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GAME PRODUCTION OPTIMIZATION WITHIN A NEW ERA:

THE ESSENCE, THE PRINCIPLES, THE PENDULUM TO FINANCIAL SUCCESS

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ABSTRACT

Dramatic changes in the socio-economic environment in southern Africa lead to transformation from livestock to integrated game farming. This results in a rapid growing game industry and thus, greater game produce supply, risking present market forms with saturation. Consequently a survival struggle develops for the "smaller", marginally profitable game farmer. A 10-year study (1990-2000) of integrated game\livestock production systems in the eastern Cape Valley Bushveld revealed a strategy and means to optimize game production. Population performances per game species can be raised by as much as 20% by manipulating natural population dynamics through a) management of individual species needs, b) annual control of age and sexual structures, c) filling of all potential niches in all habitats and d) selection of most performable game species. Focussing and managing game production, for annual yields and for specific pre-defined markets has become the key to future survival of the "smaller" landowner.

Keywords: Animal needs, Animal performance, Eco-production principle, Habitat suitability, Livestock transformation, Management, Market risks, Niche seperation, Stratefic planning, Value adding.

INTRODUCTION

Production of game: a poorly understood term which has become the key to sustainability and survival to the majority of modern game farmers. Definite distinction is to be made between game production farming (implementation of livestock farming principles to an extend fitting the natural limitations of individual game species), game ranching (managing ecological biodiversity) and game conservation. The game industry, other than pure conservation, implemented the agricultural Large Stock animal-Unit (LSU) as benchmark and tool to determine carrying capasities and game stocking loads to optimize financial returns. This doing does not fit the needs of game, nor the co-existence and eco-functioning of a multi species eco-system. A mis-consumption of game production evolved, resulting detrimental degradation of natural resources and non-viable economic returns. A game production optimization strategy had been developed from a 10-year study[4] of integrated game\livestock production in Succulent Valley Bushveld in the eastern Cape, South Africa. Confusion has rissen with regards to the risk of the eco-tourism and trophy markets being pulled from under the "smaller" game farmer. It is due to the development of a series of greater wilderness parks and international transfrontier parks across southern Africa[5]. The scenario is worsened by a rapid increase of landowners entering the game industry (42% and 48% increase in 1999 and 2000 in the eastern Cape, SA, alone). New markets and new products need to be developed[6,7] to safegaurd and secure the industry from a sudden collapse in near future.

PRESENT South African SOCIO-ECONOMIC ENVIRONMENT

Number of game ranches (eco-tourism & conservation) and game farms (conservancies and production systems) in South Africa at present exceeds 9 000, covering more than 13% of the country's total land area[1]. National and provincial parks covers an additional 5%. In addition some 3 000 smaller (<4 000ha; of which 80% <2 500ha) livestock farms had been estimated to be in a process of partial or full conversion to integrated game\livestock production. Vague estimates from the eastern Cape alone indicates that 25-30% of all livestock farms have already incorporated\integrated some form of game production (not included in the statistics above. This is terrifying and alarming, taking that all compete for the same produce market than the larger ranches. Most privately owned landunits has become too small in area size to sustain the animal numbers needed (at natural production rates) to be economically viable. Thus, they operate on meagre profits gained from professional hunting and eco-tourism, with accommodation and human hosting rendering the bulk of income. Many ranches survives merely by subsidy from external commercial businesses other than the game industry.

Main trends responsible for the present status of the sosio-econimic environment[1]:

- Deregulation of the farming sector by the World Trade Organization followed by local Government forcing the agricultural sector to improve productivity and to become less dependent on government support;
- Loss of political leverage - Agriculture has lost its clout in Parliament by the political changes in voting power on the platteland and rural areas - agricultural subsidies disappeared, production costs increased and sales prices inheritted severe pressure from international competition - marginally profitable farming operations are being forced out of business;
- Climate - 60% of South Africa receive <500mm annual rain (internationally considered as semi-desert) and 21% <200mm (desert) - at best, maize production in SA may reach 2,3 tons/ha compared to 7,9 tons in the USA, and livestock carrying capacity in SA may reach 4ha/Large Stock Unit compared to 1,5ha in New Zealand - The dry South African climate makes it difficult to compete with World Markets abroad;

- New labour legislation inforced by law, rapidly increased labour expenses, decreased productivity and thus, declined profitability;
- Aids and malaria increases, especially in rural environments, resulting in decreasing productivity of labour forces - also having a negative impact on foreign eco-tourists and hunters visiting the country;
- Stock thefts - since the death pennilty and hard labour in SA prisons had been abandoned law and order turned into havoc - enhanced by unemployment, poverty and illegal immigrations - the expense of stolen livestock, running expence of increased policing and security, and the exclusion of large portions of land (at high theft risk) from production - all contribute to livestock farming becomming less profitable and less viable.

Rapid transformation of marginally profitable livestock production systems into game ranching and\or game production farming seems to be the only ultimate short-term solution. However, it is not simple. Limitations set by land area size and habitat requirements, spatial seperation & interaction, social behavioural needs, and performance potential of game species are poorly understood by both landowner and scientist. Even worst, is the understanding of the difference in animal production principles between livestock and game, and the extend to which game can be manipulated to increase and optimize production. Complifying the matter of transformation, is the risk of furure unstability of the present game produce markets in future, the need to develop alternative markets[7], and the potential to develop alternative or new products[6]. Of concern is the impact that the present development of eight enormously large transfrontier parks in southern Afrika[5] as well as various large (>100 000ha) wilderness parks (eg.: Greater Addo; Cape penninsula; Baviaanskloof; Oudtshoorn; Lake St'Lucia; developments in northern Angola; ect.) would have on eco-tourism and trophy hunting. Especially the competition upon a) the "smaller" landowner (>4000ha) and b) the integrated game\livestock farmer; who is incapable of supplying the great African "Experience" Atmosphere, but still dependant upon game profits for survival. Currently 85% of all Africa's trophy exports come from South Africa[1], what would it be in 10-15 years time? From the total income from game ranching, 80% comes from hunting, 10% from eco-tourism and venison export and 10% from live sales[1]. What is the viability of trophy and\or venison production for the "smaller" game farmer with regards to the limitations set by spatial needs of the game species?

"GENESIS" OF ANIMAL PRODUCTION WITH GAME

Diversion and differentiation due to the needs of the living started with Genesis. Evolution that led to the development and dividing of different living creatures, is the outcome of two major parameters: a) changing of existing environments and habitats and b) differences in spatial needs of different groups of animal and plant creatures. Man has developed skills and technology enabling him to withstand extremely poor environmental conditions. He can change the environment to his advantage and needs. This led to the distinction of other life forms and the resources of the modern planet Earth. Human politics are in principal a function of differences in needs and space of different nations. So more, is human warfare the onslaught of ever expanding densities of people against limited area and space.

Livestock has been bred by man (since 4000 years BC) against its natural social and spatial needs, for outrageous performances (primarily for quantity and secondly quality) enabling one male to mate with up to 40-60 or more females. The outcome - continuous maximum reproduction under prevailing, adequate, high quality, food supplies. Food abundance became the major parameter affecting livestock production. Frankly a simple system. Nature's Law, "Survival of the fittest" (not quantity, but quality), still applies to all non-domesticated wild animals, irrespective of: a) the management system being followed, b) land area size, c) species composition, or d) degree of integration with livestock. Game still has its natural instincts and requirements and therefore restricts production to the limitations associated with confined (fenced-in) land areas. As laid down by "Nature's Law", only the strongest males will mate. The weaker and younger gets driven away by the stronger. Oftenly females refuse mating with the weaker, they seek for the strongest genes to be carried forward in their offspring. Consequently dominant males spend more time securing females than mating, thus rarely reaching its potential mating limit. Reducing male numbers in favour of females does not necessarily mean a counterbalanced increase in production and population growth. Game management is thus, highly complex, never simple.

Table 1: Most important ecological differences between game and livestock production systems.

	GAME	**LIVESTOCK**
1	Social heirarchy & spatial seperation	Natural social structure are lost
2	Territorial behaviour important	No territorial behaviour
3	Migration with larger and more gregarious species	No migration
4	Co-existence of various species	Loss of co-existence
5	Multi species conundrum	Mono species culture
6	Self regulating, harmonic ecological equilibrium of co-existence between plants and animals	Opportunistic machines only to be controled by the manager himself
7	Ecosystem adapted for co-exsistence of species	Exotic animals being bred to take maximum advantage of the system, to the detriment of other species
8	Niche seperation	Loss of niche seperation
9	Stratified feeding to minimize species competition	Maximum competition
10	Production for quality and strength	Production for quantity

11	Co-evolution is positive, it inforces the ecosystem	Co-evolution is negative, it demolishes the ecosystem
12	Eco-production principle	Exploitation principle
13	Forward succession of the resource	Backward succession of the resource
14	Carrying capacity based upon animal social needs and habitat requirements	Carrying capacity based upon fodder production, consumption and Veld Type

PRODUCTION PRINCIPLES

Game production is determined by the most limiting of various parameters with regards to the landunit and habitat[4]:

1. Suitable habitat:

Each species has specific habitat requirements regarding refuge, feeding and social activities. Variation in stratified wody canopy sructure and grass talness render different suitability to the very same Veld-(vegetation)-Type towards a specific game species (eg. Suculent Valley Bushveld renders 9 different habitats in relation to geological substrate alone, resulting only three being optimal suitable for kudu). **Kudu** (browser) prefer less dense bush enabling good visibility at head hight. On frequent human disturbances refuge is taken in dense thicket and forest-like habitats, while more open woodland remain compulsive for feeding. **Impala** (mixed feeder) tolerate thicker bush than kudu, but are selective towards short grasses. **Sable** prefer low density savanna woodland with medium to tall grasses of less sweet species, on sandy granite soils. **Roan** prefer sweeter grass, of the same height (as sable), but within thicker woodlands on alluvial soils and basaltic plains. **Mountain Reedbuck** are sensitive towards rocky outcrops and undulating topography. **Buffalo** prefer plains, marshlands and drainage lines with abundant tall, sweet grasses and surface water. Although some species may survive in various habitats, their production potential will rarely come to full extend. Some may breed poorly, as gemsbok in the eastern Cape, or some may take liberty of new habitats, as for the exotic fallow deer. Most important is the specialized type of feeding behaviour of the species which differs entirly from livestock catogories. Their are no such thing as a non-selective game animal. Even the bulk feeding buffalo is selective towards grass species.

Table 2: A detailed breakdown of the feeding behaviour of game.

Species \ Feeding type	**Selectiveness**	***Grass Tallness***	***Grass Nutritiousness***
BROWSERS:			
Kudu (+Forbes)	Highly	6 - 30cm	Mixed

Giraffe	Hihgly - Concentrate	6 - 30cm	Mixed
Common duiker (+Forbes)	Hihgly - Concentrate	1 - 8 cm	Mixed
Black rhino (orbes)	Highly	6 - 30cm	Mixed
Bushbuck (+Forbes)	Hihgly - Concentrate	6 - 30cm	Sweet
Nyala (+Forbes)	Hihgly - Concentrate	6 - 30cm	Sweet
Klipspringer	Hihgly - Concentrate	6 - 30cm	Sweet
MIXED FEEDERS (Browse; Grass; Forbes):			
Eland	Partly	6 - 30cm	Mixed\Sour
Gemsbok	Partly	6 - 30cm	Sweet\Mixed
Impala	Hihgly - Concentrate	1 - 8 cm	Sweet
Springbuck	Highly	1 - 8 cm	Sweet
Grysbok	Hihgly - Concentrate	1 - 8 cm	Sweet
Steenbok	Hihgly - Concentrate	1 - 8 cm	Sweet\Mixed
Elephant	Low - Bulk	6 - 150cm	Sweet\Mixed
Fallow Deer	Partly	6 - 30cm	Sweet\Mixed
Boergoat	Partly	1 - 30cm	Sweet\Mixed
Grey Rhebok	Highly	6 - 30cm	Mixed\Sour
GRAZERS:			
Buffalo	Low - Bulk	6 - 150cm	Sweet\Mixed
Waterbuck	Partly	6 - 30cm	Sweet\Mixed
Roan	Partly	6 - 150cm	Sweet\Mixed

Sable	Partly	25 - 150cm	Sweet\Mixed
Zebra (Hartmann Mountain)	Partly	6 - 30cm	Mixed\Sour
Zebra (Cape Mountain)	Partly	6 - 30cm	Mixed\Sour
Zebra (Burchell)	Partly	6 - 30cm	Sweet\Mixed
White rhino	Low - Bulk	6 - 30cm	Sweet\Mixed
Tsessebe	Partly	6 - 30cm	Sweet\Mixed
Blesbok	Highly	1 - 8 cm	Mixed\Sour
Oribi	Highly	6 - 30cm	Mixed
Bushpig	Hihgly - Concentrate	1 - 8 cm	Sweet
Warthog	Highly	1 - 8 cm	Sweet
Red hartebeest	Partly	6 - 30cm	Mixed
Ostrich	Highly	1 - 8 cm	Sweet
Black wildebeest	Highly	1 - 8 cm	Mixed\Sour
Blue wildebeest	Highly	1 - 8 cm	Sweet\Mixed
Bontebok	Highly	1 - 8 cm	Sweet\Mixed
Lechwe	Partly	6 - 150cm	Sweet\Mixed
Common Reedbuck	Partly	25 - 150cm	Sweet\Mixed
Mountain Reedbuck	Partly	1 - 30cm	Mixed\Sour

2. Adequate food resource:

Adequecy (a certain composition, structure, quality and quantity, as required by the different animal species) and sustainability (fodder production rate) of food supply within the habitat, as for the dryiest season. Can the food supply cater for the various diets of the different game species and numbers roaming the landunit? Inadequate supply limits reproduction, whereas inadequate quality (nutritiousness) results physically stressed animals and possible mortalities with sudden climatic change.

3. Social structuring:

The major difference between livestock and game production lies with social structuring. Hierarchy ranking (an off-come of "Nature's Law") is important to game. Social structuring which is a function of home range, territoriality, social maturity and physical body condition differs greatly between game species. For solitary species, both males and females have defined territories and home ranges with little (<20%) overlap. Either, pair bonding (steenbok) occur sharing one territory, or the male wanders across the bordering territories of one or two females (duiker, bushbuck, black rhino), for mating only. For semi- gregarious species (zebra, kudu, hartebeest, sable, impala) the males become territorial only during the rut. With to high a bachelor male ratio, the dominant males will spend more time fighting than mating. Gregarious animals (giraffe, buffalo, wildebeest, springbuck) are less territorial and hence the males less aggressive. Mating ratios may vary between 1:6 and 1:15 depending on the species. Some species form strict family bonds for life (buffalo, zebra, sable). For kudu, giraffe, springbuck and impala, groups constantly restructure due to movement of individuals between groups, forming only temporarily associations. Individuals of the latter species will however, stick to a defined home range that may overlap by as much as 80%[4]. These ranges are not to be assigned to groups, but to individual animals. Overlapping for the strict family and pair bonding species is rarely greater than 20%[4]. Higher animal densities can be maintained for species with greater overlap of home ranges (providing it remains within the carrying capacity). Socially immature males consume food and take up space that could be used by productive females. Hence, if trophy production is the goal, the interim bridge of unproductive bulls have to be maintained to prevent the bull structure from age declination.

4. Land area size:

The single parameter of greatest influence upon financial budgets and turnover, determining the viability of the ranch or system. It limits animal numbers and species composition to be kept. Game may not be stocked according to the area size of the ranch or farm. A percentage suitability of each habitat variation on the ranch\farm towards each game species has to be defined. Game numbers must be culculated for each species individually, against the proportional size of the suitable habitat (multiplied by the % suitability thereof).

5. Carrying capacity:

After the generall agricultural norm with regards to the ecological status of the veld. The most unstable feature of the habitat, ever changing with climatic fluctuation and varying veld condition. A maximum density (level of saturation) exists for every animal species on every land unit, proportionally to the size of suitable habitat. Beyond the saturation level, social behavioural needs inhibits further density inclinations. Carrying capacity is by definition the number of Large Stock Units (LSU) to be carried per hectare per year ($LSU.ha^{-1}.yr^{-1}$) without deterioration of the habitat. One LSU equals a 450-kg steer feeding exclusivly on grass, gaining 500 gram weight per day. Other important parameters affecting carrying capacities for game are: a) Minimum Hectare per Animal Unit (ha/animal) of optimal habitat needed to fulfill in the diversity of dietary fodder needed year round; b) Minimum Habitat-Area Size (ha) per animal or associated animal groups (family) needed to fulfill the species social and spatial needs; and c) Browser Equivalent Unit for browser animals (one browser unit equals a 140kg kudu feeding upon 1500 edible, acceptable trees\shrubs with a canopy between 0,6-2,0m height sustaining >35% of its foliage year round[4]).

Table 3: Minimum game stocking criteria for optimal suitable habitat condition

Species	***LSU Equivalent***	***Browser Equivalent***	***Minimum Ha/Animal*** *(Feeding needs)*	***Min. Size Habitat-Area*** *(Social needs)*
BROWSERS:				
Kudu (+Forbes)	0.40	1.00	12	250 ha
Giraffe	1.60	4.10	80	900 ha
Common duiker (+Forbes)	0.07	0.02	3	3 ha
Black rhino (+Forbes)	1.67	4.17	30	200 ha
Bushbuck (+Forbes)	0.13	0.33	4	4 ha
Nyala (+Forbes)	0.26	0.65	8	80 ha
MIXED FEEDERS (Browse; Grass; Forbes):				
Eland	0.90	2.25	22	200 ha
Gemsbok	0.43	0.80	20	450 ha
Impala	0.16	0.40	6	150 ha
Springbuck	0.11	0.28	10	100 ha
Grysbok	0.06	0.15	4	10 ha
Steenbok	0.06	0.15	4	30 ha

Elephant	2.50	6.25	500	2000 ha
Fallow Deer	0.26	0.65	9	200 ha
Boergoat	0.17	0.45	2	20 ha
Grey Rhebok	0.09	0.30	12	120 ha
GRAZERS:				
Buffalo	0.10	0.00	30	1200 ha
Waterbuck	0.45	0.00	15	300 ha
Zebra (Hartmann)	0.50	0.00	25	500 ha
Zebra (Burchell)	0.70	0.00	25	800 ha
White rhino	2.50	0.00	30	600 ha
Tsessebe	0.34	0.00	20	400 ha
Blesbok	0.21	0.00	15	200 ha
Bushpig	0.20	0.00	8	150 ha
Warthog	0.13	0.00	15	60 ha
Red hartebeest	0.50	0.00	20	300 ha
Ostrich	0.24	0.00	20	60 ha
Black wildebeest	0.35	0.00	20	400 ha
Blue wildebeest	0.50	0.00	20	300 ha
Bontebok	0.21	0.00	15	150 ha
Lechwe	0.28	0.00	15	120 ha
Common Reedbuck	0.20	0.00	5	70 ha

Mountain Reedbuck	0.10	0.00	5	60 ha

Every landunit or farm differs from one another and has its own unique carrying capacity and game composition potential. General norms for game stocking for the major Veld-Types does not exist. Landowners trying to optimize game production by applying so come, claimed to be "general norms" is fooling themselves. The smaller the scale of farming the greater this error to be. No two farms can be compared or managed alike for game production. Professional advice and planning are needed continuously (as environments, climate and management objectives are not stable, but ever changing). Production optimization is a thumb print for every landunit individually, which can not be generalized.

6. Reproduction physiology:

The sexual and social maturity ages and the natural and optimal male : female mating ratios? Production potential (reproduction) is a function of the sexual and age structure of the population and of the physical condition of individuals. Physical condition is a function of social and spatial structure (degree of stress) and abundance and quality of food supply. Degree of social and spatial stress is determined by animal density (numbers and land-unit size) and animal-species composition (species interaction). Food supply is determined by habitat, climate and veld-condition. For example: **Springbuck** become socially mature at nine months (female) and 20 months (male). Gestation period is 5½ months. An ewe can give first birth at 15 months and every seven months thereafter (optimal conditions), and may produce 16-18 lambs through expected life-span of 10 years. **Kudu** reaches sexual maturity at 16 months (female) and 24 months (male); become socially mature at 20 months (female) and three years (male). Gestation period is eight months. A cow may produce only 4-7 calves over the expected life-span of 6-9 years[4]; life span for males is 12 years. **Buffalo** cows reaches social maturity at four years with a gestation period of 11 months (but a calving interval of 20-26 months) and a life-span of 20 years, producing a aximum of seven calves per cow.

Solitary game species mate at a ratio of 1 (male) :1-2 (female); semi-gregarious species at 1:4-6; and gregarious species at 1:10-15. Natural ratios in populations are generally 1:1-2 due to the natural birth ratio of 50% male and 50% female. Thus, up to 75% of the males in the population is either sosially inmature or to old (socially post-mature) to compete with the stronger jounger mature males, and thus do not breed. Important of game is that only the dominant males and sosially mature females breeds. For some species like the impala, females are highly fastidious towards the male. Inferior rams are neglected by the ewes. With larger gregarious animals the hirarchy is less strict and some sub-adult males will mate only with sub-adult females.

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Maturity:

Sexual maturity: The age at which the animal has physiologically sexual development to be able to mate with a female. Fertility has been reached.

Social maturity: The age at which the animal has developed sufficient body strength to defeat opposition of its own sex from the opposite sex. The animal can now insure that its own genes would be transferred in reproducing to future generations. The animal are now able to maintain a leading functional role within the social hierarchy of the population.

Post-maturity: The animal has lost its strength to compete for social dominance, or it has become infertile, but still dominant in keeping fertile males from mating.

Sub-adult: The period from sexual maturity up to the average age at which members of the species generally reaches social maturity.

Calf \ lam: Generally from birth until one year of age.

Youngster: From one year until sexual maturity is reached.

Sub-adult males render the least contribution to animal production on the game farm. They consume and utilizes the habitat and fill up the animal load in terms of roaming space and carrying capacity, while they do not contribute to reproduction. Mostly they also have no trophy vallue. Sub-adult males must thus be kept low in number by management. Only sufficient replacement males are to be kept according to the number of breeding herds in the population on the farm.

7. Ageing criteria:

The rate of body growth in relation to age and the social hierarchy rank of the animal in relation to age. Probably the most ignored parameter in managing a game population for production. Maximum production versus maximum trophy animals is in direct conflict with each other. Heading for maximum production for kudu, the sexual ratio of socially matured animals has to be kept between to 1(male) : 3-5(females), never to exeed 1:8. Important to note that trophy status for kudu is only reached at >8 years[4] (Fig. 2). Once the population has reached ecological equilibrium, optimal sustainable take off (reproduction) for kudu is only **19%** (ranging from 12-26% depending on rainfall). Kudu cows increase in body mass until 4 years, after which growth stabalizes to start deteriorating after 5,5 years. If sudden cold, wet spills are experienced after 5 years of age, during droughts, up to 75% of all famales >5 years may die prompt[4]. From the above take off, 44% need to be old females (>5 years), 44% socially mature males (3 years) and only 12% trophy animals (>8 years). For a optimum population of **250 kudu** on 3000ha suitable habitat: a) for maximum animal production - management will yield a sustained growth rate of **34 animals**; with annual take-off of 15 old females, 15 males (3 years) and four trophy bulls; b) For maximum trophy production - management will yield a growth rate of **22 animals**; with annual take-off of 11 old cows and 11 trophy bulls (6 of 8 years and 5 of 10 years). Old females have to be culled as they start deteriorating after five years with an ever increasing risk of mortality during sudden climatic fluctuations (Fig. 3). Population growth reaches a plateau at a sexual ratio of 1:4-5, then females have to be taken off to sustain optimal reproduction. Allowing more males of the age 4-7 years (as for maximum trophy production) would result over stocking. In consequence, more females will have to be taken off to sustain the stocking load, hence reducing total population production (reproduction). For **springbuck** at the saturated equilibrium, **35%** of the total population may be harvested annually. The harvest ratio to be 49% females (>4 years), 45% socially mature males (2 years) and 6% large males (>3 years).

Population dynamics are extremely sensitive towards sudden changes. One misjudged harvest of the sexual and age structure of a kudu population can reduce production by more than 30%, which may take 4-12 years to restore (depending on the habitat area size, population size, and rainfall). Species having high production potentials such as springbuck are just as sensitive, but restoring can be reached much sooner (as little as 2 years). On larger land units the reduced population growth rate, due to a misjudged harvest, can be counterbalanced by the greater animal numbers to be carried by larger habitat areas.

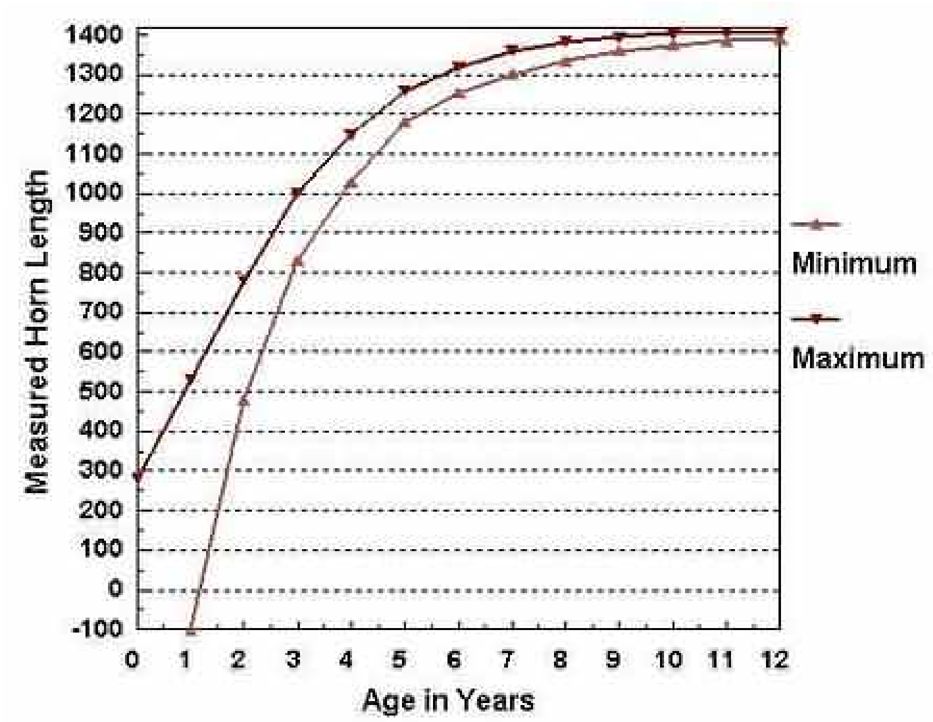

Figure 2: Trophy growth (length in mm) for kudu males on annual increments in 242 animals[4].

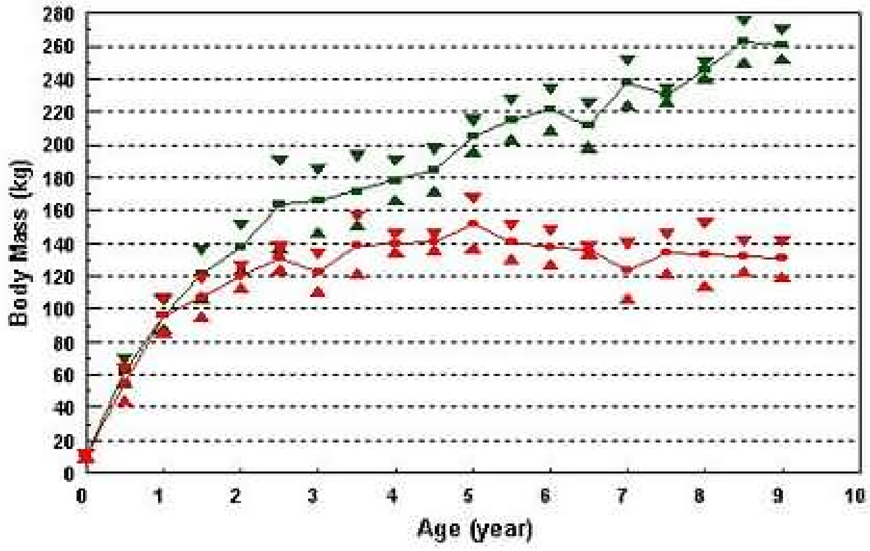

Figure 3: Kudu body growth rate in relation to age, determined from 440 animals harvested on the Krkwood Prison Farm (1989-1993)[4].

8. Stocking rate (animal load as a % of carrying capacity):

The number of animals to be kept on any land unit is determined by: the habitat-area size (providing it is suitable for the species); carrying capacity; social and spatial needs of the animal; and animal-species composition (interaction & composition). Example: A landunit size is 6000 ha (carrying capacity is 10 ha/LSU/yr = 600 LSU's); 6000 ha is suitable habitat for roan and cattle, but only 4000 ha is suitable habitat for kudu and black rhino;

A) **Rhino** are a highly solitary with a home range of 200 ha per individual or breeding pair (less than 20% overlapping), thus the ranch has room for 25 + 50% pairs = **37** animals. By LSU (one rhino = 1.67 LSU's) the ranch should sustain **239** rhino. Dietary & social needs require 30 ha/animal by which the ranch would have room for **133** animals.

B) **Kudu** are gregarious (average group size 6), but not territorial, with a home range of 250 ha (up to 80% overlapping), thus the ranch has room for **7680** animals. By LSU (one kudu = 0.4 LSU's) the ranch should sustain **1000** kudu. Dietary & social needs require 12 ha/animal by which the ranch would have room for **333** animals.

C) **Roan** are gregarious (average group size 15), highly territorial, with a home range of 2000 ha (less than 20% overlapping), thus the ranch has room for **50** animals. By LSU (one roan = 0.59 LSU's) the ranch should sustain **1017** roan. Dietary & social needs require 30 ha/animal by which the ranch would have room for **200** animals.

D) **Cattle:** By LSU's the ranch could sustain **600** heads of cattle.

By means of the most limiting needs parameter the ranch can singularly sustain a maximum of: **37 rhino** (by home range); or **333 kudu** (by ha/animal); or **50 roan** (by home range); or **600 cattle** (by LSU). The numbers for the four species have still to be reduced to fit into the total 600 LSU grazing as well as the browsing capacity of the ranch. If mixed feeder species are to be included into the game composition, browsing and grazing capacity have to be allocated proportionally to the % proportion of either consumed by the species.

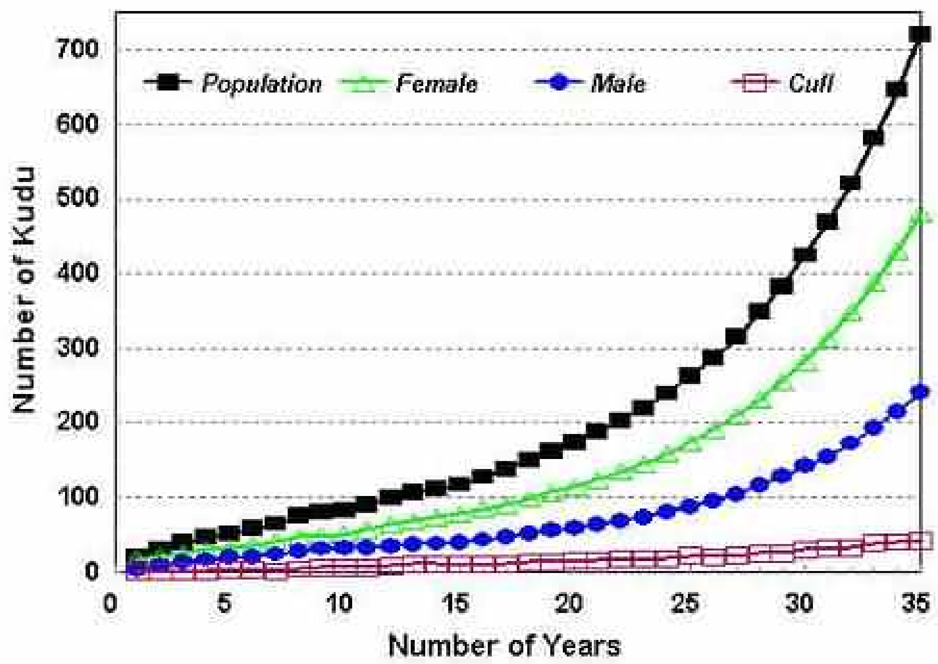

Figure 1: Optimal expected population growth for kudu within sustained optimal habitat conditions (Annual rainfall 300-400 mm, sustained at the median), starting with only 20 animals. Habitat size (land-unit size is unlimited). Exponential growth

only starts on exceeding 200 animals. Minimal numbers are taken off as to sustain the optimal sexual ratio.

9. Animal-species composition: Species composition is determined by: a) the objectives set by the land owner, b) the suitability types of habitats available, c) by species interaction and d) by the socio-economic markets. For eco-tourism greater species diversity is required meaning less animals per species, which puts the populations at the bottom of the exponential growth curve (Fig. 1) and thus, belittles any production. All income will have to be generated from eco-tourism as population harvesting will be unsustainable. For venison and game production for local hunting and live sales, fewer species are to be kept at greater numbers to put the population higher on the exponential growth curve, meaning greater production.

10. Management objectives of land owner: Which market is targetted and managed or produced for? And what is the time frame and scale of the farming operation.

The main parameters are: a) financial outlay of the landowner and his aesthetical values towards wildlife. Starting a new farm, introducing game at numbers <20 per species, return on investment will only start to be generated after 5-7 years for most of the median to larger game species. Capital will be needed to carry the owner through this period.

PRODUCTION OPTIMIZATION:

- A ranch need to be divided into structural, floristic, landscape units (stretching far beyond the mere superficial Biome or Vegetation Type). These units are based upon the habitat requirements of each animal species.
- The percentage suitability of every portion of every unit on the ranch need to be classed and quantified for each animal species. The past feeding criteria of selective, non-selective and browsing game is totally inadequote. There does not exist anny game animal that is non-selective.
- Apart from feeding behaviour, game animals are also to be classed according to their social and spacial needs. This has proved to have a greater effect upon game production than feeding.
- Every potential game species that the habitat might be suitable for (by some quantified degree), is then allocated with an appropriate stocking proportion.
- Stocking load is culculated by the most limiting factor towards the animals performance potential, expressed either as large stock unit carrying capacity, browser unit carrying capacity, minimal social roaming space, or minimal feeding space.
- The proportion of browse and grass taken by each animal species are being distinquished and quantified and treated seperately with regards to the fodder potential of the habitat.
- Devide the most limiting parameter into the sum of the allocated percentage suitabilities of al potential habitats. The calculation wil give the maximum number of animals per species ever to be kept or sustained singularly by the landunit.
- Define the animal feeding structure ratio to be kept on the farm; ratio of highly selective short grass grazers to bulk grazers to browsers to intermediate low-selective grazers.

- Once the maximum load for every suitable game species had been calculated, the species composition can be selected with regards to animal performance potential (Table 4), long-termvision and objectives and the produce market to be entered.

Table 4: Generall production norms for the differnt game species for optimal habitat conditions; this is the annual growth rate of the population with natural mortalities taken into considderation:

Kudu	19%	Common Duiker	45%
Ostrich	40%		
Wildebees	30%	Red Hartebeest	23%
Impala	30%		
Eland	20%	Mountain reedbuck	29%
Zebra	25%		
Bushbuck	20%	Hippopotimus	20%
Giraffe	12%		
Warthog	120%	Grey Rhebuck	20%
Buffalo	14%		
Waterbuck	20%	Springbuck	33%
Elephant	20%		
Blesbok	28%	Bontebok	25%
Sable	20%		
Steenbok	30%	Klipspringer	30%
Rhino	12%		
Gemsbuck	15%	Fallow Deer	35-60%
Nyala	28%		
Red Ledchwe	25%	Common reedbuck	18%

The average norm being 25%.

POPULATION DYNAMIC MODELLING FOR PRODUCTION

Once the objectives have been set, the landowner need to know how to manage and what to expect because of his management. Especially smaller populations of most game species are extremely sensitive towards any changes of the sexual and age structure of the population due to human harvesting (hunting, culling, capturing, introductions). Individual natural growth rate norms had been compiled for each game species individually. By studying the natural behavioural needs of every species, production can be optimized by manipulating sexual and age structure of the population to a certain extend (application of livestock principals). Natural production is now transformed to "intensive" managed farming production, which means maximum sustainable annual produce and off-take. The essence of game production has become the maximum usage and filling up of the entire range of feeding niches occuring on a farm, to maximum capacity; a) with the greatest performer animals possible, b) with minimal interactive animal competition and c) without a degrading trend of the overall fodder production and\or specialized structural environmental features and conditions needed for performance by certain of the suitable, chosen species. At first glance it seems highly complexed and out of reach. Yes! It is complexed, but once the principal is clearly understood, and a fair knowledge is gained by the compiler and manager for every animal species, then the picture unfold itself in realism and obviousness. Most of the needed behavioural and performance information concerning the different animal species already exsits in literature. It only need to be reviewed from a holistic, big picture approach. Most important is to define and break down the habitats on the farm or ranch to a detailed nich scale, and not to stick to vegetation types only.

When the carrying capacity of the farm has been reached by the number of game present (either by LSU or by the minimum roaming space needed) the number of animals within the population have to be effectively managed by correct off-takes. This is done by two means: **a)** To achieve optimal sexual ratio for maximum breeding and thus for maximum production, male animals have to be reduced. Mainly the sub-adults. The individuals hunted by professional hunters for trophees only, have little impact on reducing animal numbers in the population, especially if it is of game species where the males take 4 years or more to reach trophy status (this is the majority of the species); **b)** The size of the population (number of animals) are managed by the off-take of old mature and post mature females. Reducing the females has a direct reducing impact upon animal numbers as well as a direct reduction in the exponential reproduction rate of the species.

A narrow balance have to be followed to manage and maintain the correct animal numbers per species (regarding the vision and farming objectives) at the maximum carrying capacity potential of the habitat in relation to the fluctuating climate and veld conditions. Within the maximum number of animals the maximum production rate need to be maintained by managing. Different to livestock, production are being allowed to extend beyond the carrying capacity, but only with regards to roaming space (not by LSU), providing that the annual off-take equals the annual reproduction rate as for the specific year’s climate conditions. Lambs and calves do not take up any social roaming space within the behavioural niche of the species. Game are being managed it terms of numbers and not in terms of metabolic mass. Iinnitial carrying capacity is calculated regarding to metabolic mass. By only utilizing sub-adult and adult animals (to maintain the animal numbers within the carrying capacity) the metabolic mass of the population would never exceed the ecological carrying capacity of the land. Tthe removed adults gets replaced in the comming season by infants only of far less mass.

By managing sexual and age ratios or structures scientifically correctly production of semi-gragarious animals can be increased by 3-10%. Take note that production norms various with climate. For kudu it varies from 12 to 26% between dry and wet years. Sub-adult males will mate with sub-adult females only in years of good rainfall and extremely good veld conditions. Game production thus follows a climate related cyclic fluctuating trend with frequent dry and wet periods. Game numbers has to be managed accordingly. For climatic cycles exists: A) Short term, unstable, wet-dry cycle ranging from 6-12 years each, B) Medium term, stable cycle ranging from 18-23 years each, C) Long-term, highly stable cycle of 45 years each, and D) Super long-term, highly stable cycle of 88 years each[4].

Whenever 2 or more of these cycles combines at top (wet) or bottom (dry) assymbtope, severe wet (flooding) and severe droughts occure. Female animals are taken off only at a high age, when they stop breeding and\or the risk for mortality increasses. Males are taken off mainly as sub-adults. Only some replacement males and some males for trophees are left from each years bred. Some species the optimal trophy is reached during the peak breeding age of dominance, this is usually the dominant breeding males, after this age the trophy quality starts deteriorating (Wildebeest). Other species like the bufallo and kudu, optimal trophy status are reached in the post-breeding ages, normally with the rejected outcasted old males. The farmer has to farmiliarizes himself with the age that each species reaches maximum trophy status and manage accordingly.

INTRODUCING GAME:

Numbers builds numbers. For game production large numbers (viable) breeding populations of few game species are needed. Most of the vallued game species have low growth production rates. To start with only 20 bufalo it will take 10 years to build up a population of 70, whereas starting with 20 springbuck a population of 750 can be reached within 10 years. On smaller farms (<3000ha) lesser animal numbers can be kept and thus will the high production exponential phase never be reached for a species. Thus it is of importance to keep less species (no more than 5) to keep the numbers per species as high as possible to increase the production rate to the exponential phase.

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