.

i) Mechanical Control

There are various methods of controlling bush encroachers mechanically. The main procedures are as follows:

- ***Chopping, slashing and felling:*** An axe, hand-held or tractor-driven chainsaw, circular saw or brush cutter is used. The stumps are treated immediately with a chemical weedkiller. Coppicing can be controlled by browsers. A tractor-driven saw and mill can also be used to cut the bush at ground level and then to convert the material into food pellets or charcoal. Up to 2.4 ha per day can be cleared using a tractor equipped with a circular saw.
- ***Chains or cables:*** A heavy, 100 mm anchor chain is pulled between two caterpillar tractors in such a way that the vegetation is uprooted. This method is unselective, causes considerable

disturbance and is not effective for large, well-rooted trees. Coppicing occurs and needs to be treated chemically or by means of browsing.

- ***Digging or bulldozing:*** This is an effective method for uprooting plants, but it is expensive and also causes considerable soil disturbance.
- ***Ring-barking or girdling:*** The bark of the tree is removed around the trunk with an axe or a power-driven saw. The damaged area should preferably be treated with a herbicide. The trees will usually die within one to three years after being ringbarked.

ii) Fire control

Fire can be used to rid the environment of weeds. Stem-burning of woody plants is done by packing wood around the stem of an individual tree. This is effective, but practical only when done on a small scale. In the sour-mixed bushveld it was found that a single fire promoted bush encroachment. The topic on fire is described in more detail below.

iii) Biological control

Biological control can be effective through the pressure exerted by various animal groups on the vegetation. The following methods can be used:

- ***Browsers:*** This includes wild browsers and domestic ones such as goats and camels. Where this method of biological control is used, the type of browse must be acceptable to the animal and occur at a suitable height. Using browsers has ecological and economic advantages because more of the natural resources are utilized and an income is provided.
- ***Insects:*** Insect control of especially exotic invaders is a promising approach to plant control. Insects have been used successfully against plants such as the prickly pear, jointed cactus, hakea, sesbania, chromolaena and the Australian species of the genus Acacia.

iv) Chemical control

Herbicides can be used effectively to control a range of problem plants. When using herbicides, however, the following considerations are important:

- Toxicity for man and animal.
- Volatility of the herbicide.
- Length of the active period.
- Precautions that are vital for proper and safe use.
- Economic justification.
- Proper training of the staff who use or apply the herbicides.

Currently there is a wide range of sophisticated chemical herbicides available under a range of trade names. Although herbicides are registered for most of the troublesome invader plants, there are still species for which products have not yet been registered. When using a herbicide, it is vital to follow the instructions on the label strictly regarding the application, safe and proper use and storage of the product. The chemical treatment of problem plants is usually recommended in the following situations:

- When exceptional bush encroachment prevents the accumulation of enough fuel to sustain a hot fire.
- When the available browse is out of reach of browsers and there is a low fuel load that prevents the use of fire.
- When the bush is impenetrable for browsers.

- When the bush is unacceptable to the browser species as food.
- When the chemicals have enough selectivity to control the target plant species.

The following basic approaches are employed when using herbicides to control problem plants:

- **Foliar application:** The chemicals are applied with a hand-operated spray apparatus, or a power-driven one mounted on a trailer, tractor, truck or aircraft. The best time to spray is when the leaves of the plant are fully developed, and a high photosynthetic rate is being maintained.
- **Stem-notching and application:** This method is most effective on trees with a trunk diameter of less than 150 mm. Downward-sloping notches are made around the lower 300 to 500 mm of the trunk. The chemical is either sprayed or painted onto that area. The plants should die after a period varying from six months to three years.
- **Stump treatment:** Trees and shrubs are cut off approximately 200 mm above ground level. The stumps are treated immediately with herbicides, sometimes mixed with diesel oil.
- **Soil treatment:** The chemical is applied in the form of a water-soluble liquid or powder to the soil around the base of the trunk, or is buried in the soil in the case of pellets. The chemical is then dispersed during the rainy season and taken up by the roots of the target plant. These chemicals are most effective in sandy soils. The chemicals remain active in the soil for up to four years. Depending on the rainfall, it may take two to three years for the plants to die.

The **advantages of applying chemicals** to the soil include the following:
- The chemicals can be applied at any time of the year, and in any kind of weather.
- Depending on the soil type and rainfall, these chemicals remain active for up to four years and therefore prevent the establishment of seedlings of the woody plants.
- Little coppice formation and regrowth from the roots take place, which limits the need for follow-up treatment to a minimum.
- The chemicals can be applied selectively by hand.
- The pellets are safer to the handler than the spray.

The **disadvantages of applying chemicals** to the soil include the following:
- Their effectiveness decreases as the clay and organic content of the soil increases and the acidity decreases to create higher pH levels. In soils with more than 20% clay, the required application levels can become uneconomical.
- Some chemicals remain active for long periods, and some are not target specific and may kill a variety of non-target plant species.

Fire as a Management Tool

Fire plays an important ecological role as a management tool in rangelands, because it acts at a landscape level as a disturbance agent for creating diversity in time and space. Fire is a natural ecological factor caused by lightning. Lightning is the main source of fire in the natural veld. For example, in the Etosha National Park, up to 73% of the veld fires that occurred from 1970 to 1979 were caused by lightning and took place mainly from October to December.

In the arid savannas, the Karoo and the desert regions fire is not a major environmental element because the fuel supply often limits fires there. Moreover, the rainfall in the arid regions is unreliable and recovery of vegetation after a fire may take many years. Fire can be used to maintain open grasslands only in savannas that receive an annual rainfall of 350 mm or more. Nevertheless, after seasons of high rainfall in the Kalahari region and the eastern Karoo, sufficient fuel can accumulate to fuel extensive veld fires.

Many semi-arid rangelands have suffered extensively from injudicious grazing that has led to decreased grass fuel loads and reduced grass-shrub competition. As a consequence, fires have become less frequent there, leading to an increase in shrubs, a reduction of perennial grasses, an increase in soil erosion, and often to a permanent change in the ecosystem because of the loss of surface soil. This process is called desertification.

Different types of fire

There are basic three types of fire, and the distinction is based on whether the vegetation burns under the ground, on the surface or in the crown or canopy. A ground fire is a fire that burns or smolders beneath the surface of the soil, usually in thick layers of organic material or plant debris. A surface or grass fire burns mainly in the grass or the herbaceous layer, while a crown or canopy fire burns at all height levels of the vegetation. Head fires burn with the wind and backfires burn against the wind. It is recommended that head fires be used in all cases when burning savannas, because they cause the least damage to the grass cover.

Objectives of fire

There are three basic approaches to burning: avoiding burning, applying prescribed burning, and leaving fires to natural causes.

In veld management, fire is mainly used as a tool for:

- Providing nutritious grazing by removing the moribund plant material that has accumulated from previous seasons.
- Managing undesirable woody or herbaceous invasive plants or weeds that reduce the productivity of the grass layer.
- Making firebreaks and burning portions of an area to stimulate grazing pressure in underutilized areas.
- To manipulate plant populations.
- To maintain and create habitat for animals.
- To decrease the height of browsable material.
- To increase biotic and habitat diversity
- To kill ectoparasites
- To drive out animals for hunting purposes.
- To contribute to nutrient cycling.
- Used as a fire break to reduce fire hazards.

Prescribed burning

Before implementing prescribed burning it is essential that the following necessary infrastructure for controlling veld fires is in place: fire-fighting equipment, water, firebreaks and manpower. An accurate weather forecast should be obtained before starting a prescribed burn. One of the advantages of prescribed burning is that it can be used under less hazardous conditions to reduce the fuel load,

thereby limiting the potential damaging effects of wildfires. The creation of a firebreak system is essential in most grassland and moist savanna areas. Any burning operation should start as a backfire along such a firebreak. Once the fire has burned for a sufficient distance away from the firebreak to ensure safety, a second fire may also be started on the upwind side, so that a headfire will burn the greater portion of the area.

Determining the fuel load

A disc pasture meter may be used to estimate the standing crop of grass in the veld quickly. This apparatus relates the settling height of an aluminium disc to the standing crop of grass that holds it off the ground. A standard calibration for the disc pasture meter has been developed for the Kruger National Park and experience has shown that this calibration is also valid elsewhere in savanna areas.

The effect of fire on grasslands and savannas

Fire frequency

The effects of the frequency of burning on vegetation are both event and interval dependent. The event-dependent effects occur at the time of the fire and are influenced by the type and intensity of the burn and the condition of the vegetation. The interval-dependent effects are influenced by the treatment of the vegetation, such as the grazing intensity and the rainfall-related growing conditions that occur between successive burns. The frequency of prescribed fires is sometimes determined by the need to reduce the bush to an available height and an acceptable state for browsing, the browsing management applied after the burn, the above-ground grass production in combination with the degree of foliage utilization by herbivores, and the occurrence of high rainfall seasons.

To maintain optimum productivity, field experience has shown that natural veld should be burned when a fuel load of not more than 4000 kg/ha is reached. The frequency of fires may vary from annual burns on high-rainfall sour veld, to a burn every three to four years on mixed veld, to even longer or not at all on arid sweet veld. Arid savannas will burn only after exceptionally heavy rains that lead to high fuel loads. This may occur no more than once every ten years or more. A fixed burning interval has no meaning in the arid and semi-arid savannas because of the rainfall variability experienced there.

Grasslands deteriorate when they are not defoliated regularly, be it through grazing or fire. The frequency of burning depends on the veld condition and production rate of the grass plant. This, in turn, is related to soil conditions and rainfall. The removal of grass through grazing also determines the available fuel load for fires. A minimum fuel load of at least 1000 to 1500 kg/ha spread uniformly is necessary to sustain a fire in the arid savannas. In the Etosha National Park, a fire will apparently not spread when less than 2000 kg/ha of fuel is available. The frequency of fire in a savanna is also determined by the rate at which the shrubs grow beyond the reach of the browser species and may depend on the need to control invasive plant species too.

Fire intensity

The intensity of a fire is influenced by the fuel load, the fuel moisture content, the relative humidity of the air, the ambient temperature and the wind regime. Research has shown that fire intensity has no significant effect on the recovery of the grass sward after a burn. However, increased fire intensity does cause a significantly greater topkill of bush. A headwind or a downwind is required to remove accumulated organic material. It is therefore recommended that, if possible, headfires be applied to the grass layer when the ambient temperature is below 20°C, the relative humidity of the air is above 50% and the soil surface is moist (after first 15 mm of rain in spring). These conditions also help to keep the intensity of the fire low at ground level and thus cause the least damage to the grass layer.

To control undesirable plants or encroaching bush up to a height of 3 m, one needs the following conditions to ensure a high fire intensity: there should be a fuel load of more than 4000 kg/ha; an ambient temperature of 25°C or higher; a relative humidity of the air of 30% or less; and a wind speed of up to 20 km per hour. These conditions generally occur between 11:00 and 15:00 in the late spring before the main rainy season starts.

Season of burning

Lightning fires in the Kruger National Park occur most frequently during the late spring and the summer from October to January when thunderstorms are most frequent there. Therefore, the common practice of prescribing burning from July to October is questionable when the natural fire season only starts at the end of the dry season once the woody plants have already flushed and are vulnerable, but the grasses are still dormant. In most of the semi-arid areas of South Africa, the natural fire season is also from October to January.

The timing of a burn should be such that the veld is able to recover as quickly as possible. The physiological condition and phenological state of the grass plants at the time of the burn rather than the burning season determine the degree of damage done by a fire. Veld that is burned before the first spring rains remains bare and is susceptible to soil erosion by both wind and water action. In some high-rainfall grassland areas, regulations allow burning during the six weeks before the expected start of the growing season, provided there is ample soil moisture for the grasses to grow, until two weeks after the start of the growing season. If the veld has not been burned before the first spring rains, it is usually done as soon as possible after the first spring rains of 15 mm or more.

Woody plant mortality

The mortality rate inflicted on woody plant species by fire varies from 1.3 to 33% in the arid savannas. A mean mortality rate of 15% was recorded for the black thorn Acacia/Vachellia mellifera following grass fires, while packed wood burns resulted in a 75% mortality rate. In an arid savanna, the bush can be controlled by a combination of domestic goats and fire.

Management of veld after fire

The interaction of burning and grazing after a fire probably has a greater effect on the vegetation structure and composition and the grass production of the next season than any other aspect of veld burning. After a fire, sour veld should not be grazed before the grass sward has regrown to a height of at least 150 mm. When it is necessary to burn sweet veld, it should not be grazed until the full bloom stage has been reached. With wild herbivores this is problematic, however, because animals such as blue wildebeest, Burchell's zebra, blesbok, impala, sable antelope, buffalo and white rhinoceros will all move onto the burnt area almost immediately following the fire. The reason for this is the new growth that has an increased protein and mineral content after a fire. On a game ranch the burnt area should be large enough and be stocked at a conservative stocking rate to minimize the potential harm to the veld. Licks may also be removed from recently burnt areas and watering points closed until the veld has recovered sufficiently.

Image 5: Livingstone eland bull

E. ANIMAL SELECTION

Ecological Principles

The choice of the animal on a game ranch will be determined by the production system. These animals can be fed during dry periods and animals that did not occur in the past in the specific geographical area can be introduced on the same basis as cattle. The decision to introduce animals on nature reserves must be taken on sound ecological principles. This will be based on the historical records and evaluation of habitat and veld condition by trained ecologists. Both cases will be addressed in a management plan that must be compiled by trained ecologists.

Only animals that occur naturally in Mozambique should be introduced on game ranches. Species such as black wildebeest should not be imported from South Africa. Impala, (*Aepyceros melampus*), Lichtenstein hartebeest (*Alcelaphus lichtensteinii*), Blue duiker (*Cephalophus natalensis*), Bluewildebeest (*Connochaetes taurinus*), Roan antelope (*Hippotragus equinus*), Sable antelope (*Hippotragus niger*), Waterbuck (*Kobus ellipsiprymnus*), Suni (*Neotragus moschatus*), Klipspringer (*Oreotragus oreotragus*), Oribi (*Ourebia ourebi*), Blue duiker (*Philantomba monticola*), Steenbok (*Raphicerus campestris*), Sharpe's grysbok (*Raphicerus sharpie*), Common reedbuck (*Redunca arundinum*), Mountain reedbuck (*Redunca fulvorufula*), Grey duiker (*Sylvicapra grimmia*), African buffalo (*Syncerus caffer*), Eland (*Taurotragus oryx*), Nyala (*Tragelaphus angasii*), Bushbuck (*Tragelaphus scriptus*), Greater kudu (*Taurotragus strepsiceros*), Giraffe (*Giraffa camelopardalis*), warthog, (*Phacochoerus africanus*), Neves, *et al* (2018).

Genetic Principles

Practical Principles of Genetic Management

- Game ranchers should keep only those wild animals that are ecologically adapted to a region and that are known to have occurred previously in that region. This will ensure that competition between ecologically equivalent animals is eliminated, for example between sable antelope and gemsbok.
- The aim should also be to accommodate healthy breeding herds that satisfy the social requirements of the animals. Genetic impoverishment is difficult to determine in wild animals because of the strong tendency towards natural selection. It is recommended that when wild animals are utilized commercially and there are fewer than 50 breeding animals on a ranch, the percentage of males removed annually or biannually should be replaced by the same number of local males from unrelated herds.
- Game ranchers should preferably re-establish complete breeding herds because it can take some time for new social groupings to form. In doing so, they should avoid buying odd parcels at auctions. For example, rather than buying two sable antelope each from five different sources for re-introduction, buy a group of ten sable antelope from the same herd.
- A single individual of any type of animal that occurs on a game ranch should be removed. For example, one tsessebe bull on a game ranch with 100 blesbok is a clear recipe for hybridization, especially when the single animal is a bull of an anatomically stronger type of herbivore.
- In rarer animals, such as sable antelope, which are hunted for their trophy value, the trophies should only be taken from the bachelor or male herds. Whenever possible, the population growth of all the wild animals should be calculated during annual counts. If the rate of growth or increase is inadequate, a few males should be culled from the breeding herds. For example, a growth rate of at least 5% is required for Burchell's zebra because infertile stallions can decrease the overall population growth rate by appropriating the fertile mares.
- Identify the key animal species for the ranch.
- Determine the minimum size of the population that is necessary to ensure the survival and genetic diversity of the species.
- Make use of known population densities and calculate the minimum size of the area necessary to accommodate at least a minimum population of that species.
- Consider the social behavior of the species so as to prevent dominant males from killing young animals, as may happen in various wild herbivores including the white rhinoceros and the sable antelope.
- Prevent competition between ecologically related herbivores that prefer the same type of habitat. For example, avoid keeping nyala and bushbuck in the same area.
- Prevent hybridization of various types and subspecies of herbivore by maintaining genetically viable populations and eliminating closely related groups. For example, do not keep black wildebeest and blue wildebeest in small numbers on the same game ranch, nor subspecies such as the blesbok and bontebok.

Hybridization and Inbreeding

Biologists often debate on what is best for the survival of healthy populations of especially the rarer animal species. The question can be asked? What is the best, a single large nature reserve or game ranch or various small reserves or game ranches? The best approach appears to be to establish a variety of populations of a given species in more than one locality in order to prevent an entire species from being affected or even exterminated by a catastrophic event, such as exposure to a specific disease. Such an approach will also encourage the natural distribution of the animals. A nature reserve or game ranch should always be as large and diverse as possible. One of the purposes of managing a game ranch should be to ensure sufficient genetic integrity and heterogeneity of especially small

populations of animals.

Minimum Genetic Populations

Amongst other things, inbreeding leads to the loss of genetic fitness, increased mortality in young animals, reduced fertility and depressed growth. This is often referred to as inbreeding depression. The number of breeding animals present in the herd is extremely important, because they influence the effective population size and the rate of inbreeding in each generation. Based on the information obtained from studies on domestic herbivores, 50 breeding animals are the effective population size that is required to maintain an inbreeding coefficient or degree of inbreeding of below 1% per generation. The sex ratio also plays an important role in the flow of genetic material in a population, because it affects the random variation of the gene frequencies between one generation and the next. An effective population size of 50 breeding animals can be structured according to sex with the help of the following equation:

$Ne = 4 (Nm\ Nf) \div (Nm + Nf)$
Where:
Ne = Effective population size
Nm = Number of effective breeding males
Nf = Number of effective breeding females

An example of the effect of the effective population size (Ne) with a varying number of females on the population: The size of a breeding herd influences not only the effective population size, but also the rate of inbreeding per generation. Suppose a game rancher wants to ranch with buffalo. To be able to keep the inbreeding coefficient below 1%, 50 breeding animals are required. Suppose the sex ratio under natural conditions is 1:1. Therefore, when the above equation is used, 25 sexually mature cows and 25 sexually mature bulls will be necessary in the population to keep the breeding coefficient below 1%. However, suppose that the rancher has a surplus of males that he wants to utilize for trophy hunting, while at the same time, he wants to increase the productivity of the herd and apply genetic conservation. Then the equation can be modified as follows:

The number of breeding bulls required = $(3 \div 8) \times 50$ effective breeding animals = 19
The number of breeding cows required = $(5 \div 8) \times 50$ effective breeding animals = 31
Therefore: $Ne = [4(19)(31)] \div [19 + 31] = 2356 \div 50 = 47$ animals

Here the natural parity of the sex ratio of the herd is changed to three males for every five females. This leaves 19 breeding males and 31 breeding females, which are substituted in the above equation to give an effective breeding herd size of 50 animals. The degree of inbreeding will therefore now be a little more than 1% with an effective population size of 47 animals. Now, suppose further that effective breeding animals make up 40% of the total herd. Then the minimum herd size that is necessary to apply genetic conservation will be a total of 125 animals. The generation interval influences the rate of inbreeding in the following way: With a generation interval of five years, the rate of increase in inbreeding will be $(1.5 \div 5) = 0.3\%$ per year, with an inbreeding coefficient of 1.5.

Minimum Social Herd Size

A certain minimum number of individuals of an animal species are required so that the animals can execute their normal social behavior. The absolute minimum social group for re-introduction is three males and five females. Such a breeding herd will usually consist of six adult animals, of which one is a

bull and five are cows, plus two young males. Any young males born to this herd will join the other young males in a bachelor herd when they leave the breeding herd later because of social pressures.

Minimum surface area

Suppose the same example that was used above for the buffalo is used again, and assume that the game rancher has the following objectives:

- The grazing capacity is 10 ha per large animal unit.
- Buffalo must make up 15% of the total biomass of herbivores on the game ranch.
- The total buffalo population is 125 animals.
- The large animal conversion factor to large animal units for the buffalo is 1.0.

Then: number of animals × conversion factor = large animal units in buffalo, or large animal units present = 125 × 1.0 = 125 large animal units in buffalo. The size of the area needed for these buffalo = number of large animal units × grazing capacity required per large animal unit = 125 large animal units × 10 ha per large animal unit = 1250 ha. Therefore, 15% of the total stocking rate is equivalent to 1250 ha, and the total size of the ranch that will be needed for a herd of 125 buffalo is: (100 ÷ 15) × 1250 ha = 8333 ha.

Hybridization

For healthy population growth to occur, a genetically viable population is essential. Wild herbivores appear to be less susceptible to inbreeding than domestic ones; this is because they are genetically more heterogeneous than domestic animals. Many cases are known where large populations of wild animals have been built up from small herds or a few individual animals that were introduced in an area. However, it remains sound policy to obtain breeding males from another genetic source from time to time, especially when all the animals available are from the same local genetic stock.

Game ranch fences prevent the free exchange of genetic material between animals of bordering or neighboring game ranches. There are already indications that this may be leading to genetic impoverishment in rhinoceroses. It would therefore be advantageous for the owners of neighboring game ranches to swop healthy breeding animals from time to time to prevent inbreeding depression in their own herds. A further option is to remove the fences between adjacent ranches to form conservancies where natural genetic exchange will occur within the larger and more viable populations.

Individual members of genetically impoverished herds may display conspicuous physical defects, or the herd will not produce sufficient healthy young. Inbreeding is also detrimental to the fertility of the surviving animals and the vitality of the young animals. Any deviant individuals, such as those with thin or twisted horns or other defects, should be removed from the breeding herd as soon as possible.

A sound economic and genetic rule is rather to obtain animals from the available local stock than to import them at great expense from distant places. Apart from the genetic implications, losses in animals that are kept in captivity for a long time or are transported over long distances can be unacceptably high.

Wild animals will also hybridize on a game ranch when the area is too small and minimum herd sizes are not maintained. The following are known possible hybrids between wild herbivores and other animals:

- *Fertile hybrids:*

    - Bontebok x blesbok
    - Blue wildebeest x black wildebeest
    - African wild cat x domestic cat
- *Infertile hybrids:*
    - Tsessebe x blesbok
    - Red hartebeest x blesbok
    - Roan antelope x sable antelope
    - Eland x kudu
    - Hartmann's mountain zebra x donkey
- *Possible hybrids:*
    - Burchell's zebra x Cape mountain zebra
    - Cape buffalo x Indian water buffalo

Biologists firmly believe on scientific grounds that closely related animal species that are separated geographically develop unique physiological and anatomical adaptations over time. This is a natural process. Consequently, they should not be allowed to cross-breed with one another so that these unique characteristics may be maintained. Examples of animals that have to remain isolated from each other are the black-faced impala and the common impala, the giant sable antelope and southern sable antelope, the West African roan antelope and the southern roan antelope, the blesbok and the bontebok, and the ostriches from northern and southern Africa.

Image 6: White giraffe Kruger National Park

F. ANIMAL CENSUS METHODS

Census Techniques

The primary objective of an animal count is to get an estimate of the population size in a given area. The main problem is to obtain a count that will be a reliable foundation for population management. Animal counts can be total counts where the objective is to count all the animals in a given area, or they can be sample counts where conclusions about the number of animals in the entire area can be

drawn from counts done by sampling smaller surface areas. The problem is exacerbated by the fact that wild animals are usually distributed unevenly across the area because they congregate in patches of preferred habitat. When one counts wild animals on a game ranch, it is therefore desirable to divide the area on the basis of the habitat preferences of the animals. For example, because nyala occur only in dense thickets, it is illogical to search the entire game ranch when one is interested only in nyala numbers. Likewise, it is unnecessary to conduct counts of klipspringer anywhere other than in the available klipspringer habitat. However, when all the animals on the game ranch are to be counted on a sample basis, then representative sections of all the available habitat types should be covered in the survey.

There is no single comprehensive counting technique that is suitable for all the possible animal species and their habitats. Knowledge of the animals present and their habitat requirements is essential before any count can be attempted. For example, ungulates in treeless regions or open bushveld areas can be subjected to aerial counts, but in dense bushveld or forested areas a combination of methods will produce better results.

The cost, the size of the area, the animals to be counted, the type of habitat, the available manpower and the purpose for which the count is required will all influence the final selection of the counting technique or the combination of techniques that will be used. The more animals there are on the game ranch, the more evenly they will be distributed, and consequently the better the estimate will be when it is based on samples. The fewer the animals, or the more they are clustered, the more sample counts will be necessary to give reliable results. Although wild animals may be distributed unevenly over an area as individuals, herds tend to be distributed more evenly. In such a situation, sample counts can be done more successfully. No counting technique is flawless, but the most consistent methods give a more constant margin of error and are therefore more reliable for effective game ranch management. Various counting techniques will yield a useful result on a game ranch. When the above general considerations are taken into account, the final selection of a specific technique or a combination of techniques can be, as set out below.

Drive Counts

Drive counts are particularly suitable for small game ranches with an open grassland and/or open savanna habitat, although a modification of the technique can also be used on larger ranches. The main requirement for this technique is an adequate number of people who are able to identify the various animals to be counted. On small game ranches, drive counts give a total count of all the animals present. On large game ranches, a modified technique gives an estimate of the number of animals on sample strips. When the counts are to be done in open savanna areas, it is preferable to do so in July or August when most of the trees have shed their leaves and visibility is optimal.

For a small game ranch, the available counters are placed 50 to 100 m apart in a line along the entire length of a boundary fence. The counters can move on foot or on horseback, but each person in the line should always be able to see at least the counter who is immediately on either side. The entire line proceeds at the same time towards the opposite boundary fence. By using two-way radios or by sending commands along the line, the progress of the line can be regulated so that it does not break up or develop gaps. When the line does break up, it should be halted and re-formed before continuing. When the counters are on foot, a few riders on horseback distributed at regular intervals along the line can assist the counters to maintain contact and line integrity. When the count is done in an open savanna, markers attached to trees throughout the area can help to keep the line moving in the correct

direction. When there are suitable observation points such as hills or high termite mounds, additional observers stationed on each such lookout point can further monitor the progress and integrity of the line. They can also help to alert the counters to any animals that may be difficult to see from the ground level. A few observers should also be stationed along all the boundary fences so that any animals that may jump the fence can be counted. Such animals may later return. Nevertheless, they have to be counted to determine the population growth rate properly and to interpret the stocking rate pressure on the available food supply.

Each observer in the line counts all the animals that break through the line either on his left or right side, but not on both sides. Animals that break back from behind the counting line to the uncounted area should be subtracted from the total of the specific observer. In open habitat, a rope may be dragged between every two observers to flush small animals like the steenbok, and game birds that are slow to flee. Since the counters also make a noise of some kind as they move along, the animals usually flee spontaneously and eventually break through the line to be counted.

On larger game ranches the technique is modified. In every habitat type, at least one strip set is counted by at least three persons working together. The strips can initially be marked out on an aerial photograph before the count, or on the ground by means of colored material or some other marking method. The desired direction can also be followed merely with the aid of Global Positioning System (GPS) equipment or a reliable knowledge of the ranch. The strips should be parallel. On large game ranches with a uniform habitat, the sets of strips should be at least 1 km apart. In even larger areas, such as conservancies, the sets of strips can be 5 km apart. The entire set of strips is walked and counted at the same time and at the same pace. The time of observation, the group or herd sizes, the age and sex structure and the direction of animal movement are also recorded where possible. This helps later to eliminate duplication. The data are also useful for management purposes. By recording this information on a map, it is easy to determine whether any herds were counted twice or not at all in adjoining strips.

Example: On a game ranch of 2110 ha, five strip sets are placed 1 km apart. The mean visibility distance for the first strip set is calculated as follows:

The total length of the strip set is 3 km, with 60 visibility distance calculations (30 on either side) that yield a total visibility distance of 4806 m. Therefore, the mean visibility distance is 4806 ÷ 60 m = 80.1 m. On this strip set the counter on each of the side strips of the central line walks 75 m away from the central counter. This distance is easy to control and still within the maximum visibility distance of 80.1 m. The two side counters count all the animals that they see. These are counted in a strip with a mean width of 80.1 m. Therefore, the total counted surface area is two strips of 75 m x 3 km on either side of the central counter and two strips of 80.1 m x 3 km on the two extremes. This gives a surface area of 450 000 m2 + 480 600 m2 = 930 600 m2 = 93.06 ha that was counted. The surface area of each of the other strip sets is calculated separately in a similar manner.

Suppose the following animals were counted on the indicated surface areas of the five strip sets:

Strip set 1: On 186.120 ha there were 16 impala, 5 kudu, 7 giraffe and 9 Burchell's zebra.
Strip set 2: On 179.336 ha there were 27 impala, 4 kudu, 10 roan antelope and 3 duiker.
Strip set 3: On 164.164 ha there were 11 impala, 2 kudu, 4 giraffe, 31 blue wildebeest, 12 Burchell’s zebra and 4 duiker.

Strip set 4: On 179.872 ha there were 23 impala, 8 kudu, 10 giraffe, 3 blue wildebeest, 7 Burchell's zebra and 2 duiker.
Strip set 5: On 81.804 ha there were 11 impala, 3 kudu, 1 giraffe, 10 Burchell's zebra and 3 roan antelope.

When the five strip sets all occur in primarily the same type of habitat, the figures can be combined and applied to the total surface area of the entire game ranch. However, when each strip set lies in a different type of habitat, the data of each strip set should be processed in terms of the surface area of each type of habitat. Aerial photographs can be used to calculate the surface areas of the different habitats. The surface areas of any combination of habitats can be calculated in a similar way. In the accompanying example, it is accepted that the entire area represents a reasonably homogeneous habitat and that the animal herds are all fairly evenly distributed across the area. The total animal population is now calculated from the above data as follows:

Total surface area of the ranch: 2110 ha
Total surface area counted in strip sets 1 to 5: 791.296 ha
Total number of animals counted on all the strip sets: 88 impala, 22 kudu, 22 giraffe, 38 Burchell's zebra, 13 roan antelope, 9 duiker and 34 blue wildebeest

For the entire ranch the number of animals is therefore calculated to be 2110 ÷ 791.296 = 2.67 times the number counted for each type of animal. This translates into 2.67 x 88 = 235 impala, 2.67 x 22 = 59 kudu, 2.67 x 22 = 59 giraffe, 2.67 x 38 = 101 Burchell's zebra, 2.67 x 13 = 35 roan antelope, 2.67 x 9 = 24 duiker and 2.67 x 34 = 91 blue wildebeest.

Road Strip Counts
All game ranches have tourist and firebreak roads. When the habitat is reasonably homogeneous, and particularly when the road itself does not create a localized change in habitat such as a zone of dense vegetation next to the road because of the additional water run-off, all the animals that are visible from a road in a given period can be counted. The mean visibility distance of the area along the road can be determined in a manner similar to that for drive counts. It is calculated from the centre of the road. It can also be calculated by estimating and recording the perpendicular distance of all the animals actually seen and counted from the centre of the road.

In open habitats and using a permanent visibility distance, the strip to be counted should be marked out in advance with small flags or something similar. This will prevent one from counting animals that occur outside the strip. The permanent strip should include only those areas in which the animals are certain to be seen. The total length of the road multiplied by the mean visibility distance on either side of the road gives the surface area that is being counted, provided counts are done on both sides of the road.

A fixed route should be counted at, or as near as possible to, the same time every year. The starting point, type of vehicle, starting time and a driving speed of about 30 km/h should also be kept as constant as possible. All the animals on both sides of the road should be counted when there are enough counters in the vehicle to cover both sides. Otherwise, only one side is counted. This technique cannot be used for animals that flee long before they can be seen and counted, and especially not when the animals on the game ranch are hunted regularly from a vehicle. The count should preferably start early in the morning about an hour after sunrise.

When various types of habitat occur, the transition from one habitat to another can be marked along the road with a tag or a ribbon. The animals are then counted for each habitat type and the total distance driven through each habitat type is measured. In conjunction with the mean visibility distance for each habitat type, the surface area of the counting strip for each habitat type can now be calculated. On the basis of these calculations, the counts can then be converted to the total surface area for each habitat type. Thereafter the totals for the entire game ranch are calculated. By calculating the density of each type of animal in a specific habitat, a broad indication of habitat preference can also be obtained.

Irrespective of how the width of the visibility distance strip is determined, the number of animals in the entire area can be calculated by using the equation $N/n = H/h$ or $N = nH/h$, where N = the number of a specific animal on the whole ranch, n = the number of that animal that is counted on the strip(s), H = the surface area of the entire ranch and h = the surface area of the counting strip(s).

Known Group or Individual

When animals occur in fixed herds, an indication of their number can be obtained by regularly recording the number and composition of every herd that is encountered. This is particularly valuable during the mating season. Animals with spotted or striped patterns or any other recognizable characteristics are unique with regard to their skin pattern. By regularly photographing these animals and building up a photographic register, their population size can be estimated reasonably well in time. However, photographs should be taken of both sides of every individual because the skin pattern of an animal is not bilaterally symmetrical. Good photographs can be taken from shelters at waterholes for this purpose. Moreover, by taking such photographs of young animals as soon as they have acquired their adult coat, a record of the age of each individual can be kept that may be valuable in other age-related aspects of animal use and management.

Ratio Methods

Ratio methods make use of changes in the ratio of the number of animals in a given category in an area. Usually this involves changes in the ratio of two age groups, two sexes, signs such as tracks or dung, or even the numbers of two types of animal. These changes may occur as a result of the removal or addition of certain individuals. Two such methods are useful particularly on game ranches where animals are harvested annually by hunting or any other method. The one considers the age, sex and number ratios of two types of animal in relation to each other. The other considers changes in the size of one animal population relative to the size of another animal population. Both methods require detailed and meticulous records of all the animals removed.

Age, Sex and Number Ratios

This method is based on a change in the ratio of, for example, two age groups, such as lambs to adults, or of the sexes after a known number of animals has been added to or removed from a certain group. An initial survey is done to determine the number of one group as opposed to the number of the other. This is expressed as a ratio. After the addition or removal of a known number of animals has occurred, a similar survey is done to determine the changed number ratio. All the calculations or figures given in the example below with a subscript 1 indicate the situation before the removal or addition, while all the symbols with a subscript 2 indicate the situation after the removal or addition. The two categories of animals are indicated by the subscripts x and y. The following symbols are therefore distinguished:

$N1$ = Population size during the first survey

N2 = Population size during the second survey
V1 = Number ratio of the one group in population N1
V2 = Number ratio of the same group in population N2
Tx = Number of animals of group x that were added (+) or removed (-) between the surveys
Ty = Number of animals of group y that were added (+) or removed (-) between the surveys

The number of animals in the population during the first survey can then be calculated from the following equation:
N1= (Tx - V2T) ÷ (V2 - V1)
Where: T = Tx + Ty

Known Number of One Species
In cases where the population size of at least one species on the game ranch is known, the density or number of this species can be used relative to that of another species to calculate the number of animals of the unknown species. Suppose it is known that there is a population of 114 Burchell's zebra on a game ranch. By means of a road strip or field strip count as explained above, the number of animals of the other species can be determined relative to that of the known one. Suppose 78 Burchell's zebra and 283 impala are counted on this game ranch during a road strip count. The true number of the unknown animal can now be calculated, where:

Nx = Number of the unknown animal, here the impala
Ny = Number of the known animal, the Burchell's zebra = 114
nx = Number of the unknown animal, the impala, counted during the strip counts = 283
ny = Number of the known animal, Burchell's zebra, counted during the strip counts = 78

Then:
Nx = [(Ny)(nx)] ÷ [ny]
= (114)(283) ÷ 78
= 414 impala

However, this technique demands that both species being counted should display similar behavior, which may influence their visibility in the strip counts; that both should be equally conspicuous to the counters; and that both should have the same distribution pattern or habitat preferences on the game ranch. For example, this technique can be used for impala and Burchell's zebra, for Burchell's zebra and blue wildebeest, and even for impala and red hartebeest where they occur together. It cannot, for example, be used for lions or other predators and impala, or for klipspringer and steenbok.

Counting Wild Animals from the Air
A fixed-wing aircraft and a helicopter are useful aids for obtaining fairly reliable information on wild animal numbers. Particularly in large areas, it is often the only realistic way of counting them. Although it is relatively expensive per unit of time, it takes less time to do an aerial count than to use the other counting techniques. A helicopter count therefore remains an acceptable option, especially when several game ranches in the same area do counts at the same time to share the cost of having a helicopter positioned in the region.

For general management it is not necessary to count the animals on a game ranch intensively every year, because trends obtained from some of the other less-intensive techniques already mentioned may be adequate. However, when possible, but particularly when large numbers of animals are to be harvested or captured, it is preferable to do a thorough advance count from the air, preferably by helicopter. The following guidelines and considerations apply to aerial counts of wild animals.

Time of year

Animals should be counted when their visibility is maximal. In open grassland areas antelope are especially visible against the clear, green background of the spring veld that is still quite short after the first rains. In savanna areas, they should be counted when most of the trees have shed their leaves. This usually is from the second half of July to the first half of September. The optimal period for counting will vary from one region to another and from year to year. Therefore, the best time should be determined by an on-site inspection every time.

Type of aircraft, the crew and some counting problems

A fixed-wing four- to six-seater aircraft with the wings mounted on top of the fuselage and a four- to six-seater helicopter are preferred to a fixed-wing aircraft that has its wings mounted below the fuselage. It is essential to have an experienced pilot who is able to maintain the flying speed, flight attitude, altitude and direction meticulously. The pilot can also draw the attention of the observers to any animals that may be ahead of the aircraft. The recorder sits next to the pilot and records all the information, helps the pilot to maintain direction, and counts any animals in the blind spot in front of the aircraft. This person should be familiar with the area in which the count is being done. Two teams of two counters each count the animals on each side of the aircraft. They convey their information to the recorder.

The counters should be familiar with the wild animals that are present on the game ranch and should be able to recognize and count them from the air. This requires a practiced eye and quick reflexes. No one should be susceptible to airsickness because aerial counts often require the aircraft to make frequent short turns, especially on smaller game ranches. An experienced person can count three animals per second from the air. Compact herds of about 100 animals are the maximum that can be counted from a fixed-wing aircraft. When the herd is more dispersed, larger herds can be counted. In the case of larger herds, the experienced counter will count the animals fairly accurately in multiples of five to ten or be able to divide the herd mentally into two or four parts. He will then count only half or a quarter of the herd. The size of the entire herd will be calculated from this information. Larger herds can be counted more effectively from a helicopter because it can fly slowly and hover when required to do so. A large herd can also be counted by circling the animals in a fixed-wing aircraft, but this disturbs the animals, is more time consuming, can have a detrimental effect on the direction and height of the flight, and can quickly cause airsickness in susceptible counters.

Large herds can also be photographed or videotaped from the air with a digital camera. By enlarging the photograph or taking a color slide and projecting it onto a large screen or showing the video on a screen or linking the digital camera to a monitor, the animals in the herd can be counted accurately. The sequence of the photographs or video footage should be recorded carefully during the counting process. An ordinary 35 mm camera with a 50 to 135 mm zoom lens and high-speed film is recommended for photographs or color slides. When only a section of a large herd falls inside a counting strip as marked by streamers on the wing struts or by markers on the windows, the photograph or video image should include the ribbons or markers so that only the animals within the

counting strip are counted. The focus depth allowed for by a high-speed film is adequate for this. The more counters there are, the more effectively can larger herds be counted. Even when a photograph is taken, or a video recording is made of a large herd, a visual estimate should still be made of the size of the herd and recorded in case of camera or film problems, or even the loss of the film.

The probability of detecting and counting animals accurately increases as the number of counters increases. A larger crew is necessary when a large number of species or a large game ranch or conservancy has to be counted. Earphones and microphones increase the effectiveness of the count because they facilitate communication and eliminate the excessive noise caused by the aircraft, and thus reduce fatigue. The ideal is to use the same crew and equipment year after year on the same game ranch or conservancy.

Counting area, strip width and strip length

The distance at which wild animals can be counted effectively in the two strips on either side of the flight route of the aircraft depends primarily on the visibility of the animals, the speed of the aircraft and the experience of the counters. For counts in which various types of animal are involved, the effective strip width is determined by the visibility distance of the animal that is the least visible. Over extensive areas a maximum strip length of 15 km is recommended. Such a distance can usually be covered in four to six minutes of flying and does not make excessive demands on the ability of the counters to concentrate. At the end of the strip, the counters rest while the aircraft turns and gets into position for the next strip. The turning of the aircraft takes too much time when strips are too short and the repeated short, successive turns are tiring and uncomfortable for the counters.

Total counts can be done in areas that are small enough for the whole surface area to be counted in less than an hour. In larger areas, strips can be flown 800 to 1500 m apart. In the Kruger National Park, counting strips are flown from east to west, or vice versa. As counting should ideally take place in the mid-morning or late afternoon, a north-south strip would impair the vision of the counters and exhaust them. In an east-west strip, the sun will be in the eyes of the pilot and the person recording the information in every alternate strip, but both can compensate for this without detrimentally influencing the count.

Strips can be plotted with the aid of familiar landmarks such as dams, windmills and hills on an aerial photograph. Localities can also be recorded with GPS equipment. GPS flight instruments will also help the pilot to fly in fixed strips, especially in more uniform areas. In large uniform areas, such as open grassland plains, strips with a fixed width and length can be marked out in advance on the ground and then be counted. Otherwise, strips of varying width and length can be counted. On game ranches flags of various colors attached to fences or posts in places where a strip crosses a tourist or firebreak road may help with visual navigation. Marker points can also be recognized from an aerial photograph on which the strips are drawn in advance. It is important to remember that over longer distances animals are generally more visible than countable, therefore visibility should not influence the effective width of the strip. In parts of a game ranch where animals are known to be abundant additional strips may be flown to achieve a more reliable result.

When the entire area is counted in adjoining strips, the total number of animals counted is also the total population for the area. When the strips counted are set apart from one another, the total strip length multiplied by twice the strip width on one side of the aircraft gives the surface area counted for each strip. When the habitat is uniform, the total surface area of the ranch divided by the total surface

area of all the strips gives the figure by which the total number counted for each species should be multiplied to calculate the total number of animals in the area. When the habitat varies, the surface area of each habitat type and the surface area of the strips counted for that habitat type will in the same way give the number of animals in each habitat type.

Special modifications for fixed-wing aircraft

Aircraft with fixed upper wings and wing struts can have streamers (plastic or twine) attached to the wing struts to help mark out the area that is to be counted. In this way, animals directly below the aircraft will not qualify for counting or be inadvertently missed. This eliminates one potential source of error. The head of the counter is held in a normal position for the duration of each strip, and only those animals that come into view within the marked strip between the two streamers are counted. When there are no wing struts, strip markers on the window next to each counter will give the same result. However, any modification of the aircraft, such as streamers, should first be cleared with the Civil Aviation Safety Authority.

The streamers or window markers are positioned in advance either by making the necessary calculations or by flying at the desired height over a previously marked strip on the ground, such as the runway. As an experiment, one permanent marker may first be attached to the wing strut near the fuselage of the aircraft, and a series of temporary markers of different colors to the strut further towards the wing tip. By flying at the counting height over a strip of the desired width of say 100 m that has been marked out on the ground, one can determine which temporary marker on the strut will define such a given strip width for the counter. The pilot is guided by the counter, so that the bottom marker on the strut corresponds with the ground marker nearest to the aircraft when the aircraft flies over the strip marked out on the ground. Once the correct position of the second marker has been established, streamers that are more permanent can then be attached to the struts. The same basic method - a permanent marker at the bottom of the window and a series of temporary markers further upwards - can be used for aircraft without wing struts, and for helicopters.

When strip-width calculations are made on the ground for positioning the streamers or markers correctly, the following method can be used: The aircraft is parked with its wings level, on a level runway or on the floor of the hangar. Jacks are then used to keep it in the normal horizontal flying position. This means that the tail is jacked up in the case of aircraft with a tail wheel. On both sides inside the aircraft, a counter sits in the seat to be occupied during the count, with his head held in the normal comfortable counting position. The perpendicular height of the eye of the counter from the ground or from the floor of the hangar is now measured (h). Using the same measuring unit throughout, the height at which the aircraft will fly during the count is recorded (H). The strip width (W), measured in the same measuring unit, is now used to calculate the strip (w) that must be measured out on the ground or floor on one side of the aircraft by using the following equation: $w = Wh \div h$, where w = the distance, in the same measuring unit, between the two different points on the ground, each in line with the eye of the counter, the top and bottom markers on the wing strut and the ground marker. By now varying w, W or h as the known constant, the corresponding height that has to be flown for a certain strip width can be calculated. Inversely, the actual strip width can also be determined when animals are to be counted at a certain flying height. By predetermining W and H, the distance between points a and b on the wing strut can be calculated for a specific counter. By using the line of sight of the counter to the marks on the ground, points a1 and b1 on the window can be marked out. By then using the same line, points a and b are marked off where the lines of sight cross the wing struts.

Example: The eyes of a counter are 2.57 m (h = 2.57 m) perpendicularly above the ground level. For a counting height of 90 m above the ground level (H = 90 m) and a counting strip width of 100 m (W = 100 m) on one side of the aircraft, the width of the strip to be measured out on the ground or floor of the hangar when positioning the window or strut markers (w) is calculated as follows:

w = Wh ÷ H
= (100 m)(2.57 m) ÷ 90 m
= 2.855 m

During flight the wings of the aircraft have to be kept as horizontal as possible because the position of the wings will influence the strip width on the ground for a given set of markers. A wing that lifts enlarges the surface area of the strip on the ground, while one that drops reduces it. When the wings of the aircraft move rhythmically up and down, they tend to cancel the resultant errors. This will then have little effect on the eventual count in areas where the animals or herds are fairly evenly distributed. However, when a constant strong crosswind is blowing, the aircraft may constantly fly with one wing higher than the other and this may influence the count. The same error occurs if the artificial horizon instrument of the aircraft is incorrectly adjusted. An experienced pilot will soon recognize the problem and make the necessary corrections.

When the entire area has to be covered, successive counting strips should be adjacent to one another. Suitable markers on fences or along roads can help the pilot to keep direction. GPS instruments are also of great help. When ground markers are used, they are placed after the position and width of the strips have been drawn in on an aerial photograph. Strips that are 300 m or wider are more difficult to count than strips that are narrower. The narrower the strip, the more a given surface area can be searched for animals. A counter is also more inclined to overlook animals in broad than in narrow strips.

Flying speed and flying height

The general flying height suitable for aerial counts of wild animals is 90 to 100 m. The flying speed should be as slow as is safely possible. On account of the angle of sight in which a counter counts the animals, a constant, correct flying height is essential. This requires an experienced pilot. An ordinary aircraft altimeter does not serve this purpose over undulating landscapes. Radar and laser altimeters are much more reliable but are costly to install. Modern, good quality GPS instruments may also be used. Above a height of 100 m, animals are overlooked because of the counting angle and the inherent camouflage of most animals. Below a height of 90 m, the ground passes too swiftly to be able to count animals effectively. With just a little preparation the shadow of a fixed-wing aircraft can also be used to maintain a fairly constant flying height.

Counting time and recording data

The probability of seeing an animal from the air decreases markedly from midday to early afternoon. At this time, most animals are inactive and shelter beneath trees. On hot summer days the best counting time is from 07:30 to 10:30 and again from 15:00 to 17:30. The best time for morning counts in the summer is when the sun is between 30° and 60° above the horizon. In the winter it is from 10:30 to 12:30 because the animals are inactive early in the morning when it is still cold. They become active again only after 16:30 in the afternoon, but then light conditions are too poor for reliable counts. Morning counts are at all times preferable to afternoon counts, because the morning light is optimal for animal counts, the animals are more active then, and the counters are still fresh and rested.

The recorder records all the information gathered, preferably on a data sheet designed in advance. The counters convey the information to the recorder through the intercom system. Tape recorders and direct computer loggers can also be used, but they can become defective during the flight and information may be lost in this way. It is therefore always better to write down the information on suitable data sheets, even though it may be recorded in other ways too. Counters should not write down any data, because an animal may be overlooked when the counter is glancing from the ground to the data sheet and back. Constant refocusing of the eyes is also required when looking from the ground to a data sheet and vice versa. This causes errors and undue fatigue. When a two-seater aircraft is used, animals can be counted only on one side of the aircraft. The counter then also has to record the data. This method has the potential for serious errors.

The countability of wild animals

Few people would believe that they could overlook a large wild animal on the ground from a flying height of less than 100 m in excellent light. However, there is ample proof that this often happens even to experienced counters, especially when the animals are motionless.

The following factors influence the countability of wild animals from the air:
Cloud cover: Cloudy weather causes poor background contrast. Therefore, aerial counts of wild animals should not be done on heavily overcast days or when the clouds cast large shadows. Even the bright, filtered light of totally overcast days creates poor counting conditions. On summer days, the mornings are usually relatively cloudless.

- **Weather:** Counts in rain or strong wind give poor results.
- **Soil and ground cover:** A soil color that corresponds with the color of the animal, and the extent of the vegetation cover both influence the countability of wild animals from the air.
- **Angle of the sun:** Oblique sunrays are best for aerial counts of wild animals, especially when the flank of an animal is turned towards the counter and the sun is behind the counter. Visibility is poor when the sun shines into the eyes of the counter.
- **Wind:** A constant, strong wind can influence the counting strip width through the tilting of the aircraft. Gusts of strong wind can have a detrimental influence on the concentration of the counters and can make it difficult for the pilot to maintain a constant flying direction and height.
- **Inability of a counter to detect or recognize animals from the air:** This can be greatly improved when color slides of the various animals present in the area are taken from the air at the correct flying height in advance and are studied by the counters before the count begins.
- **Exhaustion and hypnosis:** Flights that are done over large areas should be interrupted at least once every 1.5 hours to give the counters an opportunity to relax. Short strips with numerous turns lead to intense exhaustion of and discomfort for the crew.
- **Strip width and flying speed:** The effect of strip width on the visibility of a given animal when counting narrow strips is a question of the time available to detect an animal. In the case of wide strips, the ability to see an animal is an additional factor. When the strip width or flying speed is doubled, it halves the available time to explore a given surface area.
- **Disruptions:** When wild animals have been disturbed for any reason such as hunting or capture by means of a helicopter shortly before a count is done, their normal flight behavior will have changed, and this will affect aerial counts.
- **Social behavior:** Large herds are easier to detect than solitary animals.

- **Appearance of the animal:** Animals whose skin pattern and color stand out against the background are easier to count than animals that blend with their environment. Black animals are more visible on ordinary winter veld than light brown, dune-colored or reddish-brown animals. Large animals are easier to detect than small animals.
- **Activity patterns:** Moving animals are easier to see than resting ones, especially when they rest under trees.
- **Vegetation:** Most wild animals are optimally visible against an open, green background of grass. In savanna areas, dense leaves and branches impair visibility and counts must inevitably be done against a dune-colored background at times when the trees have shed their leaves. Animals are more difficult to detect against the mottled background of a mixed savanna than against a uniform background. The optimal counting height over open areas is 90 m. Over densely forested areas or dense thickets, an increase in the flying height to a maximum of 107 m will improve the sight angle to such an extent that it will be easier to see between the patches of bush and count the animals. At this higher elevation relatively, more time is also available to explore a given piece of land, provided the aircraft flies as slowly as it can do safely.
- **Visibility:** A counter cannot count what is not clear to see. Individual animals in a large group can be difficult to count, especially when the herd is resting. Certain animals form a distinct line when they are alarmed and flee. They are then easy to count. However, other animals will bunch and mill around when disturbed, and they are difficult to count. Predators usually hide as soon as they hear an aircraft and are then virtually impossible to spot or count from the air.

Terrain

In regions with mountains and plains, the mountainous areas should be counted separately from the plains and foothills. A different flying speed, flying height and strip width will also possibly apply. Large areas that cannot be counted in a single day should be divided into blocks for counts on different days. The best flying speed is a compromise between the searching capacity and counting effectiveness of the counters and the available equipment, money and time.

Practical hints for counts from a helicopter

The following practical hints will help to plan an aerial animal count on most game ranches:

- Use at least a four-seater helicopter. The flying costs are approximately 33% more than for a two-seater helicopter, but the improved accuracy of the count and the higher-flying speed compensate for this financial disadvantage.
- A helicopter will use about one drum (200 litres) of fuel for every two hours of flying time.
- In savanna conditions 1000 ha can be counted easily in one hour of flying time.
- Use a 1:50 000 topographic map to determine the flight lines. Mark any power and telephone lines clearly on the map. They are a major safety threat.
- Wear warm clothes, gloves and a hat because the doors are often removed when counting animals and the air temperature especially on early winter mornings is quite chilly.
- Wear wool or cotton clothes and do not fly with contact lenses in case there is an accident.
- Fix spectacles so that they do not blow off.
- Put extra counters on standby so that any counter who becomes airsick can be replaced immediately. Becoming airsick is not a sign of weakness; it is normal for most people.

Counting errors

It is seldom possible to count all the animals on a game ranch accurately. As already indicated, precise or repeatable counts are the rule. They are also desirable for establishing harvesting rates and quotas. However, sometimes it is necessary to determine the actual population size of one or more species on a ranch as accurately as possible. This can only be done by obtaining an idea of the inherent counting errors for given species when using general counting techniques. It is clear that aerial counts should be done in the morning, and preferably by helicopter. A field strip count with a fixed strip width equal to the mean visibility distance of the animals in their specific habitat type, and where the calculation is based on the perpendicular distance of the animals from the strip line, is relatively accurate and inexpensive.

Data during a count can be used to estimate the number of animals the next year by ***using the population growth formula***:
N = No e(λ - μ)t where; N = population at present value
No = population at starting value (count 909 impala of which 318 are yearlings = 35%)
e = logarithmic function
λ (lambda) = births
μ (mu) = mortalities
t (time) = years

Annual population growth for impala
N = 909 × e0.35
= 380 lambs will be born during next lambing season
Therefore, the total expected number of impala for the next year is (909 + 380 = 1289).

Image 7: Bell Jet Ranger with marked strips as indicators of the grid lines for census team

III. ANIMAL MANAGEMENT & VETERINARY SCIENCE

Game ranch managers must follow a code of conduct when dealing with wild animals, which in some cases aligns with domesticated species but differs in many respects as well. Any research on a game farm must take animal welfare into account; the same goes for the capture of wild animals, which must ensure the health of the animals take priority. Similarly, holding facilities for game farm animals should follow clear guidelines, and transporting animals within and between parks must be done in a cautious and planned manner to ensure safety of both the animals and human operators. Animal culling and disease control measures are also key to any game ranch management plan, for both the health of animals in the area and to sustain the investment. Best practices on each of these themes follows in the sections below.

A. THE WILDLIFE MANAGER& RESEARCH

This section emphasizes the responsibilities of investigators, teachers, handlers, owners and institutions using wild animals for research purposes to:

- Ensure that the care and use of wild animals is justified, taking into consideration the scientific or educational benefits and the potential effects on the welfare of the wild animals.
- Ensure that the welfare and humane care and use of wild animals are always considered.
- Promote the development and use of techniques, procedures and practices that replace the use of wild animals in scientific, teaching and management activities.
- Minimize the number of wild animals used in research projects.
- Refine methods and procedures to avoid pain or distress in wild animals used in scientific activities.

General principles for the care and use of wild animals for scientific purposes

Wild animal researchers are committed to implementing the four R's when involved with research:

- Reducing the number of animals used for research.
- Replacement by non-animal methods whenever possible.
- Refinement of the techniques used to eliminate or reduce suffering and improve animal welfare.
- Respect to ensure that appropriate care is taken in the conduct of all our animal studies.

Justification

Scientific and teaching activities using wild animals may be performed only when they are essential:

- To obtain, evaluate and establish valuable and significant new information relevant to the understanding of humans and/or wild animals.
- For the maintenance and improvement of human and/or wild animal health and welfare.
- For the improvement of wild animal management or production.
- To obtain and establish significant information relevant to the understanding, maintenance or improvement of the natural environment.
- For the achievement of the educational and training objectives of students studying wildlife.

Responsibilities and the 4R's

Investigators and teachers who use wild animals for scientific purposes have personal responsibility for all matters relating to the care and use of these wild animals. They have an obligation to treat these wild animals with respect and to consider their welfare as an essential factor when planning or conducting projects.

Replacement

Techniques that totally or partially replace the use of wild animals for scientific purposes must be sought and used wherever possible.

Reduction

- Each project must use no more than the minimum number of wild animals necessary to ensure scientific and statistical validity.
- The principle of reducing the number of wild animals used should not be implemented at the expense of greater suffering of the individual remaining wild animals.
- Scientific and teaching activities involving the use of wild animals must not be repeated unless essential for the purpose or design of the project.
- Teaching activities must involve no more than the minimum number of wild animals required to reach the educational objectives.
- Overproduction of wild animals bred for scientific research purposes should be avoided so that the need to kill healthy wild animals is minimized.

Refinement

- Wild animals must be suitable for the scientific purpose taking into account their biological characteristics including social behavior, genetic attributes, nutritional and ecological requirements and general health status.
- The design and management of wild animal accommodation should meet species-specific needs (SANS 1884-1:2004 Holding pens for temporary housing of animals Part 1: Holding pens for wild herbivores at auctions and in quarantine facilities). Special consideration is required where this is precluded by the requirements of the research project.
- Animals should be transported, housed, fed, watered, handled and used under conditions that meet species-specific needs. The care and use of the wild animals must be a primary consideration in the provision of care, which should be based on social behavioral and biological needs.
- Wild animals should not be taken from natural habitats unless wild animals bred in captivity are not available or are not suitable for the specific scientific purpose.
- Investigators and teachers who use wild animals for scientific purposes must employ the best available scientific and educational techniques and be competent in the procedures they perform or must be under the direct supervision of a person competent in the required procedures.
- Research projects should be planned and designed to avoid both pain and distress in wild animals. If this is not possible, pain or distress must be minimized.
- Pain and distress cannot be evaluated and measured easily in wild animals and therefore investigators and teachers must assume that wild animals experience these in a manner similar to humans unless there is scientific evidence to proof the contrary. Decisions regarding the wild animals' care and use should be based on this assumption.
- An animal with clinical signs of pain or distress not predicted in the protocol must have the pain or distress alleviated promptly. If this is not possible the wild animal must be euthanized without delay or where possible released back into the wild.
- Scientific and teaching activities that may cause pain or distress of a kind or degree, for which anesthesia would normally be used in medical or veterinary practice, must be carried out using anesthesia appropriate to the species and the procedure.
- Pain management appropriate to the species, procedure and circumstances must be provided.

- The use of local or general an aesthetic, analgesic or tranquillizing agents must be appropriate to the species and should at least parallel their use in current private medical and/or veterinary practice.
- Where it is established that the purpose of the project precludes the use of an aesthetic or analgesic agent to alleviate pain, the planned end-point of the project must be as early as feasible to avoid or minimize pain or distress in the wild animals.
- Neuromuscular blocking agents must not be used without appropriate general anesthesia, except in wild animals where sensory awareness has been eliminated. If such agents are used, continuous or frequent monitoring of paralyzed wild animals is essential to ensure that the depth of anesthesia is adequate to prevent pain or distress.
- 'Death as an end-point' (see definition) should be avoided wherever possible.

Respect

- Wild animals have no rights according to the Constitution, but there is no reason for treating any animal with disrespect.
- There is a very fine line between animal rights and animal welfare.

Conducting of Research Projects

Detecting pain and distress

- Researchers and teachers should be familiar with the normal behavior of the specific wild animal species chosen and knowledgeable about signs of pain and distress specific to that species and must assess these animals regularly for these signs.
- Wild animals must be observed for deviations from normal behavioral patterns that are often the first indications that these animals are experiencing pain or distress. Changes in patterns of sleeping, feeding, drinking, grooming, exploratory behavior, performance in learning or discriminatory tasks, and social and reproductive behavior should be recorded, and appropriate action taken to minimize distress.
- Wild animals must be regularly assessed for signs of pain or distress. These may include aggressive or abnormal behavior (some species may become unduly submissive), abnormal stance or movements, abnormal sounds, altered cardiovascular or respiratory function, abnormal appetite, rapid decline in body weight, altered body temperature, vomiting and abnormal defecation or urination. Indicators of sustained pain or distress may include loss of body weight, failure to thrive, impaired reproductive ability and reduced resistance to disease.

Limiting pain and distress

- Pain and distress cannot be evaluated easily in wild animals and therefore investigators and teachers must assume that these animals may experience pain in a similar manner to humans unless there is scientific evidence to the contrary. Decisions regarding the animals' welfare should be based on this assumption.
- Investigators and teachers must anticipate and take all possible steps to avoid or minimize pain and distress including:
- Choosing the most humane method for the conduct of the research project.
- Ensuring that the technical skills and competence of all people involved in wild animal care and use are involved in the project.
- Checking and assessing wild animals regularly for evidence of pain or distress throughout the course of the research project. The frequency of observations will be determined by the nature

of the protocol and must be such that changes in any animal's condition can be detected at an early stage.

- Acting promptly after appropriate advice to alleviate pain or distress in these wild animals.
- Using an aesthetic, analgesic and tranquillizing agents that are appropriate to the species and the scientific or educational objectives.
- Determining a set of criteria for early intervention and humane end-points.
- Conducting studies over the shortest time practicable and using appropriate methods of the humane killing of animals where necessary.
- Where the condition of a wild animal indicates that there is a need for intervention to limit pain or distress, actions that may be taken include an increase in the frequency of observation, consultation with a veterinarian, administration of analgesic agents or other appropriate medication, removal from the project and euthanasia.
- Scientific and teaching activities that are liable to cause pain of a kind and degree for which anesthesia would normally be used in medical or veterinary practice must be carried out under anesthesia.
- If wild animals develop signs of severe pain or distress despite the precautions outlined above, the pain or distress must be alleviated promptly, or the animals must be euthanized without delay. Alleviation of such pain or distress must take precedence over continuing or finishing the research project.

Repeated use of Animals for Scientific Purposes

Individual wild animals must not be used in more than one scientific activity, either in the same or different projects, without the approval of the Animal Ethics Committee (AEC). However, appropriate re-use of wild animals may reduce the total number of animals needed in a project, result in better experimental design, reduce distress or avoid pain to other animals. When considering approval for the re-use of wild animals, the AEC must consider:

- The pain or distress and any potential long-term or cumulative effects caused by any previous procedures.
- The total time that a wild animal will be used.
- The pain or distress likely to be caused by the next and subsequent procedures and whether a wild animal has recovered fully from the previous procedure before being used in the next.

Duration of Scientific Activities

Scientific and teaching activities, particularly those that may cause pain or distress, should be as brief as practicable. AEC approval must be sought for the continued long-term use of individual wild animals. The decision to continue must be based on the clinical wellbeing of the animal and behavioral evidence of aversion to the situation.

Handling, Restraint and Confinement of Wild Animals

- The total time that a wild animal will be used.
- Wild animals must be handled only by personnel instructed and competent in methods and techniques that avoid pain or distress.
- When the use of restraint devices appropriate to the wild animal is necessary for the animal's welfare and the safety of the handler, it should be for the minimum period required to accomplish the purpose of the research project.

- Tranquillizing or anesthetic agents may aid restraint but may prolong recovery from the procedure. When these agents have been used, greater attention may be required in assessing the recovery of the animals.
- Periods of prolonged restraint or confinement should always be avoided. However, where prolonged restraint or confinement of wild animals is proposed, such as housing livestock in metabolism cages, consideration must be given to the wild animals biological, including behavioral, needs. Such wild animals must be assessed regularly by a veterinarian or other qualified and competent person not otherwise involved in the research project. If any negative impact on a wild animal is detected, the animal must be removed from the restraint or the method of restraint must be modified to minimize the impact of distress.

Completion of projects

Upon completion of the research project, wild animals must be returned promptly to normal husbandry conditions or their natural habitat if appropriate and permitted, or where necessary, killed humanely. However, euthanasia must be the last option.

Image 8: Removal of a snare in an African wilddog

B. THE WILDLIFE MANGER & GAME CAPTURE

Ethical handling of game capture medicine/drugs by veterinarians

The major problem that the wildlife veterinarian faces is that there are very few veterinary products registered to be used in wildlife. Most products are registered for the use in humans or other animals and must be used off-label. However, the wildlife veterinarian remains responsible for the off-label use in wild animals.

Responsibilities for the Use of Chemical Products by Veterinarians

- A veterinarian may treat a wild animal with a registered veterinary or medical chemical product off-label or with a medicine compounded by a pharmacist in a suitably registered facility except where such treatment is prohibited by this Code or in other relevant legislation.
- A veterinarian must not treat a wild animal of a major food species with a veterinary or agricultural chemical product unless:
  - The product is registered for that wild animal species.
  - The product is registered for another major food species.
  - The use of the product on that wild animal species is authorized by a valid permit issued by the relevant authorities.
- A veterinarian only treats a single wild animal which can be fully identified.
- A veterinarian must not treat an animal of a food species with a registered product off-label, with unregistered products, or with registered human pharmaceuticals unless the animal is under his care and can be fully identified.
- A veterinarian treats a wild animal of a food species with a veterinary chemical product must provide the person in charge of the animal with an advice note on the with drawl period.
- A veterinarian must not treat a wild animal of a food species with a veterinary chemical product in a manner contrary to an instruction under a "Restraints" heading on the product label, except for a single animal. He may treat a wild animal in a manner contrary to a label "Precautions" heading, if necessary.
- A veterinarian must not inject a wild animal with a product that is labeled only for oral or topical use.

Responsibilities for the Supply of Chemical Products by Veterinarians

- A veterinarian should not supply or prescribe to a person a veterinary chemical product for the treatment of a wild animal of a food species unless the product is packaged and labeled appropriately.
- A veterinarian must not supply or prescribe to a person a veterinary chemical product for the treatment of a wild animal of a major food species unless the product is registered for that species, or another major food species, or the supply or prescription is for a single animal.
- A veterinarian must not supply or prescribe a veterinary chemical product, when there are reasonable grounds for suspecting that the product may be used by human, or otherwise misused.
- Where there is a veterinary chemical product already registered for a specific treatment, a veterinarian cannot supply an equivalent product that he had prepared or repacked for that specific treatment.
- Where a veterinarian had prepared a veterinary chemical product, he should only supply a quantity sufficient for a single course of treatment.

Responsibilities for the Provision of Prescriptions, Labels or Record Keeping by Veterinarians

The following information is important:

- Name (trade or generic) of the chemical product.
- Name and address of the person prescribing or dispensing the product.
- Name of the owner of the wild animals.
- Address of the owner of the wild animals.
- Particulars of the wild animal(s) to be treated, including the specie, sex, age, number, and identification, or the information that is available.
- Dosage of product to be administered to each animal.
- Date of treatment, or the proposed treatment date.
- Re-treatment interval.
- Withholding period.
- Hand signature and date of the veterinarian that write the prescription.

Responsibilities for the Use of Veterinary Medicine/Products by Persons other than Veterinarians

A non-veterinarian must not treat a wild animal with a veterinary medicine unless:

- The product is registered for that use.
- The product is supplied or prescribed by a veterinarian and is handled in accordance with the product label and where provided or directions of the veterinarian.
- The product is administered by a person under the direct supervision of a veterinarian.
- A person must not use a veterinary medicine in a manner other than in accordance with the product label, a permit, or an advice directions or label provided by a veterinarian.
- A person must not use a veterinary medicine in a manner contrary to an instruction under a label "Precautions" heading, except in accordance with a direction note or label provided by a veterinarian.
- A person must not use a veterinary medicine in a manner contrary to an instruction under a label "Restraints" heading except in the case of a single animal that is treated in accordance with a direction note or label provided by a veterinarian.
- A person must comply with all instructions on a direction note or label provided by a veterinarian.
- A person must not inject an animal with a product that is labeled only for oral or topical use.
- A person that uses a veterinary medicine to treat an animal of a food species belonging to another person, he must ensure that all label information relating to withholding periods, handling requirements, relevant directions for use and any information provided on labels from a veterinarian is supplied to the person in charge of the animal.

Buying from Authorized Sources

- The game rancher must only buy animal medicines from his veterinarian, except for the over the counter products.
- Only buy and use registered animal medicines.
- Only buy enough of the appropriate medicine that is needed.

Keep Proper Records

The rancher must keep a full record of all the medicines he buys and uses on the wild animals on the ranch. It is a legal requirement to keep records of all the medicines that are administered to food

producing wild animals, including those administered by the veterinarian or in-feed. These records must be kept available for inspection by authorized persons.

- At the time of purchasing the medicine your record must show the;
- Name of the product.
- Date of the purchase.
- Quantity purchased.
- Withdrawal period.
- Name and address of the supplier.

At the time of administration, the rancher must also record:

- Name of the product.
- The date of administration.
- Quantity and frequency of administration.
- Withdrawal period of the medicine.
- Identification of the game animals treated.

Responsibility in food production. Because of the legal requirements which fall on the food industry about avoiding residues of animal medicines in human food, the authorities will look to the rancher for valid information about the medicines used on wild animals. Especially when the game rancher wants to produce organic meat for the export market. The rancher must remember that consumers will do residual tests and can trace the product back to his ranch:

- Dates on which any withdrawal period for meat or any other animal product ended.
- Date on which the treatments finished.
- Name of the person who had administered the animal medicine.
- Batch numbers and expiry dates of all products used in the wild animals.

All records must be kept for at least five years. This is the minimum period that is required by the law. The veterinarian should inspect and sign these records annually.

Administer Medicines Properly

- The game rancher must make sure that any person on the ranch who handles or administers medicines to wild animals is responsible for ensuring that any withdrawal period is observed.
- Medicines should be handled and administered by a competent person or under his supervision. The veterinarian will be responsible to help with the training that the medicine is administered in the right way, including injections. Some medicines may be administered only under the direct supervision of a veterinarian or according to a veterinarian's prescription. Particular care should be taken when handling medicated animal feed.
- Avoid the unnecessary use of medicines.
- Always read the instructions carefully before administering any medicine. Check all the information that is available, including the label and package leaflet. It is important to use the correct dosage over the prescribed period. This is important where a medicine is administered intramuscular.
- Verify the expiry date on the label and do not use any medicine which is past its expiry date. Medicines have a short shelf-life following incorporation into feed or once the container is opened.
- Only use medicines in the way for which they were authorized, including the approved species, age and dosage, unless otherwise directed by your veterinarian. Never use prescription only

medicines on animals other than the ones for which they were originally prescribed – unless directed by your veterinarian it is illegal and dangerous to do so.
- The treatment program must be completed. Once starting to use a medicine the full course of treatment must be completed to minimize the possible development of resistance.

Monitor Withdrawal Periods

The rancher must observe any withdrawal period stated on the label for the medicine, or as indicated by the veterinarian. This is the period between the end of treatment and the slaughter of the animal for human consumption. It is an offence to slaughter any animal that has not completed its withdrawal period for human consumption, or to sell any animal for slaughter for human consumption.

Store Medicines Safely

- Store medicines always in accordance with the instructions on the label. Storage temperature can be critical to maintain the safety and efficacy of a medicine. Sun light can also damage certain medicines and animal medicines should never be exposed to direct sunlight or allow getting too hot. Medicines stored in a fridge must be kept at temperatures between 2° and 8°C.
- Make sure that all medicines are stored securely, under lock and key. Medicines must be kept in their original containers, clean and out of the reach of children, animals or anyone not supposed to handle them.

Dispose of Unused Medicines Safely

- Do not stock pile partly used medicines. Safely dispose of unused or out-of-date medicines and containers and application equipment (including needles to a sharps container) when you finish the treatment for which they were intended. Always follow the advice on the label about the method of disposal. Disposed medicines must not be able to come in contact with humans and animals again.
- Medicines that are not biodegradable must be destroyed in such a way that they cannot cause damage to the environment.

Management of Stress in Wildlife

The following factors will lead to stress in wild animals:

- An inborn fear of any danger, but especially the fear and anxiety related to being captured. This includes fear of the proximity of humans, vehicles and helicopters.
- Sudden and excessive muscular activity when the wild animals flee from danger.
- Bodily injuries inflicted while running through obstacles such as dense bush, or by being tangled in nets or confined in crates.
- Injuries caused by other wild animals or incurred in attempting to escape.
- Strange and unnatural surroundings such as capture bomas, holding pens and crates, and the accompanying noises and smells of fuel and humans.
- Food and water that is strange and unfamiliar to the wild animals. During capture operations, animals that remain struggling and not brought under immediate control are stressed more.

All aspects of any capture procedure will result in stress for a wild animal. Since excessive stress usually causes death, and because the success of a capture is judged by the minimization of mortalities, it is essential that stress should be avoided or limited as far as possible by using tranquilizers.

The following steps will reduce stress and promote more successful wild animal capture:

- Plan all facets carefully and thoroughly before the capture operation commences.
- Discuss the planned operation and procedures thoroughly with all the staff who will be involved, so that all persons know exactly what is expected from them.
- It is important to demonstrate practical aspects to the staff such as how to hold a wild animal, even though this may appear unnecessary.
- Wild animals that can run only a short distance tend to overheat quickly. Therefore, all capture operations should be scheduled for the cooler months of the year and the cooler parts of the day. In the warmer areas of southern Africa, capture should take place in the early morning only, and be completed before it gets too hot. It is not advisable to capture animals when the maximum daily temperature is above 25° C.
- As a general rule, wild animals should never be captured in hot weather or in the middle of the day when it is hot, and all capture operations should be planned with this rule in mind.
- In many parts of South Africa and Namibia, capture usually starts during the middle of April and ends at the beginning of October. It is not advisable to capture animals outside this period because certain wild animals will then be heavily pregnant, their physical condition will be poor at the end of the winter, and ambient temperatures will be increasing steadily to above 25° C.
- Capture in the late afternoon is not advisable because delays may necessitate handling and loading the animals in the dark. Unless the capture staff are well equipped with special lamps and lights to work in the dark with wild animals that have been recently captured, this practice should be avoided at all costs. Working with wild animals in the dark can be dangerous to both the animals and the staff.
- To avoid overheating and exhaustion, the wild animals should never be herded too far or too fast. When they are being herded towards a capture area by helicopter, they should be given an opportunity to rest before being regrouped slowly and finally pushed into the capture boma.
- Animals must never be herded and captured in hot, humid or rainy weather. This applies especially in subtropical coastal areas.
- Consideration should be given to wild animals that are captured after a heavy rainstorm when the ground and grass are wet and slippery. Under these conditions, the animals may slip and tear muscles or strain tendons (gastrocnemius tendon).
- Many wild animals, but especially browsers such as kudu and giraffe, lose physical condition during the winter as a result of the reduced availability of food and lower energy levels in the vegetation. It is therefore inadvisable to capture these wild animals at the end of the winter.
- Wild animals should not be handled or disturbed unnecessarily after their capture.
- Wild animals living in family groups must be caught and kept in these groups as far as possible. When a group of animals are herded into a capture boma, other small groups or individual territorial rams, bulls or stallions are often also chased in. This may present problems, and there would be less fighting and fewer injuries if the various animals and families were not mixed. This is especially important in the case of Burchell's zebra and the Cape mountain zebra.
- Tranquillizers are recommended for most species after their capture, but they should always be used with care. Special care should be taken not to overdose an animal or to inject it twice. An overdose of tranquillizer may result in the animal lying down in the transport vehicle and being trampled by other animals. All tranquillized animals must be marked clearly with paint for identification.
- The correct use of tranquillizers ensures that the animals are captured and transported in an effective and humane manner.

- All possible precautions must be taken to prevent wild animals from hurting themselves and one another in the crates or holding pens.
- Aggressive wild animals must be separated from the others. Bulls and rams that tend to fight with one another must be crated individually or kept apart from the others to prevent them from being injured. When wild animals such as gemsbok, roan antelope, red hartebeest, impala rams, eland and blue wildebeest are trapped or confined in a small area, they may attack, gore and wound one another fatally.
- Unnecessary noise from the staff and any onlookers must be avoided, especially immediately after the animals have been captured. Any loud noises, unnecessary shouting and revving of vehicle engines must be avoided.
- It is advisable to exclude spectators from the capture area during capture and at the holding pens for the first few days after the capture operation.
- Employ or hire people that have experience of capture techniques.

Ethics and the Game Capture Pilot

The pilot

Since it is well known that there are many possible causes of capture myopathy and those precautions have to be taken to prevent stress in wild animals, the helicopter pilot herding the animals has several tasks and should have the following abilities, qualities and knowledge;

- Besides being sympathetic towards wild animals, the pilot should be able to fly low and execute daring but safe maneuvers in bush conditions. The welfare of the wild animals must always be the first priority.
- The pilot should have a fair knowledge of the behavior of the wild animals to be captured and should especially know how they behave when they are being herded.
- The pilot should advise the seller or buyer when the herding of the wild animals by helicopter is no longer economical.
- The pilot should report the sighting of any wild animal carcasses to the owner.
- It is important that the pilot has proper radio communication with the capture team at all times. The pilot should advise the ground team timeously as to the number of wild animals being herded, especially when tranquillizers or horn pipes are needed, or male animals have to be separated from the rest. The capture team can also advise the pilot of changes in the wind direction or of any problems they may have, such as not being ready for the capture.
- Planning the erection of a capture boma from a helicopter saves time. Any roads leading to the site can be identified and scouted, and wild animal concentrations can be found by following the direction of animal trails. Thus, it can be established whether the boma is centrally and correctly placed.
- Special attention should be paid to tall trees, telephone lines, radio towers and power lines that could be a safety hazard.
- The pilot can help to plan the boma, thus easing the pressure on him if the boma is planned correctly with his needs in mind. This will also save capture time and expenses. It is therefore necessary for the pilot to have a sound knowledge of boma planning, erection and function.
- The pilot should be able to recognize the sex and age differences of the animals to be captured.
- The pilot should fly low and slowly along the boma entrance to sweep the entrance before the capture. Any drag marks of the capture materials, and human scent and tracks will be blown away by the down draft caused by the rotor blades of the helicopter.
- A trial run is recommended to see whether there are any unforeseen problems.

- The pilot should be able to handle considerable stress with the minimum problems. Patience is also required when herding the wild animals.

Ethical Considerations when Herding Wild Animals with a Helicopter

The pilot should treat and herd the wild animals in the following way:

- He should allow the wild animals time to rest. The wild animals should also be herded slowly but surely while being kept together. It is only at the end that the animals should be pushed quickly into the capture boma or nets.
- It must always be remembered that the first signs of capture myopathy and stress may be seen when the animals are kept together and herded. A good pilot is therefore in an excellent position to prevent or limit the degree of capture myopathy and stress in wild animals.
- Wild animals found near a waterhole may have drunk recently and it may be detrimental to herd them over a long distance to the capture boma.
- Some wild animals such as impala, black wildebeest, springbok and tsessebe are difficult to herd because they do not fear the helicopter. Moreover, they can easily change direction while running. This happens especially when the animals have been herded before or are exhausted.
- Nyala and bushbuck are not herded easily by helicopter. They usually run off in any direction and try to hide under trees. Kudu bulls and impala rams often refuse to move at all.
- The pilot should note any wild animals that are next to or close to the perimeter fences. He should prevent them from jumping over the fence or going through it and escaping.
- Wild animals should not be captured after a heavy rainstorm when the ground and grass are wet and slippery. Under these conditions, the herded animals may slip and injure themselves by tearing muscles and straining tendons.
- Various species should not be mixed because they may fight and even kill one another.
- The wild animals should be herded from as close to the capture boma as possible because this saves time and money and is less stressful for them.
- Wild animals in poor physical condition should be herded slowly and with exceptional care.
- All animals, but especially impala, should never be herded when the ambient temperature exceeds 25° C.
- Wild animals should never be herded fast through areas where ridges, rocks, deep sand, gulleys or dense bush occur because the animals may fracture their limbs or sustain other injuries.
- The pilot should be familiar with the calving times of the animals to be captured. Cows with young, unweaned calves should never be captured.
- Only manageable groups of wild animals should be herded at a time. Capturing too many animals at one time causes loading and sorting problems that may result in deaths.
- The wild animals should be directed to the boma entrance from a distance, whenever possible. This will make the drive easier because some animals are not easily turned when running at speed.
- The pilot should herd the wild animals past the first three curtains and then move the helicopter away. From there and on to the loading area the animals should be herded by the ground staff.
- Certain male animals such as adult impala rams fight with one another or with the females in a boma. They should be separated from the group before they reach the entrance and can be captured at a later stage.
- The pilot should herd the wild animals along the shortest and easiest route to the capture boma.
- Different family groups of especially Burchell's zebra and the mountain zebra should never be mixed during the capture. Mixing different family groups is the major source of trauma and injury for zebra.

- Wild animals that are found near the boma entrance but are not part of the capture quota should be turned away before they enter the capture boma.
- Wild animals that refuse to enter the boma should be encouraged to join the groups that were cut out of the herd near the boma. If they are not turned away, they will refuse to enter the boma again, causing some of the herded animals to follow them and thus preventing their capture.

Chemical Immobilization

The principles of selecting the drugs and dosages

- Preference for a wide therapeutic index (ratio of effective dose to lethal dose), and therefore safer to use on animals.
- Rapid effect to increase the possibilities of finding darted animals.
- Minimum side effects e.g. excitement, muscle tremors, respiratory and circulatory depression, and change in body temperature, salivation and bloat.
- Immobilize the animal effectively.
- Small Volume to fit in a 3 mℓ dart.
- Reversal agent available.

Reasons for the use of chemical immobilization

Chemical immobilization is used primarily when individual animals have to be captured from a herd, or for the capture of dangerous and unmanageable animals such as elephants, rhinoceroses and hippopotamuses. It is also used to capture aggressive and difficult animals, such as gemsbok, roan antelope, adult eland and kudu bulls. Giraffe can be captured successfully with immobilizing drugs and this is cheaper than other methods. Moreover, it allows young animals to be selected and it therefore becomes unnecessary to herd an entire family group just to capture some young animals.

Other reasons for using chemicals to capture wild animals are;

- To examine and treat sick and injured animals or animals caught in snares or traps.
- To remove aggressive individuals from a group of wild animals that was captured by other means.
- To select specific wild animals from a group.
- To mark wild animals for ecological and other studies.
- To capture and retrieve wild animals that have escaped from a wildlife area.
- To collect blood for disease studies and surveillance, such as for foot-and-mouth disease surveys.
- Safari darting, non-lethal hunting or green hunting.

Advantages of chemical immobilization

- Chemical immobilization is a safe and effective capture method when applied correctly and competently, and has the following main advantages;
- It is the safest and most economical method for capturing rare and valuable animals. However, it must be emphasized that a responsible and experienced person must perform it.
- It is more economical than other methods when only a small number or single animals are to be captured.
- It is the safest method for capturing, handling, loading and transporting large and/or aggressive animals.
- It is a useful method for removing aggressive or injured animals from holding pens or transport crates.

- Because there are antidotes to reverse the effect of some of the drugs, even an overdose of these capture drugs is unlikely to kill the animals.

Disadvantages of chemical immobilization

- According to current legislation, these immobilizing drugs are classified as Schedule 6 medicines and may not be sold to any person other than a veterinarian. A pharmacist can dispense them after receiving a veterinary prescription.
- The handling of the darting equipment, immobilizing drugs and the immobilized animals after capture requires knowledge of the drugs used and a high level of professional expertise.
- The firing range of some dart guns is limited, and wild animals are often too far away for this immobilization method to be used. Animals in a group or herd are often disturbed by the shot and may run away. It then becomes difficult to approach them again.
- Immobilized ruminants must always lie on their sternum or chest to prevent bloating and the inhalation of fluids or the stomach contents into the lungs, with subsequent suffocation or pneumonia.
- When a dart does not penetrate a suitable muscle, the absorption and action of the immobilizing drug are delayed. The animal may then exhaust itself before the drug becomes effective. This could result in the animal dying of exhaustion or capture myopathy.
- If a dart does not function properly or is incorrectly loaded, or if only a small portion of the immobilizing drug is injected, or the dose is inadequate, the wild animal can exhaust itself by running too far. This can lead to capture myopathy. The immobilizing drug is then often incorrectly blamed.
- The tracking of immobilized wild animals in dense bush or rocky areas may damage the retrieval vehicles. It can also result in the immobilized animal not being reached in time.
- When the animal cannot be darted from the ground or from a vehicle, a helicopter has to be used.
- The best capture equipment and immobilizing drugs available are expensive because they are imported.
- Some drugs may have adverse and untreatable effects or side effects on an animal.
- Most of the immobilizing drugs are safe if used correctly, but wild animals can die from overdoses, especially if the correct antidotes or other life-saving respiratory and cardiac stimulants are not administered.

Image 9: White rhinoceros bull in a well-designed boma

C. HOLDING FACILITIES

The design and management of facilities will depend on:

- The type of wild animals to be kept and the studies to be undertaken.
- Game auctions.
- Quarantine of animals for export/import.
- Doing research on animals.

The pens can also have multi-function and therefore be used for a combination of the above mention activities. The overall condition and management of holding facilities must always be compatible with maintaining wild animal wellbeing and good health.

Factors for Consideration

- Species-specific behavioral requirements, including the availability and design of space to enable free movement and activity, sleeping, privacy, contact with others of the same species, and environmental enrichment.
- Provision of single housing for wild animals when appropriate for the species and if necessary for the purpose of the project (for example, during recovery from surgery, collection of samples or to prevent fighting between individuals).
- Species-specific environmental requirements, such as lighting, temperature, air quality, appropriate day/night cycles and protection from excessive noise, cold drafts and rain.
- The need to provide easy access to clean food and water.
- The ability to clean the pen, cage or container in such a way that it is safe for the handlers and the animals.
- Prevention and protection from the spread of pests and disease between animals.
- The design of the pen must meet the requirements of the research project.
- The need to observe the wild animals readily without disturbing them.

General Requirements for Holding Pens

Layout of holding pens

The basic functional aspects of a good pen design are:

- Each pen has a roofed area and an open area. The roofed area must not be less than a third of the total area of the pen.
- Each pen must have a minimum of two doors, and access one or two separate passageways. This allows for an easy flow of animals between pens, when cleaning and feeding must take place.
- The width of the door must be wider than the width of the passage. When the door is in the open position it forms an angle with the wall of the passageways. This eliminates sharp corners or rapid changes in direction when the wild animals are moved in and out of the pens.
- The design of the off-loading ramp has a funnel effect as it approaches the passageways.
- The curved passageways between the loading ramp and the pens prevent the animals from seeing too far ahead and lead to easier loading and off-loading of the wild animals.
- The crush has sliding gates which will allow individual wild animals to be blocked by handles, treatment or tranquilization.

Location and environment

- Holding pens shall be constructed in quiet areas, away from noisy human activity, industrial activities, buildings, domestic animals, main roads, railways or overhead power lines.

- Holding pens shall be erected in such a way that wild animals are protected from strong prevailing winds, and direct sunlight. The pens should be facing north to prevent that it becomes too cold in winter months. A roof must cover at least a third of the surface area that shade for the animals are provided.
- Suitable non-toxic trees shall be incorporated into the open areas of the pens, to provide daytime shade and a more natural environment for the animals.
- Pens shall be situated on well-graded and well-drained soils. Adequate drainage and run-off of rainwater is important that animals shall not stand in stagnant muddy water.

Construction of the pens

- Enclosures and pens shall be constructed of materials of adequate strength to suitably contain the captive animals, taking into account their species, age, needs and habits, as well as the particular needs and requirements of family units.
- Locally-available construction materials like mopane logs may be used with the main purpose that it is strong enough to keep the animals in and prevent injuries.
- Construction methods used shall be such that the insides of the pens are free from sharp edged or protruding objects to prevent injuries to the animals. Creosoted poles should never be used for the construction of wild animal pens within one year of treatment, because it will cause creosote poisoning, especially in rhinoceros.
- Roofs. Pens shall be provided with a roofed area which covers at least one third of the total pen area. The roofed area can also serve as night quarters. The height to the underside of the roof shall be not less than 3 meters, except in the case of a pen which will house giraffe, where the minimum height shall be 5 meters.

Area of pens

- The total area of a pen shall consist of a day area (open), and night quarters (walled, and under a roof). In general, the night quarters shall comprise approximately 25 percent of the total pen area. The minimum pen size must not be less than 9 square meters.
- The day pen area required for antelopes and zebra may be calculated on the basis of 1 sq. per 25 kg of live body mass. The minimum square meter in brackets per adult animal for the following species are required; impala (6), wildebeest (8,5), zebra or kudu (10), giraffe (18), buffalo (30).
- The day area of the holding pen shall be constructed in such a manner that it can easily be divided into two separate compartments, so that the animals can be contained in one compartment while the other compartment is being cleaned.

Food and water

- Animals must receive appropriate, uncontaminated and nutritionally adequate food of a quantity and composition that maintains normal growth of immature animals or normal weight of adult animals as well as meet the requirements of pregnancy, lactation or other conditions.
- Where possible, animals should be given variety in the composition and presentation of food that is suitable for the species. Uneaten perishable food should be removed promptly unless contrary to the needs of the species.
- Clean, fresh drinking water should be available at all times as suitable for the species.

Quarantine pens

- An essential feature of a quarantine facility is a fence within a fence (concept is a box in a box), with an exclusion zone between the fences to prevent nose-to-nose contact between animals on either side of the fence.
- The whole quarantine area shall be surrounded by a 2,5-meter-high security perimeter fence, which shall be located at least 10 meter away from the nearest pens within the quarantine facility. The surveillance zone is the open area between the pens and the perimeter fence which shall act as an exclusion zone.
- It is recommended that the external security perimeter fence be covered with game-capture plastic (or other suitable opaque material), in order to prevent animals from seeing outside.
- Burrowing or gnawing animals (such as warthogs or porcupines) will cause holes than can help carnivores to enter the quarantine area and can kill animals in the pens.
- The surface of the exclusion zone must be sprayed with herbicides to keep it free from vegetation or long grass.
- Access to quarantine area. The purpose of quarantine is to prevent human to animal and animal to animal contact. When the official quarantine period has started, pedestrian access to the quarantine area should be limited to a single, lockable entrance with a foot bath containing an effective disinfectant.
- A suitable locker room shall be provided adjacent to the pedestrian's entrance gate to hold overalls and gumboots for the use by all persons entering the quarantine facility and leaving them on departure.
- A signboard shall be prominently displayed at the entrance to the quarantine area saying; QUARANTINE AREA. NO UNAUTHORIZED ENTRANCE.
- Insect control measures. Where insect control is necessary for the prevention of diseases transmitted by insects, appropriate measures to prevent contact between animals and these insects shall be taken. Insect lamps that will electrocute insects and spraying of the walls of the pens with insecticide will keep the insect populations low.

Responsibilities of the Person-in-charge of breeding and/or holding facilities

- Animal acquisition, breeding and holding facilities must be supervised by persons with appropriate veterinary or animal care qualifications or experience.
- The person-in-charge should be responsible for:
  - Managing the day-to-day care of the wild animals in the holding and breeding facilities.
  - Supervising the work of personnel in the facility.
- The boma manager should be knowledgeable about signs of pain, distress and illness specific to each species kept and ensure that the wellbeing of all wild animals is regularly assessed.
- The boma manager must ensure that ill or injured animals that are not assigned to projects are treated promptly. Animals that die unexpectedly should be subjected to a post mortem.
- The boma manager should contribute to the development and maintenance and improvement of the animal care policies and procedures.
- The boma manager must ensure that personnel receive appropriate protective clothing, maintain high standards of personal hygiene, do not eat, drink or smoke in animal areas, and have all required vaccinations, particularly against tetanus, rabies and other zoonoses that may be applicable.
- Written special operating procedures must be established for use in the management of holding and breeding facilities.

- The procedures should take into account the requirements of the species held, the studies being conducted and the health and safety of personnel and include:
  - Transportation, quarantine and disposal of dead animals.
  - Routine husbandry like water and feeding programs.
  - Prevention, diagnosis and treatment of disease.
  - Assessment of health status and genetic constitution of the different species and physical environmental factors.
- The boma manager must maintain adequate records to allow effective management of the breeding stock including the detection of the origin and spread of disease.
- Records should include:
  - The source, care, allocation, movement between locations, use and fate of all wild animals.
  - Details of any disease occurrence.
  - The fertility, fecundity, morbidity and mortality in the different breeding groups and the health status, genetic constitution and physical environment of the animals.

Handling of wild animals between capture and off loading

When deciding on a capture date, the following should be considered:

Time of year - Do not capture animals during their mating period, heavily pregnant stage or before calves/lambs are weaned.

Temperature - Where possible avoid the capture and loading of animals at ambient temperatures exceeding 25° C. Impala, for example, are sensitive to higher temperatures during capture. During the coldest time of the year consider transport "chill factor" and to protecting the pens to the outside by using capture sheeting or shade netting.

Condition of the animals - Never capture or transport animals in poor condition. If the veld condition is poor, remove the animals timeously to prevent wildlife losses.

Buyer of animals - When a ranch owner plans to purchase wild animals for his ranch, there are several factors that need to be considered;

- Is the species indigenous to the area?
- Are there any restrictions laid down by the Nature Conservation authorities as to their distribution?
- Do any of the neighbors have the same species and how did they adapt?
- Is the area large enough to minimize competition and maximize species diversity?
- In what condition are the animals and the grazing? Never move animals from good to poor grazing or from sweet bushveld to sour grassveld without due consideration.
- Has the mating season been taken into consideration?
- Do not move animals from a warm to a cold area, especially in the winter.
- Is the ranch where the animals will be delivered infested with ticks or other parasites? Will it be necessary to treat the animals before offloading and/or to install parasite control applicators?
- Are there predators on the ranch?
- Will the animals be transported in suitable crates?
- Will it be necessary to tranquilize the animals?

- Animals in poor condition should be fed. Will it be necessary to supplement the natural feed?
- Newly released animals usually patrol the perimeter fence and will often try to break the fence, especially at the corners. Add extra support material such as mesh wire for a short distance in the corners. Place containers filled with water in these corners.

Preparations - The following preparations and arrangements have to be made before the animals are delivered and released:

- Has a permanent offloading ramp been built on the ranch? Is the ramp adjustable to all vehicles?
- Can heavy vehicles access the ramp? Can the vehicles turn around? Is the ramp built away from fences, gullies, dams, rivers, holes, sandy soil, stones or other obstructions that can injure the animals?
- Has the ranch perimeter fence been inspected for damages or holes in and under the fence been fixed beforehand?
- Has temporary water been provided along the perimeter fence and corners, as the animals will patrol the fences first? The animals will make contact with the fence from where they originate e.g. if they come from a ranch east of the ranch where they are introduced they will make contact with the eastern boundary first.
- Have arrangements been made with a responsible person to inspect and receive the animals?
- Has a route map and contact numbers been given to the capturer and transporters?

Injuries - Factors that contribute to stress, injuries and mortalities at the offloading destination:

- The entrance gate to the ranch should not have a support wire or beam above the gate less than 4.5 meters above the ground. This will allow heavy vehicles to enter immediately.
- Delays because of a locked entrance gate.
- Nobody present to receive the animals.
- Poor road conditions.
- No offloading ramp; Animals forced to jump from the crate.
- Poor construction of offloading ramp or the angle too steep.
- Offloading too near a dam full of water.
- Difficult to turn and position on the ramp and or insufficient space to maneuver heavy trucks into the boma area.
- Vehicles getting stuck in sandy or clay soil in wet conditions.
- Offloading ramp placed amongst obstacles or near fences.
- Delays because of poor arrangements. While the transport vehicle is stationary, the temperature in the crates can increase dramatically and the animals become restless and aggressive.
- Separating the animals and offloading at several points.
- When the buyer is dissatisfied with his consignment, it can result in the transportation truck being returned to the seller unloaded or the animals being offloaded in holding pens until another buyer is found.

D. TRANSPORTING WILD ANIMALS

Using Tranquillizers for the Transport of Wild Animals

Temporary confinement in crates during transportation is stressful for wild animals. In attempting to escape, animals may injure themselves. Death may result from injuries sustained during escape attempts, fighting, and from being trampled. These injuries and mortalities can be reduced considerably by using suitable transport procedures and appropriate long acting tranquillizers. Tranquillizers should not be used to disguise poor capture or transport techniques. They should never be used on wild animals that are exhausted or overheated after capture. Tranquillized animals appear to be unconcerned about their surroundings, are less aggressive towards each other and are less likely to try to escape. They also are less fearful of humans and accept them at close quarters.

Tranquillizers must be used cautiously because injudicious use may cause more harm than good. A wild animal that has been overdosed may lose its balance, lie in an unnatural position and die of suffocation or bloat. It may not be able to protect itself and may be injured and trampled by other wild animals in the group. Individual animals may sometimes be sensitive to the effects of a specific tranquillizer and show aberrant behavior. This "funny" behavior will trigger other animals to attack this animal. Before tranquillizers are considered for use by novices, it is advisable that the type of tranquillizer and dosage be discussed with a wildlife veterinarian or an experienced game capturer.

Tranquilizers are sometimes used incorrectly, and wild animals may be overdosed or under-dosed. Animals in different areas of South Africa or those in poor physical condition may respond differently than expected. Extremely young or old animals may show unusual behavior and low doses of tranquillizer should always be used. Individual animals occasionally become overexcited instead of calming down after receiving a tranquillizer. Unexpected reactions have occasionally been seen in individual red hartebeest, springbok and Burchell's zebra after being treated with haloperidol (V-tech). This may have been the result of over-dosage or sensitivity to the drug. The following unusual behavioral reactions, also known as extra-pyramidal effects, have been seen in animals tranquillized with haloperidol (V-tech); shivering, trembling, restlessness, constant chewing, swaying of the head from side to side or up and down, pawing of the ground, grinding of the teeth, and decreased or increased appetite. These symptoms may be treated with injections of Akineton (Knoll) and diazepam (V-tech) or Valium (Roche). A supply of these preparations should always be available in the drug box. When this type of behavior occurs, a wildlife veterinarian should be consulted, and the information made available to the supplier of the tranquillizers.

Sometimes wild animals do not react as expected because the tranquillizer was given incorrectly, or was not absorbed into the bloodstream, or has lost its efficacy. Tranquilizers must always be kept cool and in a safe place. They must not be exposed to heat and sunlight in the field because high temperatures might affect the stability of the drugs. Expired and outdated stock should never be used. Tranquillizers may be classified according to their effective duration. There are short-acting, medium-acting or long-acting tranquillizers. Short-acting tranquillizers are dissolved in a watery solution and are absorbed and excreted rapidly. Medium- and long-acting tranquillizers are in an oily base that serves as a depot in the muscle or under the skin. The active ingredients are then released gradually but regularly into the bloodstream until the depot is used up.

When wild animals must be held captive for several days before or after transportation, a combination of a short- and a long-acting tranquillizer is recommended. A short-acting tranquillizer should be injected to initiate or load the tranquillization until the long-acting tranquillizer becomes effective. This

may take from 12 to 16 hours. If a long-acting tranquillizer were to be given without giving a short-acting one at the same time, the animals may stress and injure themselves before the tranquillizer becomes effective. Clopixol-Acuphase, also known as Acuphase (Lundbeck), is an exception because this long-acting tranquillizer is effective within an hour after injection. When administering a tranquillizer, the following factors will determine the dosage:

- The temperature in the shade.
- The physical condition of the wild animals.
- The distance over which it was herded.
- The level of exhaustion of the wild animals.
- The aggression of the wild animals.
- The nervousness of the wild animals.
- Whether the animal is to be transported alone or with others.
- Whether the animal will be released in the wild or into a pen.

Wild animals that must be handled physically, such as blesbok, impala rams and springbok that have been captured in nets, should be blindfolded and injected intravenously or intramuscularly with a short-acting tranquillizer as soon as possible so that they can be handled and transported safely. For rapid effect, haloperidol (V-tech) or Serenace (Searle) can be injected into one of the following veins:

- The jugular vein on the side of the neck.
- A superficial vein on the upper side of the ear.
- The vein on the upper side of the front legs.
- The prominent vein above the hock joint of the hind leg.

The injections must be given quietly and efficiently with a sterile syringe and a hypodermic needle of suitable gauge and length. If any difficulty is experienced in finding an appropriate vein, intramuscular injections must be given. Intramuscular injections take longer to become effective and are usually given in the large muscles of the front or hind legs. The wild animals should not be disturbed or harassed unnecessarily while the chemical action of the tranquillizer is taking effect. The tranquillized animals should be loaded into the transport crate efficiently and quietly. Canvas stretchers should be used when moving animals from the capture site to the transport vehicle. Pole-syringes are used to inject wild animals that have been captured by the mass capture method.

The Care of Wild Animals in Transit

Recently captured wild animals are confronted with new and unfamiliar circumstances that cause stress and test their behavioral and physiological adaptability to the limit. Wild roaming animals must suddenly stand in a restricted area. Moreover, in this strange environment they are surrounded by many unfamiliar objects, smells and sounds. With mass transport, the wild animals are also forced into closer contact with each other than is normally the case. Animals under these circumstances are under stress and experience fear. The wild animals will therefore try to escape until they realize that their efforts are in vain. Once the animals cannot escape they will calm down and accept their captivity. However, some individuals may become nervous and aggressive when they feel trapped and will start attacking any other animals or people in their vicinity and attempt to escape. The use of tranquillizers in these animals are especially beneficial to minimize mortalities.

In their attempts to escape from an individual crate, wild animals such as gemsbok, sable antelope, blue wildebeest and black wildebeest will try to turn around. In doing so, they may wedge themselves so tightly against the side of the crate that they cannot move. The resulting efforts to free themselves are

exhausting and the animals can suffocate or die of shock in this position. Some animals will attack the crate incessantly and eventually break or damage their horns or injure their heads severely. Proper precautions should therefore be taken to prevent or minimize the occurrence of such harmful and serious reactions. When wild animals are in transit, several matters are important, as set out below. Before offloading also ensure that:

- The entrance gate to the ranch is securely closed so that the animals cannot escape.
- The fences are in good repair so that wild animals cannot escape, either through or under the fences.
- Spectators and equipment will not get in the way of the released animals.
- The animals are not followed and chased by vehicles or people after offloading.
- The release area is free of any objects and obstructions that could injure the animals.

Offloading in the Dark

Despite all efforts to avoid this, it sometimes happens that animals arrive at their destination after dark. It is then tempting to offload immediately. Wild animals are at a disadvantage in the dark in a strange area because they cannot see where they are or where they have to go. They may then run towards and through the perimeter fence, or into a donga or a dam. Unless special provision has been made to provide soft lighting, wild animals should never be released in the dark. Flashlights and truck lights blind the animals and they may injure themselves by unnecessarily jumping or stepping incorrectly. Wild animals have poor vision in bright, artificial light. When blinded, they may also panic and run into objects or even jump against the sides of the crate.

The most obvious disadvantage of offloading in the dark is that the wild animals cannot be seen properly or inspected for injuries. Even with flashlights, it is practically impossible to determine whether any animals are injured and in need of treatment in the dark. Unless no other alternatives are available, the wild animals should be left peacefully in the crates overnight and released the next morning. tranquillized animals will usually come to no harm. Animals may have to be released at night, under the following circumstances:

- If the wild animals have been travelling for several days and are exhausted, it would obviously be to their advantage to release them from the crates as soon as possible.
- If there have been unexpected delays such as mechanical problems during the journey and the wild animals are showing clear signs of distress.
- If the wild animals are particularly restless or the effect of the tranquillizers has worn off.

If the wild animals are released into a holding pen under adequate tranquillization. It is also recommended that the holding enclosure be built near (not within 200 meters) a waterhole, so that the animals will be able to locate it easily by smelling the water or by following the footpaths of other animals in the area. The disadvantages of releasing wild animals immediately at their destination include the following;

- Animals that are released into a large area may disperse to such an extent that they are only seen again several weeks later.
- Animals may attempt to jump over or crawl under the perimeter fence and get entangled in the fence or end up on the adjoining property.
- If there is only one waterhole in the release area, it may take several days before the animals find it and some of them may die of thirst.
- Newly released animals tend to move up and down along the fence to seek a means of escape. While doing so they become thirsty because they have not found the water. It is therefore

advisable to provide water in several temporary water containers such as rubber containers along the fence, especially in the corners of the ranch, until the animals have become used to their new habitat. It is of no use to chase the wild animals away from the fence because they will keep returning to it until they have settled down. Therefore, rather make every effort to ensure that they drink from the temporary water containers until they find and use the permanent waterholes.

Ethical principles when transporting wild animals

- General rule of thumb for introduction of game:
  - Veld to veld
  - Boma to boma, or
  - Boma or veld
- The driver must be supplied with good communication systems; cell phone, radios and contact numbers.
- Obey all the applicable laws – the necessary permits must be valid and in the possession of the driver.
- The construction of the transport crates must ensure that dangerous wild animals cannot break out of the crates.
- Separate ages, sexes and social units but not a cow/ewe with her suckling calf/lamb.
- Transport rams/bulls in individual crates or put pipes on the horns
- Do not transport heavily pregnant animals.
- Use tranquilizers wisely and with care.
- Do not transport animals under extreme weather conditions (ideal 10 – 20° C).
- An animal should be handled as little as possible and never be shouted or screamed at.
- Unless special provision has been made to provide soft lighting, wild animals should never be released in the dark. Plan the trip if possible that the driving can take place during the night and the offloading can take place early the next morning.
- Avoid people watching the offloading and releasing of dangerous animals like elephant, rhinoceros, lion, leopard and buffalo.
- Your success equals your equipment and knowledge.

Image 10: Immobilized buffalo bull pulled down by the capture team

E. TECHNIQUES USED TO MANAGE WILD ANIMALS

Euthanasia

Responsibility

The decision to perform euthanasia is ultimately the responsibility of the owner of the wild animal. Euthanasia must be performed by a veterinarian, except in an emergency case when a veterinarian is not available. In emergencies the advice of a veterinarian should be obtained verbally.

Reasons

Euthanasia of wildlife may be necessary:

- To alleviate pain or suffering.
- When further treatment is not practical, or recovery is not expected such that the wild animal can be successfully rehabilitated back to the wild. (Unless the species is listed under CITES).
- Euthanasia of animals in wilderness areas. The reasons for practicing euthanasia are to humanely destroy wild animals with severe physical injuries sustained in intra or inter-specific interactions, or run-away veld fires, when deemed necessary. Animals hit by cars or entrapped or injured by man-made structures (including fences and snares) may also require euthanasia, depending on the extent of their injuries. Occasionally, euthanasia is practiced on obviously sick, debilitated or deformed animals, for veterinary disease surveillance purposes.

Methods

To achieve humane destruction (or 'euthanasia') of a wild animal the method must 'achieve instant insensibility followed by rapid death of the animal without first regaining sensation or consciousness'.

- The preferred method of euthanasia for most species is by ***intravenous barbiturate overdose***. Euthanasia by intravenous barbiturate overdose MUST be carried out by a registered veterinarian or a competent person under his supervision.
- The only method of ***non-veterinary euthanasia that is permissible is gunshot to the brain***. The individual performing the euthanasia must meet the relevant legislative requirements regarding the use of firearms in suburban areas. The person should have knowledge or prior experience in the methods of successfully euthanizing that particular species of wild animal. The animal to be euthanized must be properly restrained to avoid the likelihood of the shooter missing and not killing the animal with the first shot. Suitable caliber firearms and ammunition must be available for all wild animals held.
- Use of the ***captive-bolt pistol*** is an alternative to the firearm is a captive-bolt pistol (captive-bolt penetrating stunner) which is safer since a blank cartridge is used. The operator does not have to be a marksman as the instrument's muzzle is firmly pressed against the skull before firing. It must, however, be assumed that the animal has only been stunned and a follow-up method of ensuring death, such as bleeding out, is required.
    - Blank cartridges for the captive-bolt pistol are color-coded according to the amount of charge they contain. For best results, the manufacturer's recommendations should be followed on the most appropriate blank cartridge for different ranch animals. Regular maintenance of the captive-bolt pistol is essential for efficient stunning.
- The use of ***immobilization darts*** to immobilize, or passive capture cages to entrap a wild animal, followed by the administration of an appropriate drug overdose, using a captive-bolt pistol or slitting of the throat.

- ***Slitting of throats.*** In the past the slitting of throats (jugular vein) has been an accepted practice for Hallal and Kosher religious slaughter of domestic livestock. This practice is uncommon in wildlife, simply due to the fact that the close-proximity, hands-on contact required for this technique is rare with wild dangerous species. However, the slitting of throats is an acceptable technique for killing severely injured, restrained or immobilized thin-skinned wild animals. The technique is useful for killing individual small to medium sized ungulates under circumstances where a discharging firearm is undesirable or dangerous, and when the carcass is to be utilized by scavengers or humans. The humanitarian aspects of this technique are paramount and include the following;
    - The wild animal must be well restrained.
    - The animal's neck must be extended, to ensure that the major arteries and veins are severed in one swift stroke.
    - A very sharp knife must be used. A long curve-bladed carving knife is ideal.
    - This technique should not be attempted or used on large predators or pachyderms unless they are anaesthetized.

Responsibilities of the Users Firearms to Kill Wild Animals

A specialized level of training and competence is essential for any official who is responsible for the destruction of wild animals using firearms. This training should include:

- Firearms handling skills including safe handling practices.
- The person shooting must have a good knowledge of the topographic anatomy of the animal.
- Marksmanship and good knowledge of the appropriate calibers and cartridges to be used for euthanasia.
- Firearms maintenance and responsible storage of firearms.

The Using of Chemical Agents to Kill Wild Animals

Humane euthanasia in domestic species is usually achieved by the intravenous administration of certain drugs. These drugs include;

- Concentrated barbiturate solutions (e.g. Euthanase and Euthatal)
- Magnesium sulphate solution, with or without potassium chloride.
- Chloral hydrate.

In large animals, all these chemical agents need to be given in sufficient doses intravenously. It is therefore not practical to use this technique in wild animals. The euthanasia compound is then given intravenously to an anaesthetized animal. There are three major problems associated with this method of euthanasia in wildlife:

- The carcass is no longer suitable for human consumption.
- The carcass will need to be buried or incinerated, because it contains sufficient residual immobilization and euthanasia drugs to cause secondary poisoning or intoxication of scavengers.
- The additional cost of the immobilization drugs makes this technique prohibitively expensive.

The Killing of Healthy Over Populated Wild Animals for Human Consumption

Chemicals

Suxamethonium (Scoline) as a culling agent was used, because it is chemically composed of two naturally occurring physiological intermediate substances, which occur in the mammalian body, namely succinic acid and choline. Other positive aspects were that accidental exposure to intact skin posed no danger, and that the compound is not active via the oral route. Solutions of this compound are not

very stable and are rapidly broken down at low pH and by enzymes in the blood and body tissues. Heat (cooking) also breaks down any residual suxamethonium. Its final metabolites are also totally harmless. Wild animals killed with suxamethonium were therefore deemed suitable for human consumption.

However, the use of suxamethonium as a culling agent is controversial because of the question of whether its use is humane or not. Certain wild animal species, particularly the bovids and felids are acutely sensitive to the effects of suxamethonium, and become immobilized within 60 – 90 seconds, develop respiratory paralysis and die of asphyxiation within a few minutes. Certain other species on the other hand, including elephants, warthogs and primates, are more resistant to the effects of suxamethonium and the time until brain death is prolonged. With these species, the animal is still totally conscious and aware of its surrounding, can feel pain and are under stress, hence the concern regarding the use of suxamethonium as a chemical to cull animals.

Rifles

The only other consistent techniques to kill a substantial number of buffalo using a rifle are:

- To shoot the buffalo through the chest, after which they continue running and subsequently die of cardio/respiratory arrest, after several minutes. With this technique, carcasses are frequently scattered over a relatively large area.
- The other technique that has been successfully tried, is to shoot the buffalo through the spine, paralyzing the hindquarters, and then to deliver a (now stationary) head shot.

Neither of these techniques has any advantages from the animal welfare point of view but do have several disadvantages from an operational point of view.

These include:

- The possibility of wounded animals escaping, with its attendant risks to staff and tourists.
- Potential increased degree of suffering by the animal if they are wounded.
- Widely scattered carcasses at the killing ground.
- The veterinary public health implications of meat and organ damage, with resultant contamination from visceral spillage in the body cavities.

Because of these considerations it is recommended that suxamethonium is currently the best option for lethal sampling of buffalo, if it is followed up by a brain shot as quickly as possible afterwards. Not more than 20 buffaloes should be culled at one time. However more research needs to be done on age and sex groups.

Control of Damage Causing Animals

Suxamethonium is also the best choice for the following 'crisis management' tasks where safety considerations are critical:

- Problem lion prides (stock thieves or man-eaters) where silent, close-range dart delivery and rapid knock down is necessary. This technique frequently results in successful removal of the entire pride. A rifle is unsuitable for this task because the noisy discharge may cause the pride to scatter, and the individuals that escape will continue to pose a threat to life and property. Suxamethonium is accepted for use on carnivores only when other methods are unsafe or impractical.
- Problem or vagrant carnivores in the proximity of human habitation or tourist facilities, where silent dart delivery and rapid knock down are essential.

- The euthanizing of a severely injured wild animal in the capture corral/chute or transport truck situation, where over penetration or the noisy rifle discharge may jeopardize other animals caught in the capture drive.

Advantages of suxamethonium

- The carcasses of animals killed with suxamethonium are suitable for human consumption.
- The anatomical dart site is not critical. Any intramuscular or intra-osseous site is effective.
- There is no danger of secondary poisoning of scavengers.
- Missed darts expel their contents on impact with the ground and suxamethonium is rapidly broken down in nature by heat and soil pH. It is emphasized, however, that any missed dart should be recovered if there is any risk of human exposure to the drug.
- There is no wounding potential; the victim will be brain dead in less than four minutes.
- There is minimal inherent danger of ricocheting darts because of the low velocity.

In conclusion, suxamethonium remains the most effective and safest chemical culling agent for the use in buffalo group culling, as well as certain damage causing animal control scenarios. Whenever suxamethonium is used routinely on a regular basis (e.g. buffalo culling), then a person with CPR training should be present in case of accidental parental exposure of humans. Equipment for assisted ventilation (e.g. Ambu bag, laryngoscope and endotracheal tubes) should also be available.

Injection Sites

The injection of wild animals can be done in die non-immobilized animal with a dart gun or a pole syringe. In the immobilized animal bigger volumes (example antibiotics) can be injected manually.

Darting target areas

The recommended dart target sites or areas to be aimed at are the hindquarters and the shoulders. The following areas of the body are unsuitable for darting and must be avoided; the flank, the abdominal region, the chest, neck, legs and head. Stomach and chest shots must be avoided because the absorption of drugs is slower and there is a danger that the rumen, intestines or lungs may be struck and injured by the dart needle. The leaking of gut contents in the abdominal cavity will eventually lead to peritonitis. A dart shot into a rib will either fracture the bone or the drug may not be absorbed, because the needle is embedded in the bone or it is bent back by the impact. If a dart has been placed badly and the animal shows no sign of immobilization after four minutes or there is no indication that the drug will take effect within ten minutes, then a second dart should be prepared and fired as quickly as possible. Should this not be done, the animal may flee and exhaust or injure itself.

When a wild animal is darted with the correct amount of the drug, and the dart hits a well-muscled area with a rich blood supply, the drug can be absorbed rapidly, and a reaction can be expected within four to five minutes. The wild animal will lie down within ten minutes. The animal lies down on its sternum with its head held up. A few more minutes are required before such an animal is fully under the influence of the immobilizing drug and should be left alone, provided it is lying in the proper position.

The proper position for an immobilized animal varies between feeding types. When the immobilized animal is a ruminant and it lies flat on its side, it should be helped onto its sternum immediately to prevent bloat and the inhalation of the rumen content. Zebras usually lie on their sides but there is little danger that they will bloat. Elephants must lie on their sides when immobilized because lying on

the sternum interferes with their breathing (the diaphragm cannot move with the pressure of the stomach) and this could be fatal. The shorter the down time and the more rapid the immobilization, the less stress there is on the animal and the less opportunity for capture myopathy to develop.

Manual Injection

Usually large volumes are administered this way in the immobilized animal. Avoid injecting in the neck muscles, especially rhinoceros. When they lower their neck to feed or drink it can be painful. Use the gluteus group of muscles in the hind quarters. With irritating drugs do not inject more than 10 ml at an injection site. Aspirate when an oil-based drug is injected intramuscular to ensure that the drug will not be directly in the blood that will cause emboli.

The injecting of irritant drugs in the ear of an elephant, care must be taken to inject the drug in a vein and not an artery. The pressure in the arteries can be palpated versus a vein that feels flatter. Keep the finger on the vein for a minute to make sure that the drug does not leak out. When the drug leaks out of the vein it will cause sloughing of the ear cartilage.

Disposal of Carcasses and Waste Material

Waste management

Health Care Risk Waste (HCRW): Is defined as primarily source based waste that is the potentially infectious or hazardous part of the waste stream from health care facilities such as hospitals, clinics and medical practices including home based care but does also include particular types of waste, namely waste of similar properties from laboratories and research institutions as well as similar waste generated by veterinaries, tattoo artists, undertakers etc. generating potentially infectious and sharp objects including objects potentially carrying a zoonotic disease. Health Care Risk Waste includes:

- ***Infectious waste:*** All kinds of waste that is likely to contain pathogenic micro-organisms, including particular isolation ward waste, laboratory waste and infectious liquids that cannot safely be discarded via the sewerage system.
- ***Pathological waste:*** Includes parts that are sectioned from a body including body tissue.
- ***Sharps:*** Includes sharp and pricking objects likely to contain pathogenic micro-organisms that may cause injury as well as infection.
- ***Chemical and pharmaceutical waste:*** Includes all kinds of discarded chemicals, including pharmaceuticals and genotoxic waste that pose a special risk to human health and environment.
- ***Radioactive Waste:*** This includes solid, liquid and gaseous waste contaminated with radionuclides.

Whilst deceased animals are not defined as (HCRW), certain deceased animals and laboratory animals, can be discarded via the HCRW stream as a practical and safe system of disposal provided that the size of animals can be managed by the treatment facility.

Health care risk waste (HCRW) together with Health Care General Waste (HCGW) constitute the entire waste stream, Health Care Waste (HCW), produced at a health care facility or similar. Health Care General Waste is the waste that is similar by type and nature to domestic waste, i.e. waste from households

A Veterinary Approach to the Dead Animal

- The first question to be asked while doing a post mortem on a carcass is why the animal had died? When the diagnosis is made, decisions regarding suitable treatment options and management changes that can limit the spread of disease can be made. If it is a notifiable disease it must be reported immediately to the nearest state veterinarian.

- The second question to be asked while doing a post-mortem examination is what other information can be recorded from the carcass. Check the animal's breeding status and age, body condition and the amount, composition and quality of food in the stomach. Internal and external parasite burden must be assessed, and parasites collected for identification.
- The third question to ask, is what samples should be taken of the dead animal. An ideal set of samples should include a full set of tissues for histopathological examination by a pathologist; samples of ticks, fecal samples to determine worm egg counts, samples of fresh brain, heart, liver, kidney and spleen. When viral infections are suspected sterile tissues should be taken for examination for bacteria or viruses. In the case of nutritional problems take an extra faecal sample, kidney, liver and the jawbone. If the animal is a rare or endangered species and the carcass is fresh, consider having genetic samples banked.

Type of Samples

Tissues for histopathological examination can be stored in 10% buffered formalin. A full set of tissues includes; brain, tongue, thyroid, thymus, heart, lung, diaphragm, liver, kidney, adrenal, stomach, small intestine, large intestine, lymph nodes, bladder, genital organs, skin, bone marrow, and back and hindleg muscle. Tissue samples should be no bigger than 2 cm x 1 cm x 1 cm and must be placed in a wide mouthed jar so that the fixed hardened sample can be removed from the jar.

Ticks, faces and sterile samples should be stored in sealed plastic bottles or bags and should be refrigerated and should be tested as soon as possible. Ticks and worm samples can also be stored in formalin or 70% surgical alcohol. Fresh tissues should be stored in sealed plastic bottles or bags and frozen. The samples can be sent to diagnostic laboratories).

Carcass Disposal

The carcass should be disposed of in a suitable manner to prevent spread of infectious or parasitic disease. Most mortalities on game ranches are caused by traumatic or nutritional diseases which present no risk to humans, but to be safe it is best to assume that the carcasses is not suitable for human consumption and should be buried deeply unless it can be quickly disposed of by predators and/or vultures. The bones at the feeding sites should be picked up and burnt regularly to prevent botulism. Wild animals that had died of a zoonosis should preferably be destroyed in an incinerator.

Identification Techniques

Wild animals in quarantine must be identifiable, whether individually or in groups. Where possible, animals should be identified by the attachment of a label to the cage, container, pen, yard or paddock in which they are kept. Otherwise, identification of individual animals may require a physical mark such as a tattoo, neckband, individual tag, or electronic numbering device such as a microchip. It is essential that when more invasive identification procedures are performed it should be closely supervised by an experienced wildlife veterinarian. The method chosen should be the most appropriate for the species and the purpose and should result in the least pain and distress to the animal.
This is the first step in the successful monitoring of individuals. The rancher should be able to identify every valuable wild animal at a distance in the veld in order to ascertain the reproductive success of individuals and a monitor (census) method of valuable animals.

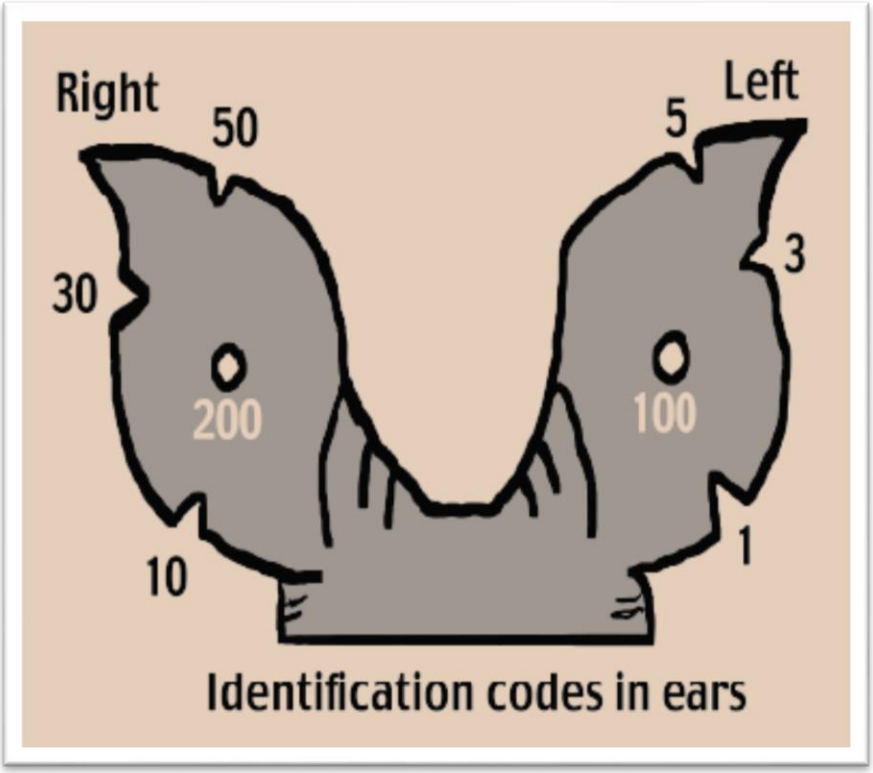
Ear Tags

This technique is generally used to identify individuals in bomas, where large numbers are offered at auction. Brightly-colored ear tags are clearly visible, but they may be torn out and the written numbers may fade. This should therefore be regarded as a temporary identification measure. Many tourists object to seeing wild animals with ear tags in wilderness areas. Sometimes ranchers put ear tags in male animals that they want to use for breeding purposes, that hunters can identify new breeding stock.

Ear Notches

Notches in the shape of small triangles 2,5 cm x 2,5 cm x 1,5 cm can be carved into the ear with a sharp razor or scalpel blade. Artery forceps can be applied for 4-5 minutes to stem bleeding; the same can be achieved by applying "steel drops" ("staaldruppels") or superglue. The piece of ear can be frozen for future DNA analysis, to prove the identity of the individual.

Image 11: Ear Notching Codes



The left ear is used for ones and the right ear for tens. Various combinations are used to denote the animal's number. Thus: left bottom is 1, middle is 3 and top is 5; right bottom is 10, middle is 30 and top is 50. A hole in the left ear denotes 100, and one in the right ear 200. For example: Rhinoceros number 18 will be numbered bottom right and left top and middle. The ear notch method is permanent; if applied correctly, it will not affect the tourism potential of the animals. It is recommended as the best field identification method.

Microchips

There are several commercial types on the market. A small microchip is inserted by means of an applicator on the right-hand side of the tail base, where the skin is thinnest. The method is permanent, but the chip may become damaged, especially when bulls butt cows with their horns around the vaginal area. The chip can only be read from a distance of 20 - 30 cm, and this is therefore not a field

identification technique. Each chip has a unique code. Microchips are important in cases where neighbors dispute ownership of specific animals. In thin skin animals the chip can migrate under the skin.

Practical implications for the rancher

- Field identification of individual wild animals is important in collecting biological data on the population, for instance a cow's estimated calving dates in order to calculate inter-calving periods.
- Unproductive and old animals can be identified and utilized for hunting.
- To confirm ownership in court cases, where ownership of individual wild animals is being disputed by neighbours.

Use of Prodders

Prodders, whether mains or battery operated, deliver a powerful and painful shock. They should therefore be used with discretion and considered intention; e.g. a handler cannot reasonably expect a buffalo to move forward by poking him in the face with an electric prodder. Neither can he expect the animal to move forward when it is jammed in or if there is no clear path in which the animal can move. To make an animal move forward the handler must stand behind the shoulder and apply the prod to its rear quarters. It is also necessary that handlers realize that continued or indiscriminate application of the prodder usually causes the animal to become excited, bellow, kick or become aggressive. Handlers should be given the necessary training to understand the natural and instinctive behavior of different species of wildlife in order to move them with the least possible stress to both the animal and himself.

Intelligent use of electric prods to move animals

The rule of thumb is if you shock the animal in front of the shoulder blade it will go backwards and if you shock the animal behind the shoulder blade it will move forward.

- Elephants can be prod behind the ear to reverse the animal. The handler must be careful that the elephant must not smell him because it will try and grab him with the trunk.
- Never shock nervous animals like eland. They will kick and can break a bone in the lower leg.
- Never shock aggressive animals like sable antelope because they will fight the prodder and can lie down.

Routine Animal Husbandry Procedures

Routine husbandry procedures that are (for example, clipping coats and hoofs, identifying techniques and vaccinations) must be performed by competent personnel.

Dehorning of Rhinoceros

The technique can be performed to;

- Discourage poachers to hunt rhinoceros.
- Commercially harvest the horn.

The horn must be cut horizontally above the hairline at the base of the horn. The side must not be rounded on the side, because the horn will flake. When the horn is cut horizontally it will grow normal and can be harvested every two years. White rhinoceros cows can produce 1 kg horn per annum.

Microchips can be inserted in the base of the horn to identify poached horns. This technique has limitations in the long term as the microchip will grow out with the horn. Drill a hole 3 mm in diameter and 30 - 40 mm deep at the base of the horn. Insert the microchip by means of the applicator and fill the hole with silicone.

Image 12: Rhino dehorning technique

Cutting of Hoofs

Wild animals in captivity must be monitored for over grown hoofs. Buffalo fed on citric pulp tend to be more prone to over grown hoofs than animals not fed on this product. The cutting of the hoofs must be done when the animals are immobilized.

Ethical Green Hunting (non-lethal hunting)

Nevertheless, the following preliminary guidelines will serve as a basis for developing a detailed code within the game ranching, hunting, game capture and outdoor sports industries. Darting safaris should adhere at least to the following principles;

- Only animals that have to be immobilized for conservation, research or wildlife management reasons should be made available for a darting safari.
- No animal should be darted for the sole purpose of providing a safari for a client on purely commercial grounds.
- No individual animal should be darted repeatedly.
- An experienced wildlife veterinarian should handle the immobilization drugs and be present throughout the entire procedure and until the animal has recovered fully.
- All the relevant laws, acts, regulations and guidelines governing hunting, the handling of scheduled drugs, game capture and animal welfare should be adhered to.
- The darting safari should only be promoted and carried out by appropriately trained and experienced professionals, with due regard for the safety and well-being of the animal, the client and all staff involved. Suitable insurance should be taken out for the animal, the client and the staff for the duration of the darting safari.
- The darted animal should be kept in sight during the entire procedure to monitor the effects of anesthesia and to render immediate assistance in potential life-threatening situations. In some cases, it is recommended that a radio transmitter be used in the dart and that a helicopter be on standby to find lost animals or render immediate follow-up assistance if required. Human trackers should also be on standby to serve the same function. In the case of elephants, the use of a helicopter on standby should be mandatory to ensure safety and success.
- The professionals involved should assess the client's ability to carry out the darting safari successfully before the actual safari commences, and appropriate training should be given in those aspects found lacking.
- In the case of a client darting safari, a hunting outfitter is required to market the safari and a professional hunter is required to guide the client.
- A number of prominent wildlife organizations in South Africa have stated that they are opposed to the darting of a wild animal and the moment the SA government does not approve green hunting. This procedure needs to be reviewed for white rhinoceros, because animals get shot and only the trophy removed for medicinal purposes. It is recommended that this specie must be available for green hunting in future. The trophy will then be removed by the hunter and the animal can be darted in two years-time again. The net result is that the animal stays alive and over its life span (26 years) can be darted up to ten times.

F. DISEASE MANAGEMENT

Quarantine

Quarantine is applied in South Africa mainly to control foot-and-mouth disease. It is based on the principle that a possible carrier should be isolated and subjected to a series of blood tests at the point of origin and introduction. This technique is effective when wild herbivores are imported from neighboring countries where the state and the occurrence of diseases are sometimes unknown. As it is expensive and requires specialized knowledge to manage animals in bomas, quarantine is of practical value only for rare wild animals, such as the buffalo, sable antelope and the roan antelope.

Fences

The principle of fencing is to make a distinction between wild and domestic animal populations. In South Africa, the fences on game ranches also keep ungulates out of an area. In neighboring countries, game fences have a detrimental effect on migrating wild animals, such as the blue wildebeest and red hartebeest. Animals migrate in dry times to alternative grazing and water sources. When a fence cuts off such a natural migration route, large-scale deaths will occur at the fence. These deaths can create a unique disease risk. It is therefore important first to conduct a study of the migration patterns of the wild animals and to establish and habituate them to artificial waterholes before a fence is erected.

The effectiveness of this method is, however, doubtful because no fence can ever be fully wild animal proof, especially in areas where elephant occur. Animals such as the eland and kudu will jump over a fence, buffalo and elephant may break through it, and red hartebeest and sable antelope will creep underneath it. Vultures fly over unhindered. The cost of fencing is high, and its low effectiveness in disease management makes its use questionable.

Ecological Effects of Fences

The following ecological effects of fences are especially important:

- The natural migration routes of wild animals are cut off and the animals cannot escape from droughts. This causes large-scale mortalities, usually at the fence itself.
- Animals that try to move through a fence may be caught, strangled, injured or killed by it.
- The lower strand of electrified fences electrocutes small mammals, such as the pangolin.
- Fences limit the flow of genetic material between free-living populations.

Shooting Disease Carriers

This drastic management measure was applied in the past for various purposes, including the control of the tsetse fly. The aim was to create a buffer zone in which the tsetse fly could not take in a meal of blood. The preferred habitat of the tsetse fly is humid and shady, and it does not cross large, unshaded open stretches. The preference of the tsetse fly for a host is determined by the availability, smell and occurrence of the host. Large, dark animals, especially in densely wooded areas, are the most common hosts for the tsetse fly. Elephants, buffalo, blue wildebeest, bushpig and warthog are therefore prime hosts.

The success of shooting a disease carrier is questionable because the removal of browsers, especially elephants, will lead to bush encroachment. This creates an ideal habitat for the tsetse fly. Hungry flies will feed on birds and rodents too. Therefore, a host can never be removed totally from the epidemiological triangle. Other methods, such as direct control of the fly itself, should rather be considered. For example, flies can be caught in tsetse fly traps and sterile males can be released in

infested areas. Manipulation of the habitat by bush clearing and fire management programmes will also cause browsers to move out of the area, creating a fly-free zone.

The shooting of contaminated herds of carrier animals that spread a disease during peak outbreaks is a control measure that is still being applied today. The aim is to eradicate the focal point of the disease before it spreads and becomes uncontrollable. An example is where buffalo occur on a disease-free game ranch and an outbreak of foot-and-mouth disease occurs nearby. All movements of domestic animals are then limited to localize and eradicate the disease before it spreads. Two ecological effects of shooting carrier populations is that it leads to disturbances in the composition of wild animal populations, and in the nature and composition of plant communities.

Burning Carcasses

A carcass is usually only burnt during outbreaks of a disease such as anthrax. It is a time-consuming technique with ecological implications but is effective in limiting the spread of a disease from a focal point. The ecological effects of burning carcasses include the following:

- The removal of carcasses puts pressure on scavengers, such as spotted and brown hyenas and vultures. These animals then must move about more, and further, in search for food. In doing so, they can spread the disease more rapidly.
- The bacteria found in old bones are removed from the ecosystem and the onset of disease outbreaks such as botulism and anthrax are prevented.
- Wild animals eat bones to satisfy their mineral requirements during the winter. Supplementary licks therefore must be provided to alleviate this deficiency when the carcasses and bones on a game ranch are burned.

Poison

The use of strychnine to control jackals in combating rabies, and DDT to control the tsetse fly in combating Nagana, has been applied with varying success in the past. However, these techniques are ***not recommended*** because of the detrimental and lasting consequences of these poisons on the ecosystem. Amongst others, these consequences include the following;

- The extermination of harmless non-target animals whose populations take a long time to recover, such as the Bateleur eagle Terathopius ecaudatus. This eagle only raises one chick per year, which takes four years to reach adulthood. When natural mortalities are taken into consideration, it takes an adult breeding pair eight years to replace them in nature. The loss of a single Bateleur eagle to poison baits meant for other animals is totally unacceptable. There is no room for mistakes with this exercise.
- Other detrimental long-term effects may occur, such as a decline in the hatching success of eggs because of the accumulation of toxic substances in nature.

Immunization

It is difficult to immunize many types of wild animal because they cannot be herded into a conventional boma to be injected. The practical problems on a single game ranch include knowing which animals have already been immunized, how long the vaccine provides protection, and how much vaccine must be administered to each animal. If inoculation for immunization is to be done, the following aspects have to be considered.

Technique

The game rancher or manager should consider the following questions before starting the inoculation:

- Which animals are most susceptible?
- Are rare animal species to be immunized?
- What are the ages and sexes of the animals to be immunized?

The technique is basically the same for all the diseases, but anthrax will be used as an example here. A four-seater helicopter can be used, from which three marksmen can shoot darts at the animals. An alternative is to use a two-seater helicopter to herd the animals into a capture boma from where they can be immunized with a pole syringe in a holding crush or mass crate. Every animal that has been immunized is marked with a white paint patch on the back and then released. While searching for herds to drive towards the capture boma, large animals such as giraffe or kudu bulls can be darted directly from the helicopter.

Four-Seater Helicopter with Three Immunizers

This technique has the following advantages:

- It is safe for the immunizers because such a helicopter is powerful.
- It is more cost-effective than the two-seater helicopter and capture boma technique because more equipment and labor are required for the latter.
- Animals are not herded over long distances, which results in less stress.
- Aggressive animals do not have to be herded into a mass crate. This eliminates injuries and mortalities to other animals.
- The procedure is quick and not as dependent on temperature and wind direction as when the animals are herded into a boma.
- No time is lost with moving and setting up a capture boma.

The technique has the following disadvantages;

- Animals that have already been immunized are not marked and some animals can be immunized repeatedly or not at all.
- The technique is not suitable for young, valuable animals such as sable antelope calves, because these animals present a small target area when running and may be shot in the stomach.
- Certain animals such as Burchell's zebra cannot be shot with heavy darts from the air because the dart will penetrate deep into their bodies.
- It can never be certain whether the full dose of vaccine has been administered to the animal.

Two-Seater Helicopter and Capture Boma

This technique has the following advantages;

- This method of administration is effective because all the animals are immunized with the required volume of vaccine.
- The method is exceptionally suitable for rare and valuable animals.

The technique has these disadvantages;

- The two-seater helicopter is not powerful enough to be used for darting under high ambient temperatures in the interior regions.
- It is more time-consuming because weather conditions can have an influence on the procedure.
- Aggressive animals, such as the tsessebe, may injure each other in the crate or loading crush.

- It is less cost-effective than immunizing animals directly from a four-seater helicopter.

Biosecurity

Refers to the prevention of disease causing agents entering or leaving the premises where animals are present (or have been present recently).

An effective biosecurity plan includes the following elements:

- How to receive and manage new animals on the ranch.
- How to regulate movement on and off the ranch.
- How to clean and disinfect equipment on the ranch to reduce pathogen levels.
- How to monitor animal health on the ranch.

The two key biosecurity measures:

- Minimizing movement of animals, animal products, people, vehicles and equipment between premises where animals are kept.
- The adoption of best practices (hygiene and protective clothing) whenever there is direct contact with animals.

The Big Five questions to ask about a disease

- Is the disease a notifiable disease?
- Is there a vaccine available to prevent the disease?
- Is there a treatment protocol with medicine available?
- Is there a diagnostic test available to identify the pathogen?
- Is the disease dangerous for humans (zoonotic)?

Parasite control

With a few exceptions, all the tick species that infest wildlife also parasitize on domestic animals. Some tick species are important vectors of well-known diseases of domestic animals that may be fatal. These include redwater and anaplasmosis in cattle, and heartwater in cattle, sheep and goats. Whether wild animals are also reservoirs of these diseases is not known. However, several antelope species are temporary carriers of heartwater, and eland, springbok, blesbok and bontebok can become infected and die from this disease. Redwater does not normally occur in wild herbivores, but they may serve as hosts for the blue tick that can transmit redwater to domestic cattle for at least two generations without the female ticks being re-infected in the interval. This makes the control of redwater difficult because of the problems associated with treating large numbers of wild animals for ticks. The same apparently applies to anaplasmosis, of which the giraffe and buffalo are possible carriers. The organism causing corridor disease or buffalo disease is carried exclusively by buffalo. If cattle are infested by brown ear-ticks that have fed on infected buffalo as larvae or nymphs, the cattle become infected with corridor disease, with fatal results. For this reason, game ranches have to be registered to keep buffalo with the authorities. Special precautions should also be taken with blue wildebeest, which can transmit the virus causing snotsiekte to cattle. In nature reserves in which domestic animals are not present, or under extensive ranching conditions, the control of worms is unnecessary except under conditions of stress.

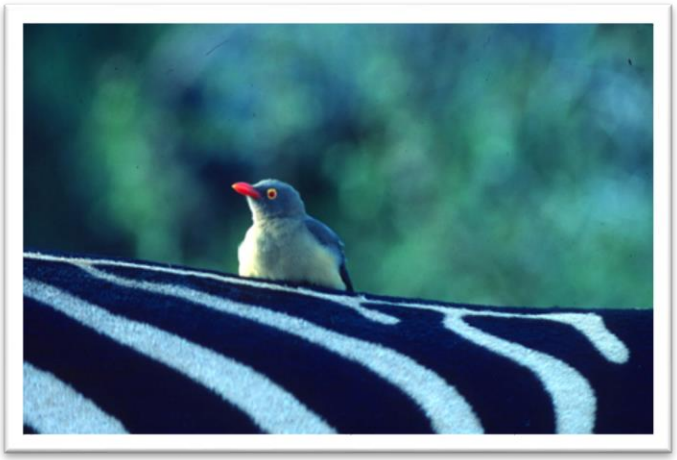
Biological control

Oxpeckers

Wild birds and domestic fowl can be efficient predators of ticks. Oxpeckers (*Buphagus africanus* and *B. erythrorhynchus*), domestic fowl (*Gallus domesticus*), guinea fowl (*Numida meleagris*) and cattle egrets (*Bubulculus ibis*) are the species considered to have the most significant effects on tick populations. However, researchers report 21 species of birds that perch on tick-infested cattle and ticks were found in the crop or gizzard of 14 of these species. Only the oxpecker species are considered to be specific predators of ticks, and all proposed predatory bird species have been found to be present in the face of very high infestations when other factors were favourable for ticks.

Red-billed oxpeckers (*Buphagus erythrorhyn*chus) and yellow-billed oxpeckers (*Buphagus africanus*) are limited to the savanna areas of Africa. The distribution of these birds is limited by the occurrence of large mammals that carry the main food source (ticks) for these birds.

Image 13: Redbilled oxpecker



The organophosphate dips with which cattle were dipped in the past, have led to a decrease in the distribution of these birds. During the political unrest and war in the south-eastern parts of Zimbabwe in the 1970s, cattle ranchers temporarily left the area. This resulted in the yellow-billed oxpeckers reappearing in this area and in the northern part of the Kruger National Park. This phenomena proof that if harmful dips are absent the birds will slowly repopulate the area.

Research has shown that the daily food intake per bird is approximately 15 gram. This is equivalent to 7 200 fully engorged larvae of the bont tick (*Amblyomma hebraeum*). The number of ticks eaten by the birds daily depends on the types of tick available and their stage of development. The mean daily intake is around 408 ticks per bird. This translates into a total of 150 000 ticks eaten by each bird in a year. However, the effectiveness of the birds is far greater when seen in terms of the reduction in offspring of these ticks. A female blue tick (*Boophilus decoloratus*) and a bont tick (*Amblyomma hebraeum*) can lay from 2 500 to 18 000 eggs respectively. By removing the adult tick, the accumulative production of larvae in a given area will be reduced substantially.

Licks

The following guidelines must be followed with anthelmintic licks:

- Introduce rock salt or licks consisting coarse salt to ensure that the animals do not have a salt hunger and get use to the lick area. As soon as the animals have accepted the salt licks, they can gradually be replaced by non-medicated mineral licks, such as 50% salt, 5% calorie 3000 and 45% dicalsiumfosphate. After the animals have accepted these licks, it can be medicated with

anthelmintics. The anthelmintics must be alternated with products such as diatomite to prevent resistance forming strains of different parasites.

- The best results are obtained by placing out several licks over the whole ranch close to water points. When more aggressive animals such as eland are present, sufficient licks should be provided at each point to avoid competition.
- Licks for giraffe can be provided on a wooden platform tied with a chain to trees at the appropriate feeding height.
- The licks should be inspected on a regular basis to determine which wildlife species are utilizing them. Licks containing urea must be placed in containers with holes drilled in the bottom to prevent rainwater accumulating in the container. Dissolved urea is toxic and will lead to mortalities in wildlife if they take this water in.
- Warthog and Burchell's zebra tend to take large bites out of lick blocks. In doing so, they also tend to overturn or break the blocks. When zebras are present on a game ranch, the licks should be anchored firmly to the ground or placed in metal or concrete frames at ground level. More than one block must be put in an area because zebra will kick and cause injuries to other wildlife species.

Image 14: Container with lick – rim filled with pour on tick dip that make contact with animal

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ANNEX A: HABITAT REQUIREMENTS, PRIMARY FOOD AND WATER DEPENDENCE OF SOME SOUTHERN AFRICAN HERBIVORES THAT ARE SUITABE FOR A WILDLIFE RANCH

HERBIVORE	HABITAT REQUIREMENTS	FOOD	WATER DEPENDENT
African savanna buffalo	Open savanna, tall grass, shade especially in summer	Grasses, occasionally browse	Yes
Black-faced impala	Dense riparian thickets next to open savannas and near open water in arid regions	Browse, grasses and forbs	Yes
Black rhinoceros	Shrubs and trees up to 4 m high, open to dense savannas	Browse, but occasionally grasses and forbs	Yes
Black wildebeest	Open plains, particularly taller Highveld grasslands, south-facing aspects, concave geomorphology	Grasses, but occasionally dwarf shrubs and forbs	Yes
Blesbok	Highveld grasslands	Grasses, occasionally browse and forbs	Yes
Blue duiker	Forest, dense thickets, coastal thickets near open patches, and deep shade	Browse, forbs, fallen fruits, and flowers on the ground	No
Blue wildebeest	Open savannas with trees and shrubs, shade close by grazing areas, short grasslands, north-facing aspects, convex geomorphology	Grasses, occasionally browse and forbs	Yes
Bontebok	Coastal plains 60 to 200 m above sea level, fynbos	Grasses, occasionally browse	Yes
Burchell's zebra	Open savannas and short grasslands	Predominantly grasses	Yes
Bushbuck	Riparian thickets, other dense shrub underbrush near permanent water	Browse, occasionally grasses	Yes
Bushpig	Open savannas, shrub and grassland to dense forest, tall grass and reeds	Omnivorous: browse, grasses, roots, earthworms and more	Yes
Cape grysbok	Dense shrubby savannas and succulent montane shrublands, fynbos	Browse, grasses and forbs	No
Cape mountain zebra	Montane grasslands, shelter in ravines, fynbos	Grasses	Yes
Damara dik-dik	Dense thickets and shrub underbrush	Browse, growing tips of shrubs, fruits, occasionally grasses and forbs	No
Eland	Versatile: mesic to open arid savannas	Browse and grasses	Occasionally

Elephant	Versatile: savannas, forests, occasionally deserts	Browse, twigs, branches, bark and grasses	Yes
Gemsbok	Open, arid savannas to shrubby grasslands	Grasses and some browse, bulbs, tubers, rhizomes and fruit	No
Giraffe	Arid to mesic savannas	Browse	Occasionally
Greater kudu	Open to dense savannas, broken and rocky terrain	Browse	Yes
Grey duiker	Thickets, savannas and woodlands, shade and cover	Browse, twigs, flowers and fallen fruits, occasionally grasses and forbs	No
Grey rhebok	Rocky hills, higher mountain slopes and plateau with a good shrub and grass cover	Browse and forbs, occasionally grasses	No
Hartmann's mountain zebra	Mountain plateau, edges of sandy plains and savannas	Primarily grasses	Yes
Hippopotamus	Open water deep enough to submerge in, sloping sandbanks next to water	Grasses	Yes
Impala	Open savannas and heavily utilized areas, Acacia veld	Browse, grasses and forbs	Yes
Klipspringer	Rocky patches: cliffs, mountains and rocky hills, arid to mesic savannas	Browse	No
Lechwe	Shallow, inundated floodplains	Grasses, sedges, aquatic plants	Yes
Lichtenstein's hartebeest	Savannas, open woodland-wetland-floodplain ecotones	Grasses	Yes
Mountain reedbuck	Arid, grass-covered, rocky slopes primarily on rocky hills and mountains with scattered bushes and trees; lower slopes of high mountains, water	Grasses, but occasionally browse	Yes
Nyala	Dense shrubs to thickets, riparian thickets, forests and floodplains	Mainly grasses in the summer and browse in the winter	Occasionally
Oribi	Open areas with slopes < 10°: floodplains, wetlands with short grassland and scattered patches of tall grassland, highveld grasslands	Short grasses, sedges and other forbs	No
Puku	Riverine areas, floodplains and dambos	Grasses	Yes
Red duiker	Sand forests, dense thickets, riparian thickets	Browse, twigs, fallen fruits and flowers	No
Red hartebeest	Arid grasslands and open savannas	Grasses, occasionally browse and fruits	Yes
Reedbuck	Tall grasslands or reeds near open water and floodplains	Grasses	Yes

Roan antelope	Open savannas, medium to tall grasslands and wetlands with scattered low shrubs, sweet and sour veld	Medium to tall grasses, aquatic plants	Yes
Sable antelope	Open savannas with scattered low shrubs bordering wetlands, medium to tall sweet grasslands	Grasses, occasionally browse	Yes
Sharpe's grysbok	Shrublands, medium tall grass and riparian thickets in savannas	Browse, grasses and forbs	Yes
Sitatunga	Semi-aquatic, dense papyrus clumps	Water plants, reeds	Yes
Springbok	Arid, open and short grasslands, Kalahari and Karoo veld	Browse, grasses and forbs	No
Steenbok	Open savannas and grasslands with scattered tall grass clumps and low shrubs	Browse and forbs, some grasses	No
Suni	Arid savannas with dense shrubs and shrub underbrush, dense thickets along watercourses, evergreen areas, sand forests	Browse	No
Tsessebe	Grassland-bushveld edges, palatable grasses, shade and water in areas with few stones	Grasses	Yes
Warthog	Open savannas, grasslands, wetlands and floodplains with short and heavily utilized grass	Grasses, sedges, forbs, shrubs and wild fruits	Yes
Waterbuck	Open savannas, wetlands and floodplains, grasslands	Grasses	Yes
White rhinoceros	Flat savannas with short grasslands	Grasses	Yes

Image 15: Waterbuck

ANNEX B: MAIN FEEDING SPECTRUM OF SOME HERBIVORES FROM SOUTHERN AFRICA

HERBIVORE	Low-selective grazers or roughage and bulk feeders	Highly selective grazers	Mixed feeders	Highly selective browsers, fruits and forbs	Tall-grass grazers	Short-grass grazers
African savanna buffalo	*				*	*
Black rhinoceros				*		
Black wildebeest		*				*
Blesbok		*				*
Blue duiker				*		
Blue wildebeest		*				*
Bontebok		*				*
Burchell's zebra	*				*	*
Bushbuck				*		
Bushpig			*			*
Cape grysbok				*		
Cape mountain zebra	*					*
Damara dik-dik				*		
Eland			*			
Elephant	*		*		*	
Gemsbok		*			*	*
Giraffe				*		
Greater kudu				*		
Grey duiker			*	*		
Grey rhebok			*	*		
Hartmann's mountain zebra	*					*
Hippopotamus	*					*
Impala			*			*
Klipspringer				*		
Lechwe		*			*	*
Lichtenstein's hartebeest		*	*			
Mountain reedbuck		*	*		*	
Nyala			*			
Oribi		*				*
Ostrich			*			*
Puku		*			*	*
Red duiker				*		
Red hartebeest		*				*
Reedbuck		*			*	
Roan antelope		*	*		*	
Sable antelope		*	*		*	
Sharpe's grysbok				*		
Sitatunga		*			*	*

Springbok			*			*
Steenbok				*		*
Suni				*		
Tsessebe		*			*	*
Warthog			*			*
Waterbuck		*			*	
White rhinoceros	*					*

Image 16: Baobab tree with elephant damage

ANNEX C: DEFINITIONS

GENETICS

As some readers of this book may not know all the terminology that is used, the following brief definitions of some genetic concepts are given. They are based on the text of Osterhoff & Eksteen (1983) and Bourdon (2000):

Breeding value: The ability of an animal to transmit certain genetic traits to its offspring.

Genetic value: The total genetic make-up of an animal. It includes all the genes that the animal has that influence its performance and production.

Coefficient of inbreeding: The probability that an individual has received both alleles of a pair from an identical ancestral source. Chromosome pairs carry different genes or alleles. The X chromosome carries the genes or alleles of the female and the Y chromosome those of the male. The effect of a given gene or allele on the phenology of an animal depends upon whether it is dominant or not. The position of an allele on the chromosome is known as its locus.

Inbreeding: The mating of closely related animals, more closely than the mean of the population from which they come.

Linebreeding: A form of inbreeding that attempts to maintain a high frequency of individuals of superior genetic qualities in a population.

Outcrossing: The mating of two individuals of the same breed that are not closely related.

Natural selection: The natural process that allows some individuals to produce viable offspring while others are prevented from doing so. Social behavior is the driving force in most animals that only allows some individuals in a group to breed.

Artificial selection: Usually found in intensive production systems where specific individuals are selected based on performance traits in producing offspring of improved quality.

Genetic selection: The process of selecting animals with a known genetic superiority for specific characteristics.

Genetic diversity: The possession of a wide range of genetic characteristics.

Extralimital: Indigenous species outside its historic natural distribution range.

FENCING

Adequate fencing: deals with the minimum specifications in terms of which a fence or enclosure is constructed in order to prevent a wild animal from escaping under normal circumstances.

A certificate of adequate enclosure (CoAE): is issued to an applicant in terms of section 35 of the Ordinance for the purpose of granting the holder thereof certain rights with regard to the utilisation of the animals listed on the CoAE.

Circuit means an arrangement of conductors for the purpose of carrying electrical energy.

Conductor means an electrical conductor so arranged as to be electrically connected to a source of electrical energy.

Dead means at or about zero potential and isolated from any positive wires.

Earthed means connected to the general mass of earth in such a manner as to ensure at all times an immediate safe discharge of electrical energy.

Electric fence means an electrical barrier consisting of one or more conductors erected against trespass of persons or animals.

Electric fence energizer means electrical machinery arranged so as to deliver a periodic non-lethal amount of electrical energy to an electric fence connected to it.

Electric fence system means an electric fence and an electric fence energizer.

Bracket means a device normally fabricated out of metal with attached fence insulators that can be attached to a building with the objective of supporting electric fencing wires.

Bracket or pole facet means a flat section on the electric fencing pole or bracket.

Dynamic bracket or pole means a bracket/pole that fulfills the function of a passive bracket and additional mechanical features/functions. (It may have an additional detection device built into it.)

Partitioning (Sectorisation) means an electric fence installation that consists of one energizer connected to an electric fence which is then divided into sections for monitoring purposes. One energizer powers a zone, and the zone is then sectorised (partitioned).

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