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Comparative Economics of Cattle and Wildlife Ranching in the Zimbabwe Midlands

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COMPARATIVE ECONOMICS OF CATTLE AND WILDLIFE RANCHING IN THE ZIMBABWE MIDLANDS

by

Urs P. Kreuter

A dissertation submitted in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Range Science

Approved:

UTAH STATE UNIVERSITY
Logan, Utah

1992
DEDICATION

To Muetti and Vati
for giving me life and love.
ACKNOWLEDGEMENTS

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Urs P. Kreuter
# CONTENTS

<table>
<thead>
<tr>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS ........................................ iii</td>
</tr>
<tr>
<td>LIST OF TABLES .................................. viii</td>
</tr>
<tr>
<td>LIST OF FIGURES ................................ ix</td>
</tr>
<tr>
<td>ABSTRACT ........................................... xi</td>
</tr>
<tr>
<td>INTRODUCTION ........................................ 1</td>
</tr>
<tr>
<td>Statement of the Problem ................................ 1</td>
</tr>
<tr>
<td>Objectives and Hypotheses .............................. 5</td>
</tr>
<tr>
<td>Literature Review .................................. 6</td>
</tr>
<tr>
<td>Ecological considerations ................................ 6</td>
</tr>
<tr>
<td>Economic considerations ................................ 7</td>
</tr>
<tr>
<td>Survey techniques .................................. 11</td>
</tr>
<tr>
<td>Previous studies .................................. 12</td>
</tr>
<tr>
<td>United States of America .............................. 12</td>
</tr>
<tr>
<td>East Africa ........................................ 13</td>
</tr>
<tr>
<td>South Africa and Namibia .............................. 14</td>
</tr>
<tr>
<td>Zimbabwe .......................................... 15</td>
</tr>
<tr>
<td>Zimbabwe's beef industry ................................ 19</td>
</tr>
<tr>
<td>Zimbabwe's wildlife industry ......................... 21</td>
</tr>
<tr>
<td>Study Area ........................................... 23</td>
</tr>
<tr>
<td>Physical environment ................................ 23</td>
</tr>
<tr>
<td>Land use .......................................... 26</td>
</tr>
<tr>
<td>Survey population and sample ......................... 27</td>
</tr>
<tr>
<td>References ........................................... 30</td>
</tr>
<tr>
<td>FINANCIAL PROFITABILITY OF CATTLE AND WILDLIFE RANCHES IN MID-ZIMBABWE ......................... 38</td>
</tr>
<tr>
<td>Introduction ....................................... 38</td>
</tr>
<tr>
<td>Methodology ........................................ 41</td>
</tr>
<tr>
<td>Financial profit estimates ............................ 41</td>
</tr>
<tr>
<td>Data analyses ...................................... 42</td>
</tr>
<tr>
<td>Data presentation ................................... 43</td>
</tr>
<tr>
<td>Results ............................................. 43</td>
</tr>
</tbody>
</table>
POLICY EFFECTS ON CATTLE AND WILDLIFE RANCHING IN MID-ZIMBABWE

Introduction.............................................. 63
Methodology............................................... 65
   Policy analysis matrix.............................. 65
   Financial prices...................................... 65
   Tradeable commodity prices........................ 66
   Domestic factor prices................................ 69
   Adjusted net revenue.................................. 71
   Data analyses.......................................... 72
Results..................................................... 72
   Opportunity cost of capital......................... 73
      Financial prices.................................... 73
      Economic prices.................................... 77
      Policy effects...................................... 78
   Zimbabwe dollar exchange rate...................... 79
   Cattle price ratio..................................... 82
Discussion and Conclusions............................ 84
References................................................ 88

COSTS OF OVERSTOCKING ON CATTLE AND WILDLIFE RANCHES IN MID-ZIMBABWE

Introduction.............................................. 90
Methodology............................................... 92
   Carrying capacity..................................... 92
   Stocking rate......................................... 95
   Overstocking......................................... 97
   Overstocking cost..................................... 98
   Profit estimation..................................... 99
   Data analyses......................................... 100
Results..................................................... 100
   Carrying capacity and stocking rate............... 101
   Overstocking cost..................................... 104
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>44</td>
</tr>
<tr>
<td>3</td>
<td>44</td>
</tr>
<tr>
<td>4</td>
<td>45</td>
</tr>
<tr>
<td>5</td>
<td>49</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>7</td>
<td>56</td>
</tr>
<tr>
<td>8</td>
<td>65</td>
</tr>
<tr>
<td>9</td>
<td>69</td>
</tr>
<tr>
<td>10</td>
<td>96</td>
</tr>
<tr>
<td>11</td>
<td>108</td>
</tr>
<tr>
<td>12</td>
<td>110</td>
</tr>
<tr>
<td>13</td>
<td>119</td>
</tr>
<tr>
<td>A1</td>
<td>145</td>
</tr>
<tr>
<td>C1</td>
<td>159</td>
</tr>
</tbody>
</table>

1. Survey sample by agricultural area and ranch type.
2. Cattle and wildlife numbers by ranch area.
3. Categories, unit mass, and mean values of cattle.
4. Unit mass, estimated population size, number shot, and trophy value of wildlife by species.
5. Average revenue structures of cattle and wildlife enterprises during 1989/90.
6. Average cost structures of cattle and wildlife enterprises during 1989/90.
7. Average fixed and moveable asset structures of cattle and wildlife enterprises during 1989/90.
8. Policy analysis matrix.
10. Biomass (kg), metabolic mass ($kg^{0.75}$) and proportion of grass fractions in the diets of herbivores.
11. Productivity loss ($Z$ $kg^{-1}$ $ha^{-1}$ overstocked) at which financial (F) and economic (E) profits were zero.
12. Productivity loss ($Z$ $kg^{-1}$ $ha^{-1}$ overstocked) at which financial and economic profits were equal.

A1. Names used in text and common and scientific names of wild animals occurring in the Zimbabwe Midlands.

C1. Life times assumed for capital items to calculate straight-line depreciation.
D1  Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: cattle and wildlife products and direct inputs.......................... 161

D2  Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: general inputs.......................... 162

D3  Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: capital items.......................... 163
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A hypothetical production possibilities frontier for cattle and wildlife</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>The Zimbabwe Midlands and the study area</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Average total revenue ha^{-1} and average total cost ha^{-1}</td>
<td>47</td>
</tr>
<tr>
<td>4</td>
<td>Financial profits of cattle, wildlife and mixed ranches</td>
<td>52</td>
</tr>
<tr>
<td>5</td>
<td>Per-ha fixed, moveable and livestock assets on cattle, wildlife and mixed ranches</td>
<td>55</td>
</tr>
<tr>
<td>6</td>
<td>Effect of capital opportunity cost on financial and economic ranch profitability</td>
<td>74</td>
</tr>
<tr>
<td>7</td>
<td>Frequency distribution of financial returns to investment</td>
<td>75</td>
</tr>
<tr>
<td>8</td>
<td>Zimbabwe dollar overvaluation effects on the economic profitability of ranches</td>
<td>80</td>
</tr>
<tr>
<td>9</td>
<td>Effect of cattle-revenue price conversion on economic profitability of ranches</td>
<td>83</td>
</tr>
<tr>
<td>10</td>
<td>Stocking rates of cattle and the grazing and browsing fractions of wild herbivores</td>
<td>102</td>
</tr>
<tr>
<td>11</td>
<td>Estimated cost of productivity loss through overstocking</td>
<td>105</td>
</tr>
<tr>
<td>12</td>
<td>The effect of estimated overstocking cost on (a) financial and (b) economic profits</td>
<td>106</td>
</tr>
<tr>
<td>13</td>
<td>Financial-economic profit disparities</td>
<td>109</td>
</tr>
<tr>
<td>14</td>
<td>Frequency distributions of financial efficiency (PCR) and economic efficiency (DRC)</td>
<td>126</td>
</tr>
<tr>
<td>15</td>
<td>Frequency distribution and mean value of estimated economic efficiency</td>
<td>129</td>
</tr>
<tr>
<td>16</td>
<td>Effect of increasing the cost of overstocking on the mean economic efficiency (DRC) of four ranch categories</td>
<td>131</td>
</tr>
</tbody>
</table>
Comparative Economics of Cattle and Wildlife Ranching in the Zimbabwe Midlands

by

Urs Peter Kreuter, Doctor of Philosophy
Utah State University, 1992

Major Professor: Dr. John P. Workman
Department: Range Science

The economics of ranches in the Zimbabwe Midlands, generating income from cattle, or wildlife, or both, were compared during 1989/90 to test the claim that wildlife ranching can generate greater profits than cattle ranching on semi-arid African savannas. Both financial (market) prices and economic prices (opportunity cost) were used.

Financial data were obtained from 15 cattle, 7 wildlife and 13 mixed ranches in four areas with wildlife and from 15 cattle ranches in two areas with sparse wildlife. Estimates of economic prices were obtained from official data.

In the first paper, gross revenues, costs, net revenues, and capital investments of each ranch type were compared. Cattle ranches in the areas with sparse wildlife provided the greatest net revenues while only mixed ranches were financially profitable in areas with abundant wildlife. Wildlife ranches had the least capital investments.
In the second paper a policy analysis matrix was used to compare financial and economic profitability. Excluding policy interventions, cattle ranches in areas with sparse wildlife were most profitable. Negative financial-economic profit differences showed that all ranchers faced production disincentives, but cattle ranchers were affected the most.

In the third paper an attempt was made to quantify the cost of lost rangeland productivity due to overstocking. Carrying capacities and stocking rates were estimated and a range of overstocking costs was used. Cattle ranches appeared to be overstocked while wildlife ranches were not. Thus the larger economic profit of cattle versus wildlife ranches decreased when range productivity loss increased.

The last paper compared the relative efficiency of cattle, wildlife, and mixed ranches from the financial perspective (using the private cost ratio) and from the national perspective (using the domestic resource cost). While few ranches were financially efficient, cattle ranches with sparse wildlife and mixed and wildlife operations were found to be economically efficient when overstocking costs were not charged. With increased rangeland sensitivity to overstocking, the probability of economic inefficiency increased more for cattle than mixed or wildlife ranches.

This study did not corroborate the claim that wildlife ranching is more profitable or efficient than cattle ranching in semi-arid African savannas. (176 pages)
INTRODUCTION

Economics deals with the efficient allocation of scarce resources among competing uses (Samuelson, 1964). In this study "cattle" is used as a general term for all domestic livestock reared for meat production because only a minor fraction were not bovine. Wildlife refers to large mammals with a mean body mass of 10 kg or more, plus ostriches and crocodiles. Ranching is the extensive production of animal biomass from rangelands for consumptive or non-consumptive use but excludes dairy, ostrich and crocodile farming.

Statement of the Problem

Options for intensifying conventional agricultural production are limited in many semi-arid African savannas by the paucity and variability of rainfall (Walker, 1979) and infrastructural limitations (Muir, 1987). Human population pressure is forcing many farmers to cultivate increasingly marginal lands and to overstock rangelands (Muir, 1988). This is accelerating soil erosion and river siltation, and producing poor quality livestock (Mahachi, 1989). In addition, human resource needs are increasingly in conflict with the habitat requirements of wildlife, particularly where wild animals range beyond national parks (Bell, 1989; Parker and Graham, 1989). Preserving genetic diversity is of little interest to people facing starvation due to depredation by wildlife (Bell, 1989; Luxmore, 1989). To
reduce poverty in semi-arid areas, increasing the value of output from marginal land and promoting development programs that minimize adverse environmental consequences must receive priority (Eltringham, 1984; Muir, 1987).

"In emergent Africa you either use wildlife or lose it. If it pays its own way some of it will survive" (Myers, 1981). Retaining wild animals (especially large mammals) in their natural habitats means providing benefits to people who bear the costs of co-existing with them (Caughley, 1986; Martin, 1984; Teer, 1986) and wildlife must compete economically with other rangeland products (Bishop, 1987).

In semi-arid African savannas, multi-species wildlife communities tend to use heterogeneous vegetation more completely than cattle alone (Taylor and Walker, 1978; Walker, 1976, 1979). Wildlife production may thus be ecologically the most rational form of land use in semi-arid savannas (Child and Child, 1986). Based on the more uniform use of vegetation by wildlife, the higher reproductive potential of wildlife and their better adaptation to high temperatures, limited water supplies, and endemic diseases (Brown, 1969; Dasmann, 1964; Mossman and Mossman, 1976; Walker, 1979), it has been claimed that more secondary biomass could be produced from wildlife than cattle (Dasmann, 1964; Dasmann and Mossman, 1961; Hopcraft, 1986).

Other studies have, however, not corroborated these claims (McDowell et al., 1983; Taylor and Walker, 1978). It
is unlikely that meat production from wild animals can compete with cattle because the beef industry has been heavily supported with marketing infrastructure (Muir, 1987) and, although the free range of wildlife reduces management costs, it increases harvesting costs (Child, 1989).

The main advantage of wildlife over conventional livestock systems is now generally considered to be the higher value multiple uses (Child, 1989; Cumming, 1989; Johnstone, 1973; Muir, 1988). Wildlife utilization may increase the output value from marginal lands without increasing ecological pressure because tourism, such as safari hunting and photo-tourism, is less dependent on stocking rate than the production of secondary biomass for consumption (Child, 1989; Muir, 1987).

Unlike most agricultural commodities, tourism products are luxuries and are therefore likely to be income elastic (Muir, 1987). Preliminary evidence also suggests that the demand for hunting is generally price inelastic (Muir, 1987). As international incomes increase, tourism should thus provide steadily rising income compared with the fluctuating markets of primary and agricultural products (Heath, 1990). It has also been argued that the multiplier effects from wildlife are greater than those from cattle (Child and Child, 1986). Tourism is, however, also a high-risk industry, dependent on tourist fashion, socio-political stability and external economic factors (Heath, 1990).
Despite some claims that African wildlife may generate greater financial profits than wildlife (Child, 1988; Clarke et al., 1985; Hopcraft, 1986; Joubert, et al. 1983) the comparative economics of cattle and wildlife have not been clearly established. These claims have been based on market prices which may not accurately reflect resource scarcity and thus may not ensure economically efficient resource use (Monke and Pearson, 1989). No studies have comprehensively compared the financial and economic efficiencies of cattle and wildlife production systems in Africa.

The commercial ranching sector of Zimbabwe provided a rare opportunity for estimating the efficiencies of extensive cattle and wildlife production systems because there is both a long history of commercial cattle ranching and landowners have the right to commercially exploit wildlife on their land.

This study was based in the Zimbabwe Midlands (which contains the most productive semi-arid rangelands in the country) because it was suitable for identifying economic trade-offs between cattle and wildlife ranching. In drier areas, sparser grass cover tends to favor browsers while more abundant grass cover in the wetter areas may favor cattle. Within the Midlands, cattle, wildlife, and mixed ranches in four contiguous areas with abundant wildlife and cattle ranches in two areas with sparse wildlife were selected for study.
Objective and Hypotheses

The central objective of the study was to determine the relative financial and economic efficiencies of commercial cattle, wildlife, and mixed ranches in the Zimbabwe Midlands. This was addressed by testing four null hypotheses as follows:

H1. There was no difference between the financial profits of the three ranch types.

H2. There was no difference in the effects of government policy on the three ranch types.

H3. There was no difference in the costs of overstocking on the three ranch types.

H4. There was no difference in the economic efficiency of the three ranch types.
Literature Review

Ecological considerations

Rainfall is the dominant factor affecting primary production in semi-arid African savannas. High basal cover and the abundance of perennial grasses enhance surface water infiltration (Walker, 1979) and carrying capacity (Danckwerts and Aucamp, 1986). Perpetual high use of the herb layer tends to lead to declines in palatable grass species, bush encroachment, and soil erosion (Bigalke, 1986; Walker, 1976, 1979; Walker and Noy-Meir, 1982). But, it has also been argued that grazing promotes high plant biomass by activating meristems, increasing tillering and leaf elongation, and promoting dwarf genotypes (McNaughton, 1986) because ungulate saliva reportedly stimulates grass growth and defoliation increases nitrogen and phosphorous uptake.

Multi-species herbivore communities tend to defoliate savanna vegetation more completely than mono-specific herds because of inter-specific niche separation (Lamprey, 1963) or overlapping and flexible habitat use (Ferrar and Walker, 1974; Walker, 1976). For example, in southeast Zimbabwe 80% of cattle diets consisted of grass compared to an average of only 59% for indigenous ungulates, but cattle utilized their preferred forage more uniformly (Taylor and Walker, 1978).

It has been suggested that wild herbivores can produce more meat per hectare than domestic livestock in semi-arid savannas due to greater selectivity by domestic ungulates,
and greater growth rates and dietary overlap among wild herbivores (Dasmann and Mossman, 1961; Pratt and Gwynne, 1977; Simmons, 1974). But this claim was disputed by McDowell et al. (1984) and was not corroborated in southeast Zimbabwe where annual meat yields from wildlife and cattle were estimated to have been 5.5 kg ha$^{-1}$ and 6.0 kg ha$^{-1}$, respectively (Child, 1988).

In addition, ecological degradation may become evident at lower levels of forage use when herbivore communities are comprised of few domestic species rather than many wild species because of differences in energy flows among ungulates (Bunderson, 1986). Furthermore, domestic livestock enterprises may not be viable at sustainable stocking rates (Child, 1989). Thus, in the absence of wild bulk grazers such as buffalo, integrated cattle and wildlife systems, with a carefully determined balance of browsers and grazers, may be ecologically the most rational form of land use in many semi-arid savannas (Walker, 1979) if the co-existence of cattle and wildlife is not prevented by disease problems (Karstad, 1986).

**Economic considerations**

The maximum output of varying herbivore mixes on a given area of rangeland is defined by the production possibilities frontier and is a function of the plant and herbivore community structures, and the dietary preferences and consumption levels of the herbivores (Mwangi and
The relationships between herbivores are complementary when an increase in the population of one herbivore enhances the carrying capacity for another; supplementary when the carrying capacity for the first is unaffected by the population of the second; and competitive when an increase in the population of the first herbivore results in a decrease of the second due to inter-specific competition for forage or other resources. The hypothetical production frontier of a simple bi-product system of cattle and homogeneous wildlife is illustrated in figure 1.

Profit is maximized when the value of the marginal products of the competing outputs are equal (Workman, 1986). This implies that, if wildlife does not generate income for private land holders, it is likely to be tolerated by profit maximizers only when complementary or supplementary relationships with cattle exist (Mwangi and Zulberti, 1986).

The value of the marginal product value is determined by the marginal product itself and the prices used to value it. In figure 1, the economic-optimum product combination using market (financial) prices is defined by El with Cl and Wl representing the corresponding production levels of cattle and wildlife, respectively. But market prices include policy effects and may exclude indirect production costs (Jansen, 1989; Masters, 1989; Monke and Pearson, 1989). Resource allocation based on market prices are thus unlikely to be economically efficient.
Figure 1. A hypothetical production possibilities frontier for cattle and wildlife with different efficient output levels for financial and economic prices.
A second optimum point, E2, might be obtained when policy neutral prices are used. Proxies for such prices are the world prices of tradeable goods and opportunity costs of domestic production factors (Monke and Pearson, 1989; Gittinger, 1982). World prices may not accurately reflect resource scarcity either, because of international tariff agreements, but alternatives are difficult to find. Further, world prices do not account for market failures.

The third equilibrium point, E3, represents the optimal output when using economic prices, which exclude policy effects and internalize production costs such as overstocking. In figure 1 the difference between C3 and C1 reflects the overproduction of cattle due to the use of financial rather than economic prices, while the difference between W3 and W1 represents the corresponding under-production of wildlife.

Financial profit of a ranch is estimated from market prices of outputs and direct, overhead and capital input costs. It addresses questions about the optimal allocation of resources from the point of view of the landholder under prevailing market conditions (Jansen, 1989). By contrast, economic profit measures economic efficiency or comparative advantage of resource use from the point of view of the nation by using economic prices to estimate the value of inputs and outputs (Jansen, 1989). It removes the effects of existing policy and market failure on profitability and
indicates which activities are economically efficient or net earners of foreign currency. Differences between financial and economic profits represent the effects on profitability of government policy and excluded costs. These differences can be estimated using a policy analysis matrix which indicates a producer’s incentive for under or overproducing the commodity (Monke and Pearson, 1989).

Survey techniques

A survey was conducted to obtain data from a predetermined ranch population in the Zimbabwe Midlands. Surveys may be conducted by means of personal or telephone interviews or mail questionnaires. Each approach has advantages and disadvantages with respect to reliability and rate of response (Dillman, 1978).

Mail surveys are popular because they minimize data collection costs but they can suffer from low response rates. Such limitations can be overcome by careful attention to the questionnaire design and presentation of the survey to respondents (Dillman, 1978; Fowler, 1988). For example, high response rates of 75% were reported by Benson (1988, 1989), who surveyed game ranchers in South Africa, but Butler (1990) reported lower response rates of 38% and 59% in an investigation of fee-hunting on private ranches in the Texas Trans Pecos and Central Oregon.

This survey was conducted by personal on-ranch interviews using a standardized questionnaire. Although this
method was costlier than a mail survey would have been, it was considered preferable due to the personal nature and detail of information required, the prevailing apathy among Zimbabwe ranchers to mail surveys, and because non-response is usually not independent of survey issues (Alreck and Settle, 1985).

**Previous economic studies**

**United States of America**

Except for exotic species, wildlife represents a non-market good in the USA (White, 1987). Revenue from wildlife on private land is derived mainly through the sale of trespass rights or fee-hunting (Shelton, 1987) and the provision of hunting services and seldom from direct sales of trophy animals or game meat. Studies have therefore tended to investigate wildlife economics independently of domestic livestock operations using the same forage base.

For example, Ramsey (1965), Forrest (1968), and Glover and Conner (1988) investigated the economics of white-tailed deer hunting on the Edwards Plateau of Texas. The economics of hunting in the Rio Grande Plains and Edward Plateau were compared by Steinbach (1988). Morgan (1988), Lacey et al. (1988), Jordan (1989), and Wunderlich et al. (1990) studied aspects of the economics of fee-hunting on private land in New Mexico, Montana, Utah, and Wyoming, respectively.

Three studies compared economic aspects of cattle and wildlife. Guynn and Steinbach (1987) compared the gross
margins of cattle, quail, and deer operations in Texas. They concluded that quail and deer hunting were more profitable than cattle due to the greater direct costs of cattle ranching. They furthermore emphasized that wildlife required no capital input for breeding stock. Butler (1990) reported that the average revenue over variable costs per livestock unit was statistically similar between ranches with and without fee-hunting in the Texas Trans Pecos, and that fee-hunting enterprises in this area received higher fees than in central Oregon. Using linear programming Cohen (1991) found Angora goat production alone provided the greatest net revenue in the Edwards Plateau while combined deer and cow-calf enterprises were most profitable in South Texas.

But these studies do not relate directly to Africa, where game ranching originated (Skinner, 1989), because of the higher species diversity (Heath, 1990) and the right of landowners to utilize wildlife in some countries.

East Africa

Although the classic African hunting safari originated in Kenya, hunting and commercial consumptive use of Kenyan wildlife have been banned since 1977. One exception has been the Hopcraft ranch near Nairobi where game meat has been produced to supply the specialist restaurants (Cumming, 1990). Hopcraft (1970) found Thomson’s gazelle to be financially competitive with Boran cattle but independent researchers estimated that less net revenue was derived from
game meat than beef (McDowell et al., 1983). Hopcraft (1986) countered this conclusion by stating that meat production from the average cattle ranch was 8.33 kg ha$^{-1}$ (but could be doubled on a well managed ranch) while that from the mixed cattle and wildlife ranch was 30% greater. He asserted that net returns were greater from game than cattle due to higher off-take rates, dressing percentages, and meat prices.

South Africa and Namibia

Sport hunting in South Africa occurs only on private land and is administered by the provincial governments. Thus there are few national statistics on game ranching (Cumming, 1990). Luxmore (1985) reviewed game ranching as a force in conservation and Benson (1989) conducted a nation-wide survey of South African game ranchers. Benson found that 51% of the respondents derived wildlife related income which averaged 14% of their gross ranch income.

A few studies have supplied financial information about game ranching in specific areas. For example, Densham and Tomkinson (1979) determined the costs of cropping impala, blue wildebeest and nyala in the Mkuzi Game Reserve but provide no revenue statistics. Berry (1986) evaluated four types of wildlife utilization. He found that trophy hunting of antelope provided the greatest net return per kg followed by live animal sales, non-trophy recreational hunting, and venison production, but the enterprises with the highest net revenue also required the most capital and expertise.
Two studies compared the returns from cattle and wildlife. On savanna rangelands in Natal the greater gross revenue per hectare from cattle than impala was attributed to more cattle meat production per hectare, but greater net revenue was derived from a combination of impala and cattle than cattle alone because direct costs for impala were low and overhead costs were unaffected by culling impala (Collison, 1979; Skinner, 1989). In a comparison of the economic returns from 10 game ranches with those of cattle ranches in northern Natal and Transvaal, Behr (1990) found gross and net revenue, returns on capital, and investment per hectare were similar for game and cattle ranches.

Namibia was the first country in southern Africa to transfer full wildlife ownership rights to landholders with appropriately fenced land (Cumming, 1990) but few studies comparing cattle and wildlife have been conducted there. Joubert et al. (1983) described the revenues and costs associated with game cropping for meat and estimated the net returns per animal in Namibia. They concluded that game ranching alone was not financially viable and had to be combined with domestic stock.

Zimbabwe

Zimbabwe has adopted one of the most progressive wildlife conservation policies in Africa which allows ranchers full use of the wildlife resource on their property. This was initiated in part by the early study by
Dasmann and Mossman (1961). They compared the net revenue from cropping eight different species of wild ungulates with returns from beef in the semi-arid southwest of Zimbabwe. They concluded that game can yield greater profits than cattle where more than 8-12 ha were required per cow but that this depended on the development of game-meat markets.

More recently Johnstone (1973) compared the returns from both game meat and sport hunting in the dry northwest with returns from cattle. He concluded that wildlife could produce more meat per hectare than cattle and that returns to investment from wildlife compared favorably with the best cattle ranches in the more productive Midlands. Clarke et al. (1985) estimated that the potential revenue from lease hunting, harvesting for meat, and live animal sales was Z$8.20 ha\(^{-1}\) compared with Z$6.00 ha\(^{-1}\) from beef cattle. Subsequently Child and Child (1986) reported a gross revenue of Z$0.18 kg\(^{-1}\) from game compared with Z$0.06 kg\(^{-1}\) from cattle in the Midlands and corresponding net revenues of Z$6.35 ha\(^{-1}\) and Z$3.78 ha\(^{-1}\), respectively.

The most useful comparative survey of cattle and wildlife operations is that of Child (1988), which provides gross margin analyses for several ranches in the Midlands, south eastern Lowveld, and the Matetsi area of Zimbabwe and includes four case studies. He estimated that in 1984, financial net revenue from wildlife was consistently greater than from cattle. However, since gross margin analysis omits
capital costs it cannot be used to determine economically optimal range use.

Child's (1988) major contribution was to estimate economic net revenue of cattle and wildlife on one ranch, Buffalo Range. To obtain economic prices he argued that net financial revenue must be adjusted for transfer payments (such as taxes and subsidies) and the net present value of future costs of range degradation from overgrazing. He attempted to apply some price adjustments in his Buffalo Range case study. Since no general set of shadow prices was available, transfer payments could not be eliminated from input and output prices but Child did estimate that the Z$ was overvalued by 43%. The main effect of overvaluation was to greatly undervalue the foreign income from wildlife. Child also tried to eliminate the effects of beef-producer price subsidies by using a nominal protection coefficient of 1.43 (Rodriguez, 1985). These adjustments reduced cattle revenues by an average of 43% but increased wildlife income by an average of 25% for the period 1975-85, while costs for both cattle and wildlife were both reduced by about 13%. When the net present value of future income foregone due to degradation was subtracted, cattle produced a net loss of Z$8.00 ha⁻¹ compared with Z$4.90 ha⁻¹ net profit from game. Child concluded that these results support the contention that wildlife ranching is a more economically efficient form of land-use than cattle ranching on Buffalo Range.
The results of a parallel study to the one being reported here, using the same methodological framework, were reported by Jansen et al. (1992). They conducted a survey of 89 ranchers in six agricultural areas in the semi-arid west and south of Zimbabwe in 1989/90.

In financial terms they found that 39% of the 77 cattle enterprises were operating at a loss and only 5% produced greater than 10% returns to investment. In contrast, 55% of the 44 wildlife enterprises produced financial returns to investment in excess of 10%. The economic profitability of these enterprises was estimated using 10% capital interest rate, 50% Z$ overvaluation, 25% implicit tax on beef-producer prices, and a range degradation cost of Z$0.13 kg\(^{-1}\) overstocked per hectare. The economic profitability of cattle enterprises was considerably greater than their financial profitability with 52% having greater than 10% return on investment and only 14% being uneconomical. By comparison 85% of wildlife enterprises provided more than 10% return on investment and only one ranch was unprofitable when economic prices were used. It was thus concluded that, on average, wildlife enterprises were economically more efficient than cattle enterprises but that these differences varied between agricultural areas.

The following sections provide background information about the cattle and wildlife industries in Zimbabwe.
Zimbabwe's beef industry

Meat products are an important agricultural commodity for Zimbabwe. The commercial sector accounted for 85% of all beef production and had an annual estimated off-take of 20% compared with 2% to 3% in the communal farming sector (AMA, 1991; Morapedi, 1989). From 1986 to 1990 revenue from meat sales contributed 17%, 27%, 20%, 21% and 19% to the value of total agricultural output (CSO, 1991). Although the volume of livestock sales increased by 12.5% in 1990, the generally low livestock prices depressed their overall contribution to the total value of agricultural production (RBZ, 1991).

Beef exports have always been a significant source of foreign earnings to Zimbabwe and varied between 6.38%, 5.43% and 6.98% of total agricultural exports in 1980, 1985 and 1988, respectively (Cumming and Bond, 1991). Beef exports declined substantially after 1979, due to reduced access to the South African market (Jansen and Muir, 1991), but increased after 1985 when the Lome IV convention was signed with the European Community (EC). This was a political concession aimed at providing economic assistance to developing countries (Veenendaal and Opschoor, 1986). Under this accord Zimbabwe has an annual export quota of 9,100 tons of boneless meat for which it is charged only 10% of the normal import tariff (CSC, 1989). This provides it with access to beef prices considerably greater than world market prices (Jansen and Muir, 1991; Tyler and James, 1987).
Zimbabwe also exports beef to a number of regional markets, such as the Canary Islands, Mauritius, and Angola, and to South East Asia (CSC, 1989). The implementation of the Economic Structural Adjustment Program (Zimbabwe, 1991) is aimed at further promoting exports, including beef.

Comparison of producer and world prices showed that Zimbabwe's beef producers were subsidized almost continuously from 1975 to 1984 (Rodriguez, 1985) but have been taxed to subsidize low-income beef consumers since 1985 (Jansen et al., 1992). There are also significant costs and risks associated with the prevailing export markets. The cost of veterinary controls and maintaining abattoirs to EC standards have substantial foreign currency components, while the risks became manifest when exports were banned due to the outbreak of foot-and-mouth disease in April 1989 and were resumed only at the end of 1990 (Cumming and Bond, 1991). In addition, there has been a loss of potential wildlife revenue through the culling of buffalo in cattle producing areas because buffalo were perceived to be the agent for transmitting the foot-and-mouth virus to cattle. The benefit cost ratio of the foot-and-mouth control program in Zimbabwe has nevertheless been estimated at 1.64 without exports and 2.64 with exports (Tyler and James, 1987). But the security of Europe as a beef market is uncertain as there appears to be a shift in demand for beef from the USA and Europe to the Pacific Rim Countries (World Bank, 1990).
Zimbabwe’s wildlife industry

Zimbabwe is fortunate in having one of the richest remaining wildlife resources in Africa, thereby having a comparative advantage over other countries in the use of indigenous large mammals (Murphree and Cumming, 1991). For this reason and due to veterinary constraints on the movement of wildlife (aimed at protecting meat export markets) the wildlife industry in Zimbabwe is based on tourism and is centered on the National Parks and Wildlife Estate, covering approximately 50,000 km² (12.8% of Zimbabwe) (Heath 1990). Tourism grew slowly until the 1960’s, declined temporarily after the unilateral declaration of independence in 1965 but soon revived to reach a peak by 1972. It decreased, due to the intensified guerrilla war, but resumed growth after independence was formally declared in 1980, and especially after internal political disturbances ceased in 1984 (Heath, 1990). Recently tourism has been targeted as one of the major export activities to be promoted under the recently implemented Economic Structural Adjustment Program (Zimbabwe, 1991).

Prior to 1960, wildlife utilization was government regulated on all land through the setting of hunting seasons and the allocation of hunting licenses (Muir, 1988). But in 1960 legislation passed some user rights to landholders and in 1975 the Parks and Wildlife Act (Child, 1975; Rhodesia,
Although wildlife remained *res nullius* (without ownership) landowners were provided a high degree of freedom to manage wildlife on private land (Masterson, 1988).

Safari operations on private land were initiated in the 1960's in response to the strong international demand for recreational hunting, and photographic and walking safaris. Since the initial experiments on Doddieburn Ranch in Zimbabwe (Dasmann, 1964; Dasmann and Mossman, 1961) and especially after deregulation in 1975, wildlife ranching has increased dramatically (Muir, 1988). The land area allocated solely to wildlife grew at 6% per year between 1974 and 1984 by which time 23% of ranch land in the dry southeastern part of Zimbabwe was devoted to game ranching (Child, 1988). However, wildlife ranching is no longer confined to areas with marginal rainfall. It now occurs in higher rainfall areas as a complement to existing production systems. This has resulted in some intensive restocking and rapid increase in the prices of breeding stock (Jansen et al., 1992).

Recently there has also been a move away from safari hunting to photographic safaris due to international pressure to restrict hunting, the limited availability of trophy animals, and the perceived greater revenue potential from non-consumptive tourism. Interest in specialized wildlife farming operations, particularly crocodiles and ostriches, has also grown dramatically. To organize the wildlife industry the Wildlife Producers Association was
formed under the auspices of the Commercial Farmers Union in 1986. By 1987 it had 450 members, some 10% of the total number of all commercial farmers (Muir, 1988).

Wildlife populations in the Midlands have fluctuated over time. Large numbers were depleted by the rinderpest epidemic during the late 1890’s and by early European and subsistence hunters until the 1940’s (Child, 1988). After the Second World War much of the Midlands was allocated to ex-servicemen. This led to a decrease in uncontrolled hunting especially after the 1960’s when ranchers began regarding wildlife as valuable (Vaughn-Evans, 1977).

The variety and abundance of Midlands plains-game species are sufficient for well-balanced trophy bags, an important factor in marketing hunting safaris (Booth and Jones, 1984). Child (1988) indicated that the four areas with wildlife can support about fifty, 7- to 10-day plains-game hunts with either sable or leopard as the main trophy species, five other large animals (wildebeest, zebra, kudu, bushbuck, eland, waterbuck, reedbuck, tsessebe) and five or six smaller animals (impala, duiker, steenbock, warthog, bushpig). Appendix A provides the scientific names of these wild animals.
Study Area

Zimbabwe straddles the central plateau of southern Africa, covering 390,700 km², and is bounded by the Zambezi River in the north and the Limpopo River in the south. The population exceeds nine million people and is growing at about 3% per annum (World Bank, 1989). Although 70% live in rural areas (Child and Nduku, 1986), agriculture contributes only 11% to gross domestic product (World Bank, 1989) because many of the rural dwellers are subsistence farmers.

The four categories of land tenure are privately owned commercial land (32%), communally owned farmland (49%), national parks and forest estates (15%), and other (4%) (Roth, 1990). Based on rainfall and soil criteria, the country has also been divided into five agro-economic regions, ranging from an intensive and diverse production area in the east to extensive rangeland-based production in the arid south and northwest (Vincent and Thomas, 1960). This study was based in the Midlands Province which lies in Natural Region III, the semi-extensive farming region in the center of the country. The Midlands and six agricultural areas selected for study are shown in figure 2.

Physical environment

Natural Region III varies in altitude from 920 to 1,475 meters a.s.l. but the greater portion lies between 980 and 1,290 meters a.s.l. The topography is gently undulating,
Figure 2. The Zimbabwe Midlands and the study area.
becoming broken towards the eastern and western drainage systems. Mean annual rainfall varies from 650 mm to 800 mm along an east-west gradient and occurring mainly during summer storms. Effective rainfall is less due to mid-season dry spells and frequent droughts (Vincent and Thomas, 1960).

Soils in the study area consist primarily of medium grained sands derived from granites. The dominant vegetation is *Julbernadia globiflora* - *Brachysegia bohemii* woodland but *Colophospermum mopane* occurs in areas of poorly drained sodic clays while *Terminalia sericea* and *Burkea africana* invade other areas with poor drainage. The grasses associated with these woodlands are of low nutritive value. In areas with loamy soils derived from the greenstones, dolerite, basalt and norite of the Zimbabwe dike (running north to south through the eastern part of the study area) mixed woodlands occur though *Combretum* and *Acacia* species often attain local dominance. Grasses are intermediate in quality. In the Chivhu, Mvuma and Somabhula areas woodlands are displaced by plateau grassland, particularly *Hyparrhenia* species, because of the high water table associated with the existence of impervious geological substrata.

**Land-use**

Due to unreliable rainfall and mid-season dry spells, Natural Region III is agriculturally suited only to drought-resistant crops and range livestock production (Vincent and Thomas, 1960). Some intensive cash cropping is possible with
irrigation on alluvial patches along major rivers but the wide-spread sandy soils are dominated by cattle ranching.

The large-scale agricultural sector in the Midlands covers 24,050 km² which is 33% of Natural Region III and 21% of the total area under that category in Zimbabwe (Roth, 1990). Only 2% of this area is arable but 78% is suitable for grazing and 20% is unusable. Of the 239 commercial ranches in the Midlands, 217 (91% by number and 84% by area) generated income mainly from cattle while 22 (9% by number and 16% by area) derived income from wildlife.

Survey population and sample

Five of the nine agricultural areas in the Midlands and one area immediately north of the Midlands boundary were selected for study. These six areas were chosen because they contained the greatest concentration of ranches sufficiently large for viable, independent operations. Four contiguous areas (Battlefields, Umniati-Sebakwe, Bembezaan, Mvuma) were selected because they contained abundant wildlife while the two others (Chivhu and Shurugwi-Somabhula) contained only sparse wildlife and were studied for comparative purposes.

The survey population consisted of all independent ranches exceeding 1,200 ha in area and generating revenue from cattle, wildlife or both. A minimum size of 1,200 ha was selected because, with an estimated maximum carrying capacity of 0.2 livestock units (LSU) ha⁻¹, smaller ranches could not sustain a herd of 240 LSU, which was considered
the minimum herd size for an independent cattle enterprise.

Fifty ranches were selected for study (table 1). In the four areas with wildlife 15 ranches generating revenue from cattle only, seven from wildlife only and 13 mixed ranches with both cattle and wildlife enterprises were selected. Ranch size ranged from 1,424 to 132,840 ha and together they covered 387,036 ha. They comprised almost all of the ranches in the survey population. Only two ranch owners declined to co-operate. In the two areas with sparse wildlife, 15 ranches generating revenue from cattle only were randomly selected. Sizes ranged from 1,284 to 16,261 ha with a joint total of 110,206 ha.

Table 1. Survey sample by agricultural area and ranch type.

<table>
<thead>
<tr>
<th>Area</th>
<th>Cattle</th>
<th>Wildlife</th>
<th>Cattle &amp; Wildlife</th>
<th>Total</th>
<th>% area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battlefields</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>9.3%</td>
</tr>
<tr>
<td>Umniati-Sebakwe</td>
<td>2</td>
<td>3</td>
<td>7</td>
<td>12</td>
<td>19.3%</td>
</tr>
<tr>
<td>Bembezaan</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>7.2%</td>
</tr>
<tr>
<td>Mvuma</td>
<td>7</td>
<td>1</td>
<td>3</td>
<td>11</td>
<td>42.1%</td>
</tr>
<tr>
<td>Sub-total</td>
<td>15</td>
<td>7</td>
<td>13</td>
<td>35</td>
<td>77.9%</td>
</tr>
<tr>
<td>Chivhu</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>10.1%</td>
</tr>
<tr>
<td>Shurugwi-Somabhula</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>12.0%</td>
</tr>
<tr>
<td>Sub-total</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>15</td>
<td>22.1%</td>
</tr>
<tr>
<td>Total</td>
<td>30</td>
<td>7</td>
<td>13</td>
<td>50</td>
<td>497,242 ha</td>
</tr>
<tr>
<td>% area</td>
<td>40%</td>
<td>12%</td>
<td>48%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Of the 50 ranches 84% (42) were privately owned, 8% (4) company owned and 8% (4) were leased. Among cattle ranchers 35% finished cattle on range, 29% sold weaners, 12% pen finished their cattle and 11% were speculators. Breeds included 67% Brahman types and 19% other Bos indicus types. Among wildlife enterprises 84% generated revenue from safari hunting, 25% from the sale of trophies or hunting leases, and 25% from the sale of game meat. Hunting clients were almost all foreigners with 49% being American, 40% European, 6% Australian and 5% from other countries.
References


FINANCIAL PROFITABILITY OF CATTLE AND WILDLIFE RANCHES IN MID-ZIMBABWE

Introduction

"In emergent Africa you either use wildlife or lose it. If it pays its own way some of it will survive." (Myers, 1981)

This paper compares the revenues, costs, profits and capital investments on cattle, wildlife, and mixed ranches in the Zimbabwe Midlands during 1989/90.

Erratic rainfall limits the options for intensifying conventional agriculture in semi-arid African savannas. To maintain human welfare the value of outputs must thus be increased and environmentally sound development programs must be promoted (Eltringham, 1984; Muir, 1987).

Claims have been made that African ungulates can produce more biomass than cattle (Dasmann and Mossman, 1961; Hopcraft, 1986) because they tend to use savanna vegetation more uniformly (Taylor and Walker, 1976; Walker, 1976, 1979) and because they are better adapted to high temperatures, limited water supplies, and endemic diseases (Brown, 1969; Dasmann, 1964; Mossman and Mossman, 1976). It was therefore argued that game-meat production should be more profitable than beef production on semi-arid African savannas (Dasmann and Mossman, 1961; Clarke et al., 1985; Hopcraft, 1970, 1986). But other studies have not corroborated these claims (McDowell et al., 1983; Taylor and Walker, 1978).
The main economic advantage of wildlife over cattle is now generally regarded to be their potential for generating multiple products of high value (Child, 1988; Cumming, 1989; Johnstone, 1973; Muir 1988). Since tourism is less dependent on high stocking densities than meat production, wildlife may be used to increase the output value from marginal lands without increasing ecological pressure (Child, 1989).

Although wildlife production may be ecologically the most rational form of land use in semi-arid savannas (Child and Child, 1986), the comparative profitability of extensive cattle and wildlife production systems has not been well established. The commercial ranching sector of Zimbabwe presented a rare opportunity to conduct a comparative economic study because there is a long history of cattle and wildlife ranching on private land.

The commercial ranching sector has accounted for 85% of Zimbabwe's beef production through an annual off-take of about 20% (AMA, 1991; Morapedi, 1989). Since signing the Lome IV convention with the European Community in 1985, Zimbabwe has had access to higher beef prices than those in other world markets (Tyler and James, 1987). Zimbabwe also exports beef to the Canary Islands, Mauritius, Angola, and South East Asia (CSC, 1989). Although Zimbabwe's beef producers were subsidized from 1975 to 1984 to promote beef exports (Rodriguez, 1985), they have been taxed since 1985 to subsidize low-income consumers (Jansen et al., 1992).
Zimbabwe is fortunate in having one of the richest remaining wildlife resources in Africa (Heath, 1990). Wildlife populations in the Midlands have fluctuated due to disease and initial indiscriminate hunting but after the Second World War, when much of the area was allocated to ex-servicemen, uncontrolled hunting decreased especially after the 1960's when ranchers began regarding wildlife as valuable (Vaughn-Evans, 1977). The variety and abundance of Midlands plains-game species have become sufficient for well-balanced trophy bags (Booth and Jones, 1984) and can annually support about 50, 7- to 10-day plains-game hunts incorporating either sable or leopard as the main trophy species (Child, 1988).

Prior to 1960 wildlife utilization was government regulated but subsequent legislation resulted in the Parks and Wildlife Act of 1975, which transferred custodianship of wildlife to landowners (Muir, 1987). Due to veterinary constraints on the movement of animals, aimed at protecting beef export markets, the wildlife industry in Zimbabwe has been based mainly on tourism where wildlife is used in situ. Safari operations on private land were initiated in the 1960's in response to the strong international demand for recreational hunting. To organize the wildlife industry the Wildlife Producers Association was formed in 1986 and by 1987 it had 450 members, some 10% of all commercial farmers in Zimbabwe (Muir, 1988).
Methodology

**Financial profit estimates**

The 1989/90 financial profits (net revenues) of cattle and wildlife enterprises in the Zimbabwe Midlands were estimated from the market values of outputs and direct, overhead and capital inputs. Revenue and cost data were obtained from the survey ranches through personal interviews using a standardized questionnaire (Appendix B).

Since this was a cross-sectional analysis, adjustments were made to the net revenues of cattle enterprises to eliminate capitalization of profits through herd increases or liquidation of profits through herd decreases. In wildlife enterprises, such adjustments were not made because population changes on individual ranches may have reflected migration rather than actual population changes. But 80% of the costs of wildlife purchased for breeding were added back to wildlife profits since such purchases were irregular and benefits were assumed to accrue over a five-year period.

Where wildlife enterprises derived revenue from extra-ranch wildlife resources, financial data were derived for the total enterprise as well as its on-ranch component. The latter eliminated possible subsidization of ranches through the use of extra-ranch resources. Only in this way could cattle and wildlife enterprises be realistically compared because cattle enterprises were restricted to the ranch on which they were based.
Annual depreciation of capital items was determined from rancher estimates of the current market values of their assets and the probable life-time of each item (Appendix C) using straight-line depreciation.

Revenues, costs, financial profits and capital investments were estimated on a per hectare basis because in the short term ranch area is immutable. Profit per livestock unit was not calculated because wildlife populations were estimated subjectively by ranchers and could not be corroborated by census. However, returns to investments in fixed, moveable and livestock assets were calculated. Land was excluded from fixed assets because inflation and the Zimbabwe government’s land redistribution policy (Murphree and Cumming, 1991) were creating a volatile land market in which prices did not accurately reflect productive potential. This was reasonable since cattle and wildlife enterprises were using the same land types. All profits were therefore estimated as net returns to management and land, a common accounting procedure (Gittinger, 1982).

**Data analyses**

The inevitably small sample size of each ranch category and the corresponding differences in sample variances required the use of non-parametric statistics to analyze the data. The statistical tests used to compare sample means were the Wilcoxon and Mann-Whitney two-sample tests (Hollander and Wolfe, 1973).
Data presentation

Results are presented in four parts: numbers and values of livestock, revenues and costs, financial profits (net revenues), and capital assets. For revenues, costs, and net revenues the following abbreviations are used to denote ranch types or enterprise components: $C_2 = \text{cattle ranches in two areas with sparse wildlife}$; $C_4 = \text{cattle ranches in four areas with abundant wildlife}$; $W_T = \text{total wildlife operations including extra-ranch revenues and costs}$; $W_0 = \text{the on-ranch components of wildlife operations}$; $M_T$ and $M_0 = \text{mixed ranches including the total and the on-ranch components of wildlife enterprises, respectively}$. In the capital assets section the total and on-ranch components of wildlife enterprises are not distinguished. The levels of statistical significance reported are: $P < 0.10$, $P < 0.05$, and $P < 0.01$.

Results

Animal numbers and values

Estimated cattle and wildlife numbers in the six ranching areas in 1989/90, are presented in table 2. Nearly 80% of cattle occurred in the last three areas while almost 90% of the wildlife occurred in the first four areas. Furthermore, the concentrations of cattle and wildlife were greatest and least, respectively, in the last two areas due to the greater grass cover and the relative sparsity of diverse wildlife habitats.
Table 2. Cattle and wildlife numbers by ranch area.

<table>
<thead>
<tr>
<th>Ranch area</th>
<th>Cattle Number</th>
<th>%tot</th>
<th>No.</th>
<th>Wildlife Number</th>
<th>%tot</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battlefields</td>
<td>5,221</td>
<td>6%</td>
<td>0.11</td>
<td>13,579</td>
<td>16%</td>
<td>0.29</td>
</tr>
<tr>
<td>Muniati-Sebakwe</td>
<td>8,603</td>
<td>10%</td>
<td>0.09</td>
<td>25,643</td>
<td>29%</td>
<td>0.27</td>
</tr>
<tr>
<td>Bembezaan</td>
<td>7,361</td>
<td>8%</td>
<td>0.21</td>
<td>7,935</td>
<td>9%</td>
<td>0.22</td>
</tr>
<tr>
<td>Mvuma</td>
<td>35,652</td>
<td>41%</td>
<td>0.17</td>
<td>30,152</td>
<td>35%</td>
<td>0.14</td>
</tr>
<tr>
<td>Chivhu</td>
<td>15,735</td>
<td>18%</td>
<td>0.31</td>
<td>5,917</td>
<td>7%</td>
<td>0.12</td>
</tr>
<tr>
<td>Shurugwi-Somabhula</td>
<td>14,787</td>
<td>17%</td>
<td>0.25</td>
<td>3,434</td>
<td>4%</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>87,359</strong></td>
<td></td>
<td></td>
<td><strong>13,579</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The average unit mass and estimated mean value of six cattle categories are presented in table 3 while the average unit mass, the relative abundance, the percentage of animals shot as trophies, and the average trophy value of each species are presented in table 4. By far the most abundant game species was impala followed by warthog, baboon, kudu, and duiker. Together they comprised almost 73% of the estimated total number of wild animals and other species each comprised less than 5% of the total.

Table 3. Categories, unit mass, and mean values of cattle.

<table>
<thead>
<tr>
<th>Category</th>
<th>Unit mass (kg)</th>
<th>Mean Value (1990 Z$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulls</td>
<td>600</td>
<td>2,000</td>
</tr>
<tr>
<td>Cows</td>
<td>400</td>
<td>600</td>
</tr>
<tr>
<td>Steers (&gt;1 year)</td>
<td>300</td>
<td>500</td>
</tr>
<tr>
<td>Heifers (&gt;1 year)</td>
<td>275</td>
<td>450</td>
</tr>
<tr>
<td>Weaners</td>
<td>180</td>
<td>225</td>
</tr>
<tr>
<td>Calves (&lt;6 month)</td>
<td>120</td>
<td>150</td>
</tr>
</tbody>
</table>

1 Anecdotal information from Commercial Farmers Union
Table 4. Unit mass, estimated population size, number shot and trophy value of wildlife by species.

<table>
<thead>
<tr>
<th>Species</th>
<th>Unit mass (kg)</th>
<th>Number</th>
<th>% total</th>
<th>% shot</th>
<th>Trophy (US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Megaherbivores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant</td>
<td>1 725</td>
<td>21</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Rhino</td>
<td>1 158</td>
<td>74</td>
<td>0.1%</td>
<td>protected</td>
<td></td>
</tr>
<tr>
<td>Hippo</td>
<td>1 000</td>
<td>11</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Giraffe</td>
<td>750</td>
<td>25</td>
<td>0.1%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Buffalo</td>
<td>450</td>
<td>9</td>
<td>0.0%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td><strong>Plains game</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eland</td>
<td>340</td>
<td>1,579</td>
<td>1.8%</td>
<td>1.9%</td>
<td>683</td>
</tr>
<tr>
<td>Zebra</td>
<td>200</td>
<td>2,802</td>
<td>3.2%</td>
<td>2.6%</td>
<td>427</td>
</tr>
<tr>
<td>Sable</td>
<td>185</td>
<td>1,618</td>
<td>1.9%</td>
<td>2.2%</td>
<td>1,164</td>
</tr>
<tr>
<td>Wildebeest</td>
<td>165</td>
<td>3,894</td>
<td>4.5%</td>
<td>1.8%</td>
<td>355</td>
</tr>
<tr>
<td>Waterbuck</td>
<td>160</td>
<td>540</td>
<td>0.6%</td>
<td>2.2%</td>
<td>564</td>
</tr>
<tr>
<td>Kudu</td>
<td>136</td>
<td>9,024</td>
<td>10.4%</td>
<td>1.1%</td>
<td>499</td>
</tr>
<tr>
<td>Tsessebe</td>
<td>110</td>
<td>2,042</td>
<td>2.4%</td>
<td>1.2%</td>
<td>480</td>
</tr>
<tr>
<td>Ostrich</td>
<td>68</td>
<td>342</td>
<td>0.4%</td>
<td>0.3%</td>
<td>300</td>
</tr>
<tr>
<td>Bushpig</td>
<td>54</td>
<td>3,217</td>
<td>3.7%</td>
<td>0.6%</td>
<td>80</td>
</tr>
<tr>
<td>Warthog</td>
<td>45</td>
<td>12,671</td>
<td>14.6%</td>
<td>1.1%</td>
<td>87</td>
</tr>
<tr>
<td>Impala</td>
<td>45</td>
<td>24,501</td>
<td>28.3%</td>
<td>0.7%</td>
<td>96</td>
</tr>
<tr>
<td>Reedbuck</td>
<td>40</td>
<td>1,484</td>
<td>1.7%</td>
<td>2.6%</td>
<td>250</td>
</tr>
<tr>
<td>Bushbuck</td>
<td>30</td>
<td>395</td>
<td>0.5%</td>
<td>2.0%</td>
<td>244</td>
</tr>
<tr>
<td>Oribi</td>
<td>14</td>
<td>38</td>
<td>0.0%</td>
<td>6.7%</td>
<td>142</td>
</tr>
<tr>
<td>Steenbok</td>
<td>10</td>
<td>3,487</td>
<td>4.0%</td>
<td>1.4%</td>
<td>73</td>
</tr>
<tr>
<td>Grysobok</td>
<td>10</td>
<td>245</td>
<td>0.3%</td>
<td>0.6%</td>
<td>71</td>
</tr>
<tr>
<td>Duiker</td>
<td>10</td>
<td>7,330</td>
<td>8.5%</td>
<td>1.3%</td>
<td>71</td>
</tr>
<tr>
<td>Klipspringer</td>
<td>10</td>
<td>519</td>
<td>0.6%</td>
<td>1.4%</td>
<td>158</td>
</tr>
<tr>
<td>Baboon</td>
<td>9,525</td>
<td>11.0%</td>
<td></td>
<td>0.2%</td>
<td>36</td>
</tr>
<tr>
<td><strong>Carnivores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheetah</td>
<td>234</td>
<td>0.3%</td>
<td></td>
<td>protected</td>
<td></td>
</tr>
<tr>
<td>Leopard</td>
<td>185</td>
<td>0.2%</td>
<td></td>
<td>6.0%</td>
<td>1,375</td>
</tr>
<tr>
<td>Hyaena</td>
<td>4</td>
<td>0.0%</td>
<td></td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td>Jackal</td>
<td>695</td>
<td>0.8%</td>
<td></td>
<td>vermin</td>
<td></td>
</tr>
<tr>
<td>Crocodile</td>
<td>149</td>
<td>0.2%</td>
<td></td>
<td>protected</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>88,660</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 See Appendix table A1 for scientific names.
2 Unweighted mean biomass of white and black rhino.
3 Cumming and Taylor (1989)
4 Coe, Cumming and Phillipson (1976)
5 Smithers and Wilson (1979)
6 These values include only the trophy off-take and exclude non-trophy animals shot for meat.
The off-take rates were similar to the 2% for ungulates and 6% for felines normally recommended by the Department of National Parks and Wildlife Management (R.D. Taylor, personal communications, Harare, Zimbabwe, 1990). Only oribi were hunted in excess of the recommended rate, but this is anomalous since most were shot outside of the Midlands.

The average trophy prices during 1989/90 are quoted in US$ since safari operators set them in this denomination for the predominantly foreign clients. The most valuable species were leopard and sable followed by eland, waterbuck, kudu, tsessebe, and zebra. Access to leopard or sable greatly increased the value of a hunt because a 10-day instead of a seven-day hunt was generally required and the daily rate was increased from approximately US$250 to around US$350.

Revenues and costs

The average revenues and costs of cattle, wildlife and mixed ranches are presented in figure 3. In figure 3 the distinction is made between cattle ranches with sparse and abundant wildlife, and between the total and on-ranch components for wildlife enterprises of wildlife ranches and mixed ranches. In addition, cattle-inventory adjustment, which eliminates profit capitalization or liquidation through changes in herd size, is represented by a side bar next to each revenue bar while the estimated depreciation is represented by a side bar next to each cost bar.
Figure 3. Average total revenue ha⁻¹ (a) and average total cost ha⁻¹ (b) of cattle ranches (C₂ and C₄ in areas with sparse and abundant wildlife, respectively), and of the total and on-ranch components of the wildlife ranches (Wᵣ and Wₒ, respectively) and mixed ranches (Mᵣ and Mₒ, respectively).
Although there seems to be separation between the standard error bars of $C_2$ and $C_4$ ranch revenues and costs, differences were statistically insignificant (revenue $P=0.15$ costs $P=0.27$) due to small sample size. There were also no significant revenue and cost differences between the $W_T$ and $W_0$ wildlife ranch components or between the $M_T$ and $M_0$ mixed ranch components. On mixed ranches the revenues and costs from the cattle enterprises comprised 83% of the totals.

Cattle ranches produced the greatest revenues and costs per ha. Revenues and costs of wildlife ranches were less than those of cattle ranches ($P<0.01$) and mixed ranches ($P<0.05$). The seemingly greater costs per ha from cattle than mixed ranches ($C_2=Z$31, $C_4=Z$21, $M_T$ and $M_0=Z$14) may be a survey artifact. Where mixed ranchers also produced crops (38%) and regarded other enterprises as supplementary, overhead costs might have been under-allocated to cattle and wildlife. These costs differences could also be due to more intensive supplemental feeding on cattle ranches than on mixed ranches where multiple income sources spread risks.

The average inventory adjustments were positive for $C_2$ ranches and negative for mixed ranches. This implies that, on average, $C_2$ ranchers increased their herd sizes during the study period because of restricted cattle movements due to the prevailing foot-and-mouth disease epidemic. On mixed ranches revenue was generated partially through liquidating herds. Depreciation costs were similar for all ranch types.
The average revenue structure of cattle and wildlife enterprises is presented in table 5. The greatest proportion (57%) of cattle revenue was derived from sales to the Cold Storage Commission (CSC, Zimbabwe’s parastatal organization responsible for exporting meat) which provided the highest average prices. Auction sales, private live sales and sales to private abattoirs provided 18%, 12% and 10% of the total revenue, respectively. Auction prices were Z$154 lower than CSC prices because there was low demand for the mainly young stock during the foot-and-mouth disease epidemic.

Table 5. Average revenue structures of cattle and wildlife enterprises during 1989/90.

<table>
<thead>
<tr>
<th>Source</th>
<th>No. sold</th>
<th>Z$ rate</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cattle (n=43)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold Storage Commission</td>
<td>10,291</td>
<td>576.92</td>
<td>56.6%</td>
</tr>
<tr>
<td>Auction sales</td>
<td>4,544</td>
<td>423.43</td>
<td>18.4%</td>
</tr>
<tr>
<td>Private live sales</td>
<td>2,718</td>
<td>455.24</td>
<td>11.8%</td>
</tr>
<tr>
<td>Private abattoirs</td>
<td>1,865</td>
<td>564.73</td>
<td>10.0%</td>
</tr>
<tr>
<td>Ranch butchery</td>
<td>552</td>
<td>412.95</td>
<td>2.2%</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>767</td>
<td>83.54</td>
<td>0.6%</td>
</tr>
<tr>
<td>Hides</td>
<td></td>
<td></td>
<td>0.0%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Total (Z$)</strong></td>
<td></td>
<td></td>
<td>10,482,765</td>
</tr>
<tr>
<td><strong>Wildlife (n=20)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day rate hunting</td>
<td>983</td>
<td>633.00=US$285</td>
<td>36.2%</td>
</tr>
<tr>
<td>On-ranch trophies</td>
<td></td>
<td></td>
<td>26.9%</td>
</tr>
<tr>
<td>Off-ranch trophies</td>
<td></td>
<td></td>
<td>6.4%</td>
</tr>
<tr>
<td>Sub total hunting</td>
<td></td>
<td></td>
<td>69.5%</td>
</tr>
<tr>
<td>Live game sales</td>
<td></td>
<td></td>
<td>18.0%</td>
</tr>
<tr>
<td>Meat</td>
<td></td>
<td></td>
<td>5.3%</td>
</tr>
<tr>
<td>Non-consumptive day rate</td>
<td>340</td>
<td>205.67=US$92</td>
<td>4.1%</td>
</tr>
<tr>
<td>Sale hunting rights</td>
<td></td>
<td></td>
<td>2.2%</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td>0.9%</td>
</tr>
<tr>
<td><strong>Total (Z$)</strong></td>
<td></td>
<td></td>
<td>1,717,272</td>
</tr>
</tbody>
</table>
Almost 70% of all wildlife revenue was derived from safari hunting, but in most enterprises the proportion from hunting was greater since the 18% from live animal sales was almost all from one ranch. The average daily rate for hunters was Z$633 (US$285) while that for hunter companions or non-consumptive clients was Z$206 (US$93). Game-meat sales comprised the only other significant revenue source.

The average cost structures (excluding depreciation) of cattle and wildlife enterprises are presented in table 6. In order of value, the major cost categories in cattle enterprises were livestock purchases, feeds, labor, and repairs and maintenance. Together they accounted for 74% of the total cattle costs.

Table 6. Average cost structures of cattle and wildlife enterprises during 1989/90.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cattle (n=43)</th>
<th>Wildlife (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live animal purchases</td>
<td>28.7%</td>
<td>4.1%</td>
</tr>
<tr>
<td>Hunting right purchases</td>
<td>0.0%</td>
<td>10.1%</td>
</tr>
<tr>
<td>Feeds</td>
<td>21.2%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Veterinary &amp; dips</td>
<td>6.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Capture &amp; culling</td>
<td>0.0%</td>
<td>13.0%</td>
</tr>
<tr>
<td>Fuels</td>
<td>4.1%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Repairs &amp; maintenance</td>
<td>8.4%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Promotional travel</td>
<td>0.0%</td>
<td>4.6%</td>
</tr>
<tr>
<td>Safari consumables</td>
<td>0.0%</td>
<td>6.9%</td>
</tr>
<tr>
<td>Power &amp; water</td>
<td>1.3%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Hired labor</td>
<td>15.8%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Administration</td>
<td>4.6%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Financial</td>
<td>5.7%</td>
<td>4.4%</td>
</tr>
<tr>
<td>Other</td>
<td>4.0%</td>
<td>3.2%</td>
</tr>
<tr>
<td>Total (Z$)</td>
<td>8,034,064</td>
<td>1,265,779</td>
</tr>
</tbody>
</table>
In wildlife enterprises repairs and maintenance, labor, capture and culling, hunting right purchases, fuels and administration were the main cost categories and together accounted for 72% of the total cost. The capture and culling costs were incurred primarily by one wildlife enterprise and on most wildlife enterprises the proportions of other costs were therefore higher.

Financial profits

The financial profits of cattle, wildlife, and mixed ranches are presented in figure 4. When depreciation costs were excluded, all ranch types provided positive net returns per ha [panel (a): $C_2 = ZS11.18, P<0.01; C_4 = ZS4.53, P<0.05; W_r = ZS6.91, W_0 = ZS3.79, P<0.10; M_r = ZS7.11, M_0 = ZS7.20, P<0.01] and positive returns to investments [panel (c): $C_2 = 3.86\%, P<0.01; C_4 = 2.03\%, P<0.10; W_r = 9.85\%, W_0 = 7.42\%, P<0.05; M_r = 5.09\%, M_0 = 5.16\%, P<0.01$. The proportions (actual numbers in parentheses) of ranches in each category that generated more than 10% returns to investment were: cattle $C_2 = 7\% (1)$; wildlife $W_r = 57\% (4), W_0 = 29\% (2)$; and mixed $M_r$ and $M_0 = 31\% (2)$.

When depreciation was included the financial profits of all categories were significantly reduced ($P<0.01$). But net returns per ha on mixed ranches were reduced less than those of cattle ranches ($C_2 P<0.05, C_4 P<0.10$) while returns to investments on wildlife ranches were reduced significantly more ($P<0.01$) than either cattle or mixed ranches. With depreciation, only $C_2$ cattle and mixed ranches provided
Figure 4. Financial profits of cattle, wildlife and mixed ranches: adjusted per-ha net revenue (a) excluding and (b) including depreciation; percentage return to investment (c) excluding and (d) including depreciation. (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively, Wt, Wo, Mt and Mo represent the total operations and on-ranch components of wildlife and mixed ranches, respectively).
significant net revenues per ha [panel (b): $C_2=Z$4.50, $M_4=Z$3.79, $M_0=Z$3.88, $P<0.10$] and only mixed ranches provided significant returns to investments [panel (d): $M_4=2.71\%, M_0=2.78\%, P<0.10$]. The cattle enterprises on mixed ranches contributed just over 75% of the total net revenue per ha [panels (a) and (b)].

Due to the small sample sizes and the large variability within ranch categories few inter-category differences were statistically significant. When depreciation was excluded, the net revenue per ha from $C_2$ ranches was greater than that from the $C_4$ ranches ($P<0.05$) and the $M_0$ category ($P<0.10$) [panel (a)]. In addition, the returns to investment were greater ($P<0.10$) from wildlife ranches than from $C_4$ cattle ranches [panel (c)]. When depreciation was included, the net revenue per ha from $C_2$ ranches was greater ($P<0.10$) than that from $C_4$ ranches [panel (b)] while the returns to investments from mixed ranches was greater ($P<0.10$) than that from $C_4$ cattle ranches [panel (d)].

These results imply that, in areas with abundant wildlife, both cattle and wildlife ranchers were, on average, living off depreciation or increasing borrowings to survive financially under the prevailing economic climate. This is not sustainable in the long-term. In addition, when depreciation was included, wildlife ranches were, on average, financially profitable only when extra-ranch wildlife resources were used.
Capital assets

Minimizing capital investments may be as important to producers as maximizing profits. The average fixed, moveable and livestock investments per ha on cattle, wildlife, and mixed ranches are presented in figure 5. Total capital assets (excluding land) varied significantly (P<0.01) between all ranch categories. C₂ cattle ranches had the highest capital investments while, in areas with abundant wildlife, C₄ cattle ranches had more capital investments than wildlife ranches and mixed ranches were intermediate.

Approximately 50% of all capital investments on cattle and mixed ranches were in cattle. Livestock investments on wildlife ranches reflect the remnants of cattle enterprises and/or cattle used for domestic consumption. Wildlife was not allocated an asset value because it is a fluid resource and does not belong to the private land owner¹.

Fixed assets were significantly greater (P<0.05) on cattle than on wildlife ranches. Differences in moveable assets were insignificant. The large investment in moveable assets on wildlife ranches may have been due to the need for more vehicles in tourist-orientated wildlife enterprises.

¹Jansen et al., (1992) used the value of the trophy component of each species (2% and 6% of the estimated populations for antelopes and felines, respectively) as the capital value of wildlife. But no capital value was given to wildlife on private land in this study because population sizes of some species were uncertain due to migration, revenue other than trophy sales can be derived from wildlife, and wildlife is owned only once it is captured.
Figure 5. Per-ha fixed, moveable and livestock assets on cattle, wildlife and mixed ranches. (C₂ and C₄ are cattle ranches in areas with sparse and abundant wildlife, respectively)
By contrast, the lower fixed and moveable assets on mixed ranches than on cattle ranches may be a survey artifact due to under-allocation of capital assets to cattle and wildlife enterprises where survey respondents perceived them to be supplementary to major crop enterprises.

The average fixed and moveable asset structures of cattle and wildlife enterprises are presented in table 7. The average asset structures of cattle and wildlife enterprises were fairly similar. The greater proportion of investments in buildings on wildlife enterprises was due to the inclusion of safari camps. Since internal fencing is undesirable for wildlife, the proportional investment in

Table 7. Average fixed and moveable asset structures of cattle and wildlife enterprises during 1989/90.

<table>
<thead>
<tr>
<th>Category</th>
<th>Cattle (n=43)</th>
<th>Wildlife (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>34.3%</td>
<td>44.8%</td>
</tr>
<tr>
<td>Water facilities</td>
<td>41.0%</td>
<td>39.2%</td>
</tr>
<tr>
<td>Fencing</td>
<td>20.6%</td>
<td>11.2%</td>
</tr>
<tr>
<td>Power facilities</td>
<td>3.7%</td>
<td>4.7%</td>
</tr>
<tr>
<td>Other</td>
<td>0.4%</td>
<td>0.1%</td>
</tr>
<tr>
<td>Total (Z$)</td>
<td>22,313,047</td>
<td>4,963,395</td>
</tr>
<tr>
<td><strong>Moveable assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicles</td>
<td>73.4%</td>
<td>74.4%</td>
</tr>
<tr>
<td>Machinery &amp; equipment</td>
<td>16.0%</td>
<td>6.2%</td>
</tr>
<tr>
<td>Contents</td>
<td>9.0%</td>
<td>19.4%</td>
</tr>
<tr>
<td>Other</td>
<td>1.6%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Total (Z$)</td>
<td>7,195,509</td>
<td>2,871,237</td>
</tr>
</tbody>
</table>
fencing was less on wildlife than cattle enterprises. Vehicles comprised the greatest proportion of moveable assets in both cattle and wildlife enterprises. Cattle enterprises had greater investments in machinery and wildlife enterprises in building contents, especially weapons and safari camp equipment.

Discussion and Conclusions

Cattle ranches in the areas with sparse wildlife provided the greatest adjusted net revenues (Z$4.50 ha\(^{-1}\)) while, in areas with abundant wildlife, only mixed ranches were financially profitable (Z$3.79 ha\(^{-1}\)) when depreciation was included. These results do not support claims that wildlife ranching is more profitable than cattle ranching in semi-arid African savannas. Profitability of alternative range-based production systems is clearly area specific.

In areas with abundant wildlife, cattle ranchers were surviving by living off depreciation or liquidating their livestock assets, neither of which are sustainable in the long run. The greater profitability of cattle ranches in areas with scarce wildlife than those in areas with abundant wildlife is probably due to the greater grass cover and less bush encroachment in the former (as a result of seasonal waterlogging). But both of these cattle ranch categories provided net losses when potential revenues from retained animals (due to the prevailing foot-and-mouth disease
epidemic) were excluded from revenue. They thus faced financial risks from disease-related marketing constraints.

Wildlife ranches were, on average, financially profitable only when the extra-ranch wildlife resources were included. They were thus surviving financially through external revenues or by living off depreciation. But, wildlife ranches had the least capital investments (particularly in livestock with its marketing risks) and may thus have represented less of an investment risk in the prevailing uncertain economic climate. In addition, they provided an opportunity to earn foreign currency. Finally, many young Zimbabweans view bush craft and hunting as a way of life and may therefore be prepared to tolerate low returns to investment in order to be hunters.

The results of this study indicate that under the prevailing economic conditions, the greatest ranch profits in areas with wildlife were realized by mixed operations and, that, in general, independent wildlife-only ranches may not be sustained by on-ranch wildlife resources in the Zimbabwe Midlands. In addition, there are substantial differences in management requirements for cattle and tourist-orientated wildlife operations. It would thus seem logical that the management of the Midlands wildlife resource be integrated under one or more co-operative systems in which each participating land owner is a share holder. This would provide a broader resource base for
wildlife operations by including cattle ranches where wildlife was not previously used but which nevertheless incurred some wildlife-related capital costs. Such a system would also spread operational risk for cattle ranchers through diversification. Further, wildlife management could be improved by monitoring populations throughout their natural home ranges rather than on individual ranches, and by eliminating potential localized over-exploitation. Finally, standards of safari operations could also be enhanced through the employment of managers specialized in tourist-orientated operations.

There is a possibility that the cattle and wildlife-associated costs and capital investments were underestimated by mixed ranchers with cropping enterprises (for whom the cattle and wildlife enterprises may be supplementary). The results are furthermore based on a cross-sectional study of the 1989/90 production season. The conclusions of this study must, therefore, be tempered by a degree of uncertainty about the true costs and capital requirements of cattle and wildlife enterprises in mixed ranching operations, and the validity of the conclusions over time. The power of the conclusions would be enhanced if they were corroborated by monitoring the performance of cattle, wildlife and mixed ranching systems in the Zimbabwe Midlands over time through systematic recording of direct, overhead and capital costs.
References


POLICY EFFECTS ON CATTLE AND WILDLIFE
RANCHING IN MID-ZIMBABWE

Introduction

This paper presents an empirical analysis of the aggregate effects of government policy interventions on the profitability of cattle and wildlife ranching in the Zimbabwe Midlands.

Maintaining range-based human welfare under increasing population pressure requires the efficient allocation of resources to alternative range products. Since multi-species herbivore communities tend to defoliate semi-arid African savannas more uniformly than cattle alone (Walker, 1979; Taylor and Walker, 1978), it has been argued that game ranching can produce greater profits than extensive beef ranching (Dasmann and Mossman, 1961; Clarke et al., 1985; Hopcraft, 1986; Child, 1988). Economically and ecologically game ranching may therefore be the most sustainable land-use in these areas (Child and Child, 1986).

Such claims have, however, been based on market prices which include the effects of policy interventions such as trade restrictions, subsidies and taxes, and price and exchange rate controls. Policy interventions are usually well intended but allocation of resources based on market distorted prices are unlikely to be economically efficient because they do not accurately reflect resource scarcity.
(Monke and Pearson, 1989). Until now, no empirical analysis has been conducted to determine the effects of policy interventions on the relative profitability and production incentives in alternative range-based production systems.

Such an analysis requires estimation of financial and economic profitability which, unlike net revenue, account for all costs including the opportunity costs of assets. Financial profit is estimated from the actual market prices of production inputs and outputs, while economic profit uses the opportunity costs, which reflect pure scarcity values of resources (Jansen, 1989). Inequality between financial and economic profits causes income transfers between activities (Masters, 1989) by promoting economically inefficient output levels. For example, profit-maximizing producers are likely to oversupply commodities whose profitability is increased by policy interventions and undersupply those whose profit is decreased.

Comparing the profitability of cattle and wildlife is often complicated by ownership differences. Cattle are individually owned and are freely marketed while wildlife is usually a fluid, common-pool resource facing the "free rider" problem of the commons. Indirect valuation methods have sometimes been used for wildlife (Davis and Lim, 1987), but the legitimacy of comparing product values derived in different ways is questionable because assumptions and errors vary between methods.
The Zimbabwe Midlands presented a rare opportunity for comparing cattle and wildlife values because there is a long history of commercial cattle ranching and landowners have the right to commercially use wildlife on their property.

Methodology

Policy analysis matrix

The Policy Analysis Matrix (PAM) of Monke and Pearson (1989) provided a useful analytical framework for comparing the financial and economic profits of production and thus assessing the effects of policy interventions on resource allocation. The matrix is illustrated in table 8. To allow comparison of the various operations, the values in the matrix are in Zimbabwe dollars per hectare ($Z ha\(^{-1}\)$).

Table 8. Policy analysis matrix (Monke and Pearson, 1989).

<table>
<thead>
<tr>
<th>Revenue (≥ 0)</th>
<th>Tradeable inputs (≤ 0)</th>
<th>Domestic factors (≤ 0)</th>
<th>Profit/loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial prices</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Economic prices</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>Policy effects</td>
<td>I</td>
<td>J</td>
<td>K</td>
</tr>
<tr>
<td></td>
<td>(A - E)</td>
<td>(B - F)</td>
<td>(C - G)</td>
</tr>
</tbody>
</table>

The first row is similar to a cost-of-production budget, representing revenues, costs and profits in terms of observed market prices. The second row provides the economic
price estimates of the same components. Row three shows the differences between financial and economic prices and thus estimates the effects of policy intervention. For example, if (A) > (E), the commodity is subsidized, and if (B) > (F), tradeable inputs are being taxed. Columns two and three separate tradeable inputs and non-tradeable domestic factors of production (capital, labor, management and land) because they are assigned economic values in different ways. In the last column, it is possible for the financial profit to be negative and the economic profit to be positive. This would indicate that government policy is turning an economically efficient enterprise into a financially unprofitable one.

A limitation of the PAM approach is that the accounting indices in the matrix are average parameters. Theoretically, they are inappropriate for assessing economic efficiency, defined by equal values of marginal products (Masters, 1989). In agriculture, where there are many producers with relatively constant returns to scale, marginal costs and returns can however be approximated by average prices.

**Financial prices**

Market values of outputs and direct, overhead and capital inputs were obtained directly from the financial records of the ranchers surveyed. Financial profits were estimated for the 1989/90 production season from data obtained through personal interviews using a standardized questionnaire (Appendix B).
Tradeable commodity prices

World prices may be used as a proxy for economically efficient prices of tradeable commodities (Monke and Pearson, 1989) because international market competition reduces price distortions. However, international tariff agreements may distort world prices but better estimators of economic prices are difficult to obtain. The relevant world prices for exports are the free on board (f.o.b.) border prices, and for imports, the cost, insurance, freight (c.i.f.) import prices (Monke and Pearson, 1989; Gittinger, 1982). The economic prices of exports and imports were thus estimated using the f.o.b./financial price and the c.i.f./financial price ratios, respectively.

Both beef and safari hunting (the predominant products from cattle and wildlife enterprises in Zimbabwe) are export commodities. The European Community is the main importer of Zimbabwe beef and, under the LOME IV Convention, it imposes only 10% of the normal import tariff (World Bank, 1990). This provides Zimbabwe access to higher than world-market beef prices. But in 1989 a foot-and-mouth disease outbreak halted beef exports which were resumed only in late 1990 (Jansen and Muir, 1991). A base factor of 1.25 was used to convert beef revenue from financial to economic prices. This was derived from the Cold Storage Commission’s (CSC) beef sales realization/mean producer price ratio weighted by the proportion of exports and local sales during 1990.
Revenue from wildlife on private land is almost all earned in foreign currency (Cumming, 1989) and there is no price intervention in the Zimbabwe wildlife industry. The economic prices of wildlife outputs are therefore equivalent to their financial prices.

For tradeable inputs, c.i.f. border prices were obtained from official sources where possible. Where not available, economic prices were estimated from financial prices by removing transfer payments due to taxes and subsidies. Financial prices were adjusted downwards by the level of subsidization and upwards by the level of taxation.

The estimated world/market price ratios are however insufficient for converting economic prices in international currencies to domestic currency values. In addition, free-market exchange rates must be used for such conversions (Jansen, 1989) because exchange rates affect the premium payable for traded goods relative to domestic factors of production (Gittinger, 1982). For example, overvalued rates of exchange create implicit taxes on exports and subsidies on imports because too little domestic currency is earned by exports or paid for imports (Monke and Pearson, 1989).

Zimbabwe’s opportunity cost for foreign currency is above the official exchange rate (Masters, 1990) because the value of its currency has been sliding too slowly to account for the greater inflation rate in Zimbabwe than in its main trading partners (Jansen and Muir, 1991). The resulting
demand/supply imbalance for foreign currency is reflected in a black-market exchange rate that is double the official rate. But black-market exchange rates do not often provide accurate estimates of free-market rates because of the risk premium inherent in black markets. The average of the official and the black-market exchange rates might therefore provide a conservative estimate of what the free-market exchange rate might be, which would indicate a 50% Z$ overvaluation during the survey period.

Economic prices for all tradeable commodities were calculated from the world/market price-conversion ratio, the foreign-content percentage (Appendix D), and the Z$ overvaluation factor (table 9).

Table 9. Economic price estimation (Z$)

<table>
<thead>
<tr>
<th>Financial price</th>
<th>Price ratio</th>
<th>Foreign content</th>
<th>Forex factor</th>
<th>Economic price foreign</th>
<th>Economic price local</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
</tr>
<tr>
<td>A = Financial value of tradeable output or input (Z$).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B = world/market price ratio (economic conversion factor).</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C = % foreign content of financial value.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>D = Z$ overvaluation correction factor.</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>E = economic price of the foreign content (Z$).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F = economic price of the local content (Z$).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G = total economic price of tradeable output or input (Z$).</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Domestic factor prices**

Among domestic factors, only land is absolutely immobile but international migration of labor and capital is
also generally constrained. Thus, domestic factor prices are determined mainly in domestic markets (Monke and Pearson, 1989). The economic prices of domestic factors are therefore valued at their domestic opportunity cost (the value of the factor in its next best use) because it measures the scarcity value of the resource.

Only labor and capital were included in the analysis and profits were estimated as net returns to management and land, a common accounting procedure (Gittinger, 1982).

Management costs were excluded because of the uncertain effect of income tax structures on the accuracy of declared management fees and salaries. Reliable average land price estimates were also unavailable because policies aimed at restricting external investments and redistributing land to peasant farmers (Murphree and Cumming, 1991) were creating a volatile market. However, exclusion of land did not weaken the analysis because financial and the economic profits were affected identically and the comparisons of the relative profits of the four ranch categories were unaffected.

The minimum wage policy in Zimbabwe has led to unskilled formal sector wages above the opportunity cost of labor, but the lack of information on income in communal farming areas (the next best opportunity for farm laborers)

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1. Land prices did not differ among the four ranch categories and the financial price of land is equal to its economic price because there are no substitutes.
made economic/market price ratio estimation difficult. Since ranchers indicated that eliminating minimum wage regulations would decrease labor wages by about 10%, a conversion factor of 0.9 was assumed for ranch labor costs.

Interest rates affect the opportunity cost of investments in capital assets. Controlled interest rates during the study were below the inflation rate but external investment opportunities were legally restricted. Further, for a cross-sectional analysis, dollar values of revenues and costs are not affected by future changes in a currency's buying power. For the purposes of this analysis, it was therefore assumed that the average nominal rate of 10% on savings accounts was equivalent to the opportunity cost of investment in capital assets. But no opportunity cost was charged on wildlife because it does not represent personal capital since it is a fluid resource, moving across individual farm boundaries, and it is owned by the state.

**Adjusted net revenue**

Since this was a cross-sectional analysis, adjustments were made to the net revenues of cattle enterprises to eliminate capitalization of profits through herd increases or liquidation of profits through herd decreases. In wildlife enterprises, such adjustments were not made because apparent population changes on individual ranches may have reflected migration rather than actual population changes. However, 80% of the costs of wildlife purchased for breeding
were added back to wildlife profits since such purchases were not made regularly and resulting benefits were assumed to accrue over a five-year period. Revenues and costs associated with the use of wildlife outside of the Midlands were also excluded from the analysis.

**Data analyses**

Uncertainty of the absolute values of the opportunity cost of capital, overvaluation of the Zimbabwe dollar, and the cattle-revenue financial/economic price ratio, required the use of sensitivity analyses. The effects of the assumed parameter values on the comparative economic profitability of the ranching operations could thus be determined.

The inevitably small sample size of each ranch category and the corresponding differences in sample variances required the use of non-parametric statistics to analyze the data. The statistical tests used to compare sample means were the Wilcoxon matched pair, the Mann-Whitney two sample and the Kruskal-Wallis tests (Hollander and Wolfe, 1973).

**Results**

Financial and economic profits are presented on a per-hectare basis to facilitate comparison between ranches. Returns per animal unit are not reported since numbers of wild animals were based on subjective rancher estimates. Returns to investments (excluding land) are also reported in the first section to clarify the discussion.
Opportunity cost of capital

Four opportunity costs of capital were used in the analysis: 0%, 10%, 5%, and -2.22%. The first rate excluded interest on capital thus providing financial profit estimates similar to those from profit and loss statements (excluding depreciation). As previously explained, the second rate assumed that the nominal and the real rates are equivalent in a cross-sectional analysis. When inflation is high and investment options are legally restricted, capital investments may however represent a hedge against inflation rather than a liability. Thus the fourth rate (-2.22%) used was the 10% nominal savings rate corrected for the average inflation of 12.22% (as measured by the consumer price index), during the study. But maintaining interest rates below inflation is possible only where external investments are restricted. The third rate (5%) was thus an intermediate rate approximating the 4% real discount rate recommended for use by the U.S. Forest Service (Row et al., 1981).

The mean financial and economic profits per hectare at each opportunity cost are presented in figure 6, while returns to capital investments are presented in figure 7.

Financial prices

When the opportunity cost of capital was excluded, each ranch category, on average, provided positive financial net revenue per hectare (C2 = Z$13.14, C4 = Z$5.27, W = Z$4.02, M = Z$7.84, figure 6a panel 1). Only the returns to C2 and
Figure 6. Effect of capital opportunity cost on financial and economic ranch profitability (Z$ ha⁻¹). (a) financial and (b) economic profitability of cattle (C₂: areas with sparse wildlife; C₄: areas with abundant wildlife), wildlife (W) and mixed (M) ranches without capital costs. (c) financial and (d) economic profitability with 10%, 5% and -2.2% opportunity cost on capital.
Figure 7. Frequency distribution of financial returns to investment (%) on cattle (C₂: areas with sparse wildlife; C₄: areas with abundant wildlife), wildlife (W) and mixed (M) ranches using (a) 10%, (b) 5%, and (c) -2.2% opportunity cost.
C4 cattle ranches were however significantly different (P<0.05). This difference may be associated with higher rangeland productivity (denser grass cover and lower competition from wildlife) reflected by a 45% higher cattle stocking rate on C2 ranches. The lack of significant differences between cattle, wildlife and mixed ranches in areas with abundant wildlife provides no clear management indicators for profit-maximizing producers in the Midlands.

With the 10% interest rate, none of the four ranch categories were, on average, financially profitable. Only 3% of cattle, 43% of wildlife, and 31% mixed ranches produced positive returns to investment. Under this scenario, cattle ranches sustained greater losses (P<0.05) than wildlife or mixed operations. The use of a 5% interest rate reduced these losses in all categories (P<0.01 except wildlife P<0.05) with 40% of cattle, 71% of wildlife and 46% of mixed ranches producing positive returns to investment. With the -2.22% interest rate, all ranch categories were, on average, financially profitable though C2 cattle ranches were significantly (P<0.05) more so than C4 ranches. Only under this scenario did any cattle and mixed ranches provide returns to investment exceeding 10%, and only 13% of cattle, 14% of wildlife and 8% of mixed ranches were unprofitable.

The increase in financial profitability, with decreased interest on capital, was greater on cattle and mixed ranches than on wildlife ranches. This was because capital interest
affected the economic cost of domestic factors more in cattle than in wildlife enterprises since no capital value was ascribed to wildlife while other capital requirements were similar among the four ranch categories. This provided at least a short-term incentive for overstocking with cattle because, due to the high level of inflation, the speculative returns on holding livestock were greater than 10%.

Economic prices

When the opportunity cost of capital was excluded, cattle and mixed ranches generated slightly greater economic profits than wildlife ranches. These differences varied significantly with capital interest (figure 6d). The economic profits of C2 ranches were greater ($P<0.05$) than those of C4 ranches at all interest rates, and at -2.22% all cattle and mixed ranches generated greater (cattle $P<0.01$, mixed $P<0.05$) economic profits than wildlife ranches.

These differences can be accounted for by the aggregate effects of the world/market price ratios and the foreign content in revenue and tradeable input items. On C2 ranches both financial revenues and tradeable costs were almost 50% greater than on C4 ranches. However, conversion of financial to economic prices increased cattle revenues by four times more than tradeable inputs, while domestic factors were little affected by the conversion process. This was because both the price ratio and foreign content were greater for beef revenue than for tradeable inputs and domestic factors.
Policy effects

Converting financial to economic prices significantly increased (P<0.01 except wildlife P<0.05) the profits of all ranches. Within each category the financial-economic profit difference was only slightly affected by varying capital interest because the aggregate opportunity cost of capital assets was very similar in financial and economic terms.

The profit difference was significantly greater (P<0.05) for cattle than for wildlife ranches. This was because financial revenue from cattle and mixed ranches was, on average, significantly greater (P<0.01) than from wildlife, and the conversion factor for beef revenue was greater than for wildlife revenue. Furthermore, in all ranch categories, price conversions affected revenue significantly more (P<0.01, wildlife P<0.05) than costs.

These results imply that the prevailing policy mix (which generated implicit taxes on beef-producer prices, high interest and inflation rates, and an overvalued Z$) was creating negative production incentives for cattle ranchers and to a lesser degree for wildlife ranchers. Both commodities were therefore probably being produced at levels below those that would prevail in the absence of policy interventions. In the four areas with abundant wildlife, this conclusion was supported by a decline in the average cattle herd size during the 1980’s and a shift to less capital-intensive wildlife ranching in areas with wildlife
Child, 1988). This might have been due to the decreasing profitability of beef production and possibly due to declining range productivity. By contrast, in areas with sparse wildlife, ranchers appeared to be increasing their herds. In the prevailing inflationary climate returns on livestock investment were perceived to exceed returns from alternative investment options.

**Zimbabwe dollar exchange rate**

Three Z$ overvaluation rates were used in the analysis: 0%, 50% and 100%. The first rate assumed that the official Z$ exchange rate was equivalent to the free-market rate. The third rate was the black-market exchange rate above the official rate excluding an estimated 50% black-market risk premium. The second rate was intermediate between the official and the black-market rate of exchange.

The exchange-rate correction factor was used to remove the effects of an overvalued Z$ when estimating economic profits. Financial profits were therefore not affected in the analysis and only the effects of the exchange rate factor on the mean economic profits of the four ranching operations are discussed (figure 8).

Increasing the Z$ overvaluation significantly increased (P<0.01 except wildlife P<0.05) economic profits in all ranch categories. This effect was greater (P<0.01) on cattle (particularly C2) than wildlife ranches. Since the foreign
Figure 8. Zimbabwe dollar overvaluation effects on the economic profitability of ranches using three Z$ overvaluation factors (1.0 = 0%, 1.5 = 50%, and 2.0 = 100% overvaluation). (C2 and C4 = cattle ranches in areas with sparse and abundant wildlife, respectively; (W) = wildlife ranches and (M) = mixed ranches).
contents of wildlife and cattle revenue were 100% and 87%\(^2\), respectively, this result might seem surprising. But, in converting financial to economic prices, the Z$ overvaluation factor operates in conjunction with the economic/market price ratio (1.25 and 1.00 for cattle and wildlife revenue, respectively). The combined conversion factors for revenue were therefore 1.09 for cattle and 1.00 for wildlife. Similarly, the exchange rate factor had a greater (P<0.01) effect on ranch revenue than on production inputs because the average foreign currency content for inputs was less than for outputs.

These results imply that, with increasing overvaluation of the Zimbabwe dollar, cattle enterprises face an increasing level of implicit taxation relative to wildlife enterprises because the effects on net earnings in local currency are greater in cattle than wildlife enterprises. If other policy interventions remained constant, use of a free-market exchange rate would thus enhance the profitability of beef production more than wildlife ranching. This could lead to a production shift away from wildlife to beef.

\(^2\)During the last 10 years annual beef exports were, on average, only 10% and never greater than 20% of total beef production. The net foreign currency content of beef sales was however assumed to be 87% because at the margin all beef could have been exported but beef exports were associated with a 13% foreign cost component (Jansen et al., 1992).
Cattle price ratio

Three ratios were used to convert cattle revenue from financial to economic prices: 1.10, 1.25 and 1.35. The 1.25 factor was the ratio of the CSC beef-sales realization and the producer price weighted for exports and local sales in 1990. During the 1980's the government stopped subsidizing beef-producer prices and began subsidizing low-income consumers by increasingly taxing producers through retained beef export earnings\(^3\) (Jansen and Muir, 1991). Since high producer price taxation is unsustainable, because it reduces the viability of beef production, the second ratio of 1.10 represented a lower producer tax burden and was derived from the weighted CSC realization/producer price ratio for 1989. The 1.35 conversion was derived like the 1.25 ratio except that the full European Community export quota was used for export sales. This removed the reduction in beef exports due to the foot-and-mouth disease epidemic of 1989/90. Since the financial profits of cattle enterprises are unaffected by the cattle-revenue conversion, only the economic profits of the four ranch categories are presented (figure 9).

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\(^3\)Zimbabwe's policy of providing affordable meat to low income consumers resulted in a 12% subsidization of consumers from 1985-1991 and a corresponding 15% taxation of producers. Over the last 10 years producer prices for export beef have increased by an average 13.5% per annum while the CPI has increased by 12.6%. But anecdotal information suggests that cattle input prices have increased more rapidly than the CPI. Cattle ranchers are thus facing an increasing profit squeeze due to the cheap meat policy.
Figure 9. Effect of cattle-revenue price conversion on economic profitability of ranches using three cattle-revenue price ratios (1.1, 1.25, and 1.34). (C_2 and C_4 = cattle ranches in areas with sparse and abundant wildlife, respectively; (W) = wildlife ranches and (M) = mixed ranches).
Changing the cattle-revenue conversion factor had the greatest effect on the economic profits of C2 cattle ranches but only the C2 and C4 cattle ranches were statistically different (P<0.10) when the 1.25 and 1.34 conversions were used. Furthermore, increasing the cattle-revenue conversion significantly increased (P<0.01) the disincentives faced by cattle enterprises. The positive correlation between the economic profit of cattle ranches and the beef revenue conversion factor, suggests that taxing beef-producer prices to maintain a cheap meat policy has resulted in greater production disincentives for cattle ranchers relative to wildlife, particularly when beef exports are not constrained by foot-and-mouth disease epidemics. Removing this policy is therefore likely to result in a shift from wildlife to beef ranching. However, the economic profit differences between cattle and wildlife ranches would be less if Zimbabwe's access to the European Community was lost. In this event removing implicit taxes on beef-producer prices would result in smaller increases in beef production profits and there would be less incentive to shift from wildlife to cattle.

Discussion and Conclusions

Since alternatives to cattle and wildlife ranching are limited in the Midlands, ranchers can only shift between beef and wildlife enterprises. In the uncertain economic climate that prevails in Zimbabwe, choice will depend not
only on the financial profitability of these operations but also on their capital investment requirements, perceived levels of risk, and potential for earning foreign currency.

When not charged an opportunity cost on capital, cattle ranches in areas with sparse wildlife were financially the most profitable. Policy interventions (which generated implicit taxes on beef-producer prices, high interest and inflation rates, and an overvalued dollar) were nevertheless providing these ranchers with production disincentives, without the option of moving to an alternative production system. In these areas, the viability of developing a wildlife enterprise is questionable. The reasons are that habitats for diverse wildlife communities do not exist, and the prices of breeding livestock have been elevated beyond their reproductive value because the demand for breeding stock exceeded supplies throughout Zimbabwe.

Since the demand for beef locally exceeded supply, the negative policy effects on beef profits increased live sales and informal beef sales, because prices in these markets are not controlled. Conversely, the share of sales to the CSC have decreased from nearly 90% in 1980 to about 50% in 1990 (AMA, 1991). This has had the combined effect of creating local meat shortages in urban areas, and reducing beef exports. Thus the government’s objectives of increasing foreign earnings (Zimbabwe, 1991) and being self sufficient in beef (Rodriguez, 1985) were both being defeated.
In areas with abundant wildlife, there has been a movement in the 1980's from purely cattle to mixed or even purely wildlife operations (Child, 1988), despite the apparently small difference in financial profits between these enterprises. Analysis of the Midlands component of the wildlife operations, indicated that movement from purely cattle to purely wildlife enterprises was not financially or economically rational. But virtually all Midlands wildlife operations were subsidized by other income including revenue from wildlife in other areas, timber sales, and independent wealth. Since the capital requirement was lower for wildlife than cattle enterprises, changes from cattle to wildlife ranching might have been motivated by the desire to reduce capital investments in an uncertain economic environment.

Although cattle and mixed ranches provided similar financial and economic profits, diversifying from cattle to mixed operations was rational under the prevailing policy because it spread the risk without increasing capital costs and reduced the impact of policy interventions on profit. Beef production faces the risk of stringent veterinary constraints to protect the export market, while socio-political instability presents risks for tourist-orientated wildlife operations (Cumming, 1989). The risk for beef production will remain if the European Community remains Zimbabwe's main export market for beef, but under a freer economy socio-political stability might persist.
The Zimbabwe government’s objectives of maximizing net foreign currency earnings and providing sufficient protein for an expanding population are not being realized in the Midlands because prevailing policy is creating production disincentives for both cattle and wildlife ranchers. Removing these policies is likely to result in an expansion of beef production in areas with scarce wildlife and further development of mixed operations in areas with wildlife.
References


COSTS OF OVERSTOCKING ON CATTLE AND WILDLIFE RANCHES IN MID-ZIMBABWE

Introduction

This paper presents a framework for comparing the cost of overstocking on cattle and wildlife ranches and includes an application of the methodology in the Zimbabwe Midlands.

Overstocking is the stocking of herbivores in excess of rangeland carrying capacity (Mentis, 1977). In the short term the effect on range productivity may not be detrimental but long-term overuse can lead to a concomitant change in vegetation composition and loss of animal productivity (Crawley, 1983; Wilson and MacLeod, 1991). In semi-arid savannas, continued defoliation of the herb layer in excess of regrowth leads to changes in species composition from perennial to annual grasses and an increase in woody plant density, (Walker, 1976; Walker et al., 1981). Associated downward trends in secondary production may not be readily reversed by removing grazers or through bush eradication. The general belief that grazing affects range productivity has thus led to stocking recommendations based on estimated carrying capacity (Holechek et al., 1989; Stoddart et al., 1975). But quantifying herbivory effects on vegetation dynamics is problematic in semi-arid rangelands because biotic and abiotic interactions often occur intermittently and unpredictably (Walker, 1988; Westoby et al., 1989).
Since short-term profit maximization does not account for inter-temporal effects of herbivory, it has been blamed for excessive stocking and rangeland degradation (Workman, 1986). It has also been argued that only in less resilient range types is the short-term, economically optimum stocking rate likely to exceed the degradation threshold (Wilson and MacLeod, 1991). If grazing impacts on range productivity are small relative to the effect on current animal performance, the short-term economic model may satisfactorily approximate long-term stocking optima (Torell et al., 1991).

In theory the costs of range degradation are borne by producers through declining land values (Stoddart et al., 1975; Holechek et al., 1989). However, in reality opportunity costs of rangeland overuse may not be reflected in land prices. This is because there may be response lags between overuse and reduced rangeland productivity, and there is often a poor correlation between productivity and land prices during inflationary periods (Rowan and Workman, 1992). Overuse of rangeland can therefore represent a production externality when the associated opportunity costs are borne by future users rather than the present users who are using biological capital for short-term gain. Since products associated with negative externalities tend to be overproduced (Bator, 1958; Buchanan and Stubblebine, 1962) range-resource allocation based on market prices may be economically inefficient.
Since multi-species herbivore communities tend to defoliate semi-arid savannas more uniformly than cattle alone (Walker, 1979; Taylor and Walker, 1978) it has been argued that game ranching is more profitable than extensive beef ranching (Dasmann and Mossman, 1961; Clarke et al., 1985; Hopcraft, 1986; Child, 1988). Such claims have not accounted for production effects on future rangeland productivity. No comprehensive empirical analysis has been conducted to compare the effects of overstocking on the profitability of cattle and wildlife production systems.

The Zimbabwe Midlands presented a rare opportunity for directly comparing the commercial cattle and wildlife production systems because there is both a long history of cattle ranching and, since 1975, private land owners have the right to utilize wildlife on their property.

Methodology

**Carrying capacity**

Ecological carrying capacity has been defined as the herbivore biomass that is sustained when, in the absence of external disturbances, the production and consumption of forage are equal (Caughley, 1979). In reality biomass densities vary with rainfall. The validity of the carrying capacity concept has thus been challenged (Bartels et al., 1991) but in practice may be defined as a band of probability determined by rainfall variability (Bell, 1984).
Estimates of carrying capacity should be obtained from long-term area-specific models. Such models were unavailable for the Zimbabwe Midlands necessitating the use of a more general model. For example, the Coe, Cumming and Phillipson (1976) model positively correlated large herbivore biomass with mean annual precipitation using data from 20 widely dispersed eastern and southern African areas with less than 800 mm mean annual rainfall. Similar positive biomass-rainfall correlations were identified for nineteen individual herbivore species (East, 1984). The correlations together with positive prey-predator relationships, support the view that large mammal populations are usually regulated at levels close to the carrying capacity (East, 1984).

The predictive power of the Coe, Cumming and Phillipson model has been questioned because it predicts herbivore biomasses corresponding to those in high nutrient areas (Bell, 1984). Low nutrient areas, such as the ubiquitous sandveld of Zimbabwe, are likely to support lower biomass per unit rainfall. Another weakness of the model is that it disregards the negative correlation between body size and energy requirements per unit body mass. Mammalian basal metabolism has been defined as $293 \cdot W^{0.75}$ (measured in kJd$^{-1}$) where $W$ is body mass in kilograms (Kleiber, 1975). Since digestive capacity is determined by body size, small herbivores must select higher quality forage than larger ones (Hudson, 1985). Metabolic mass rather than biomass
should therefore be used for estimating carrying capacity and stocking rates of multi-species herbivore communities.

Cumming (personal communications, 1991) consequently correlated metabolic mass per hectare \((MM = W^{0.75} \text{ measured in } kg^{0.75} \text{ ha}^{-1})\) with mean annual rainfall \((MAR \text{ in mm})\) using data from 15 areas used by Coe, Cumming and Phillipson. Five internal drainage areas were excluded because such systems do not occur in Zimbabwe. The relationship is presented below with standard errors in parentheses.

\[
MM = -2.47820 + 0.01965 \cdot MAR \\
(1.68835) \quad (0.00644) \\
(r=0.88; P<0.001; n=15)
\]

If long-term mean annual precipitation is used, then, according to East (1984), equation (1) should predict the biological carrying capacity for a mixed large herbivore community. The 95% confidence band at 700 mm (1960-1989 mean annual rainfall for the Midlands) is \(\pm 22\%\) of the predicted value. But in undisturbed nutrient-poor savannas, such as those of the Midlands, megaherbivores\(^1\) may comprise over 50% of a herbivore community by weight (Bell, 1984). Since few megaherbivores exist in the study area and much of the vegetation normally used by them is unavailable to other

\(^1\)Megaherbivores have been defined as plant-feeding mammals which attain an adult body mass exceeding 1,000 kg (Owen-Smith, 1988). Among African mammals they include the elephant, rhinoceros, hippopotamus and giraffe. Buffalo are also included in this category in this study for simplicity.
herbivores, it might be argued that to prevent overuse of vegetation used by other herbivores (mainly the herb layer) the predicted carrying capacity should be reduced by 50%.

Due to uncertainty about rangeland carrying capacity for existing herbivore communities in the Zimbabwe Midlands, three values were used for each ranch: the carrying capacity predicted by equation (1) using the 30-year mean annual rainfall; the upper 95% confidence limit of this value; and 50% of the value to account for the lack of megaherbivores.

Stocking rate

Herbivory pressure is a function of herbivore community structure and the population size of each herbivore species. However, since vigor of the herb layer of semi-arid savannas is the primary determinant of productivity (Walker, 1976), grazing pressure is of greater significance than total stocking rate when estimating herbivory impacts on rangeland productivity. Cattle were assumed to be obligatory grazers while the approximate proportions of grass fractions in the diets of wild herbivores are presented in table 10. Stocking rates of the grazing fractions of herbivores (SR$_{gj}$ measured in kg$^{0.75}$ ha$^{-1}$) were estimated using a constant unit body mass (mean individual body mass of each species weighted for average herd structure) for wild herbivores and six sex and age categories for cattle, as detailed in Table 10. The expression used to derive stocking rates was:
Table 10. Biomass (kg), metabolic mass (kg\(^{0.75}\)) and proportion of grass fractions in the diets of herbivores.

<table>
<thead>
<tr>
<th>Species</th>
<th>Unit body mass:</th>
<th>Grass component in diet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Biomass</td>
<td>Met. mass</td>
</tr>
<tr>
<td><strong>Megaherbivores</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant</td>
<td>1 051 3</td>
<td>289.7</td>
</tr>
<tr>
<td>Rhino</td>
<td>1 158 4</td>
<td>198.5</td>
</tr>
<tr>
<td>Hippo</td>
<td>1 000 4</td>
<td>177.8</td>
</tr>
<tr>
<td>Giraffe</td>
<td>750 3</td>
<td>143.3</td>
</tr>
<tr>
<td>Buffalo</td>
<td>450 4</td>
<td>97.7</td>
</tr>
<tr>
<td><strong>Plains game</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eland</td>
<td>340 3</td>
<td>79.2</td>
</tr>
<tr>
<td>Zebra</td>
<td>200 3</td>
<td>53.2</td>
</tr>
<tr>
<td>Sable</td>
<td>185 3</td>
<td>50.2</td>
</tr>
<tr>
<td>Wildebeest</td>
<td>165 3</td>
<td>46.0</td>
</tr>
<tr>
<td>Waterbuck</td>
<td>160 4</td>
<td>45.0</td>
</tr>
<tr>
<td>Kudu</td>
<td>136 3</td>
<td>39.8</td>
</tr>
<tr>
<td>Tsessebe</td>
<td>110 3</td>
<td>34.0</td>
</tr>
<tr>
<td>Ostrich</td>
<td>68 3</td>
<td>23.7</td>
</tr>
<tr>
<td>Bushpig</td>
<td>54 4</td>
<td>19.9</td>
</tr>
<tr>
<td>Warthog</td>
<td>45 3</td>
<td>17.4</td>
</tr>
<tr>
<td>Impala</td>
<td>45 3</td>
<td>17.4</td>
</tr>
<tr>
<td>Reedbuck</td>
<td>40 4</td>
<td>15.9</td>
</tr>
<tr>
<td>Bushbuck</td>
<td>30 4</td>
<td>12.8</td>
</tr>
<tr>
<td>Oribi</td>
<td>14 5</td>
<td>7.2</td>
</tr>
<tr>
<td>Steenbok</td>
<td>10 3</td>
<td>5.6</td>
</tr>
<tr>
<td>Grysbock</td>
<td>10 4</td>
<td>5.6</td>
</tr>
<tr>
<td>Duiker</td>
<td>10 3</td>
<td>5.6</td>
</tr>
<tr>
<td>Klipspringer</td>
<td>10 4</td>
<td>5.6</td>
</tr>
<tr>
<td><strong>Domestic Stock</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulls</td>
<td>600 6</td>
<td>121.2</td>
</tr>
<tr>
<td>Cows</td>
<td>400 6</td>
<td>89.4</td>
</tr>
<tr>
<td>Steers (&gt; 1 year)</td>
<td>300 6</td>
<td>72.1</td>
</tr>
<tr>
<td>Heifers (&gt; 1 year)</td>
<td>275 6</td>
<td>67.5</td>
</tr>
<tr>
<td>Weaners</td>
<td>180 6</td>
<td>49.1</td>
</tr>
<tr>
<td>Calves (&lt; 6 month)</td>
<td>120 6</td>
<td>36.3</td>
</tr>
<tr>
<td>Sheep/goats</td>
<td>35 3</td>
<td>14.4</td>
</tr>
</tbody>
</table>

---

1 See Appendix table A1 for scientific names.
2 Mean mass and grazing fraction of white and black rhino.
3 Cumming and Taylor (1989)
4 Coe, Cumming and Phillipson (1976)
5 Smithers and Wilson (1979)
6 Anecdotal information from ranchers
7 Walker and Hanks (1974)
8 Child (1988)
\[ SR_{ij} = A^{-1} \sum_i N_i \cdot W_i^{0.75} \cdot G_i \]  

\( j = C \) (cattle) or \( W \) (wildlife), \( A \) = area of ranch (ha), \( N_i \) = species \( i \) population size or number of cattle in age/sex category \( i \), \( W_i \) = unit body weight of species \( i \) or cattle age/sex category \( i \), and \( G_i \) is the grass fraction in the diet of species \( i \).

Since stocking rates have traditionally been measured as Livestock Units per unit area (1 LSU = 1,000 lb = 454 kg) and range managers are less familiar with kg^{0.75} ha^{-1}, the results from equation (2) were converted to LSU ha^{-1} using a factor of 454^{-0.75} (Kearl, 1970).

**Overstocking**

Overstocking was defined by positive differences between the grazer stocking rate and the predicted long-term carrying capacity. Grazer rather than total stocking rate was used to ensure conservative overstocking estimates due to the uncertain accuracy of carrying capacity estimates. Overstocking of all grazer fractions (OS) was estimated by equation (3) while the cattle and wild herbivore component of overstocking (OSc and OSw, respectively) were estimated using expressions (4) and (5). All estimates were measured in kg^{0.75} ha^{-1} of herbivores in excess of carrying capacity.

\[ OS = SR_{SC} + SR_{SW} - CC \]  

\[ OS_c = (OS \cdot SR_{SC}) \cdot (SR_{SC} + SR_{SW})^{-1} \]  

\[ OS_w = (OS \cdot SR_{SW}) \cdot (SR_{SC} + SR_{SW})^{-1} \]

where \( SR_{SC} \) and \( SR_{SW} \) = stocking rate of cattle and the grazer component of wild herbivores, respectively, and \( CC \) = predicted long-term carrying capacity.
Overstocking cost

Since plant tolerance to defoliation varies, short-term overstocking may not detrimentally affect the long-term productivity of rangeland. But if stocking rates exceed carrying capacity during droughts, range degradation is more likely to ensue, particularly in less resilient range types, because herbivory pressure is increased. Since the survey coincided with below average rainfall, it was assumed that estimated overstocking represented deleterious overuse.

The cost of overstocking can be estimated from the value of lost secondary production. For example, Child (1988) reported a continuous decline in range productivity on a cattle ranch in Zimbabwe from 1970 to 1990 despite above average rainfall from 1976 to 1980. Assuming overstocking to have been solely responsible for reduced productivity, he calculated lost revenue as Z$0.13 kg\(^{-1}\) ha\(^{-1}\) herbivore weight in excess of estimated carrying capacity.

Because of this questionable assumption, Child’s estimate is unlikely to be generally applicable but better estimates are unavailable for the Zimbabwe Midlands. Given the lack of empirical data about the rangeland sensitivity to overstocking, the only reasonable approach for estimating the relative effect of overstocking on cattle and wildlife profitability was a sensitivity analysis. Values tested ranged from Z$0.00 to Z$0.50 kg\(^{-1}\) herbivore ha\(^{-1}\) overstocked.
**Profit estimation**

Negative policy impacts on the profitability of cattle, wildlife and mixed ranches were identified by Kreuter and Workman (submitted) using a policy analysis matrix (Monke and Pearson, 1989) to compare the actual financial profits and hypothetical economic profits of ranches in the Midlands during the 1989/90 production season. In addition to eliminating policy interventions, the cost of using biological capital for short-term gain must be accounted for to ensure efficient use of range resources.

Subtracting overstocking costs from financial profits (using actual market prices) and economic profits (using hypothetical opportunity costs) (Kreuter and Workman, submitted) provided measures of production efficiency under prevailing policy and in a policy-neutral environment. Comparing financial profit (excluding overstocking costs) and economic profit (including overstocking costs) indicated the incentives for under- or over-producing commodities due to policy interventions and exclusion of overstocking costs.

In estimating the economic profit of an operation the following were assumed: zero opportunity cost on capital, 50% Z$ overvaluation, and a cattle-revenue conversion rate of 1.25. Economic analysis should account for all costs and benefits but no capital interest was charged because the true value was uncertain and varying it significantly affected profit estimates (Kreuter and Workman, submitted).
Since the data were cross-sectional rather than time series, no benefit-cost analyses of range rehabilitation opportunities or production alternatives were conducted. But there are few alternatives to extensive range-based production systems in the Midlands and the effectiveness of range rehabilitation is limited in savanna ecosystems, particularly when range degradation is well advanced.

Data analyses

The small sample size of each ranch category and differences in sample variance required the use of non-parametric Kruskal-Wallis and Mann-Whitney tests (Hollander and Wolfe, 1973) to analyze differences between the mean stocking rates of the four ranching categories.

Since the actual costs of overstocking were uncertain, regressions relating financial or economic profitability with a range of overstocking costs were generated for each ranch category. Differences between pairs of these regressions were analyzed with the abridged Chow test using dummy variables (Gudjarati, 1988).

Results

Results are presented in three parts: (1) estimated carrying capacity and stocking rates, (2) estimated cost of overstocking, and (3) the effect of these costs on the profitability of cattle, wildlife, and mixed ranches.
Carrying capacity and stocking rate

The predicted carrying capacities were very similar for the four ranch categories because of the uniform long-term rainfall statistics in the study area. The mean predicted carrying capacity (100%) derived from equation (1), 50% of this mean value (to account for no megaherbivores) and its upper 95% confidence limit (122%), together with estimated mean stocking rates of cattle, and the grazing and browsing fractions of wildlife are presented in figure 10.

When all herbivores were included, the stocking rate of C2 cattle ranches was 27% greater (P<0.05) than C4 cattle ranches. Stocking rates of C4 cattle and mixed ranches were also greater (44% and 31%, respectively, P<0.05) than wildlife ranches but those of cattle and mixed ranches were not significantly different. Similar differences occurred when only the herbivore grazing fraction was considered. Wildlife and mixed ranches had significantly greater wildlife densities than cattle ranches (P<0.01) because several of the wildlife and mixed ranches had game fences, and wildlife tend to prefer areas with less cattle-related human disturbance.

The C2 cattle ranches were stocked well above (77% with browsers, 69% excluding browsers, P<0.01) the mean predicted carrying capacity (100%) and, indeed, above the upper limit of the traditionally recommended stocking rate band of 0.13 to 0.20 LSU ha⁻¹. The stocking rates of C4 cattle ranches
Figure 10. Stocking rates of cattle and the grazing and browsing fractions of wild herbivores on cattle (C2 in areas with sparse wildlife, C4 in areas with abundant wildlife), wildlife (W) and mixed (M) ranches compared with predicted carrying capacity (100%), 50% of the predicted value and its upper 95% confidence limit (122%).
and mixed ranches also exceeded the estimated carrying capacity (C4: 35% with browsers P<0.01, 21% excluding browsers P<0.05; M: 24% with browsers P<0.05). By contrast, wildlife ranches were stocked below carrying capacity (30% excluding browsers P<0.05) and would have been stocked even lower without the residual cattle from previous cattle enterprises on two ranches.

At 50% of the mean predicted carrying capacity, all ranches (except wildlife ranches when the browser fraction was excluded) were overstocked (P<0.01). Thus, if predicted carrying capacity was twice the true carrying capacity, all ranches were probably overgrazed. However, if the upper 95% confidence limit (122%) of the predicted carrying capacity is realistic, only C2 ranches were overstocked (P<0.01) but wildlife ranches were understocked (with browsers P<0.05, excluding browsers P<0.01).

Comparing ranch types, C2 cattle ranches were overstocked significantly more (P<0.01) than C4 ranches. If predicted carrying capacities were accurate, the stocking rates on C2 ranches appear to be unsustainable. But such overstocking might have been a short-term phenomenon related to the foot-and-mouth disease associated marketing restrictions of 1989/90. Alternatively ranchers might have been encouraged to overstock because the speculative returns on holding cattle were greater than returns from alternative investment opportunities (Kreuter and Workman, submitted).
Overstocking cost

The relationship between overstocking cost and assumed value of lost productivity per kg overstocked is presented by a series of regressions for cattle and mixed ranches in figure 11. Since the grazer stocking rate of the wildlife ranches was not greater than the carrying capacity, wildlife ranches did not face overstocking charges.

The small sample sizes and the large inter-ranch variability in stocking rate resulted in small correlation coefficients between overstocking costs and value of lost productivity but all F-ratios were significant (C2: $r^2=0.33-0.46$, $P<0.01, n=15$; C4: $r^2=0.06-0.39$, $P<0.01, n=15$; M: $r^2=0.03-0.33$, $P<0.01$ except at 122% carrying capacity $P<0.05, n=13$).

The cost of stocking at the prevailing rates was significantly greater ($P<0.01$) on C2 ranches than the other ranch types at each carrying capacity level. Differences between cattle and mixed ranches in areas with wildlife were not significant. This implies that as rangeland became more susceptible to overstocking, overstocking cost differences between cattle, mixed and wildlife ranches increased.

Effects of overstocking on profit

The effects of deducting overstocking costs from previously estimated financial and economic profits (Kreuter and Workman, submitted) are presented in figure 12a and 12b, to illustrate effects on ranch profitability both under the prevailing and policy-neutral economic environments.
Figure 11. Estimated cost of productivity loss through overstocking at (a) 50% and (b) 100% of the predicted carrying capacity and (c) its upper 95% confidence limit (122%). (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
Figure 12. The effect of estimated overstocking cost on (a) financial and (b) economic profits at 50% and 100% of the predicted carrying capacity and its upper 95% confidence limit (122%). (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
Intercepts of figure 12 are the financial and economic net revenues of each ranch type with zero overstocking cost. Both financial and the economic profits of C2 cattle ranches were greater ($P<0.05$) than those of the other ranch types. None of the other inter-ranch differences were significant.

As productivity loss was increased, cattle ranch profits decreased more rapidly than those from mixed and wildlife ranches. But only when carrying capacity was set at 50% of the predicted value were differences between slopes significant (figure 12, panel 1). Cattle regression slopes (C2 and C4) were greater ($P<0.05$) than those for wildlife. When carrying capacity was set at the predicted value (figure 12, panel 2) and its upper confidence limit (figure 12, panel 3) no slopes were significantly different. Since estimated carrying capacity was similar throughout the area and productivity loss was independent of herbivore type, slope differences are due to stocking rate differences.

Although many slopes differences were not significant, they did produce convergence between cattle and wildlife profits. In figure 12a, C2 ranches were financially more profitable than C4 ranches when overstocking cost nothing but they were equally profitable at Z$0.30 \text{ kg}^{-1} \text{ ha}^{-1}$ overstocked. Cattle ranches became unprofitable at lower productivity losses than mixed or wildlife ranches because they were more overstocked. Table 11 presents the values of lost productivity giving no financial and economic profits.
Table 11. Productivity loss ($Z$ kg\(^{-1}\) ha\(^{-1}\) overstocked) at which financial (F) and economic (E) profits were zero (50%, 100% and 122% of predicted carrying capacity).

<table>
<thead>
<tr>
<th>Ranch Type</th>
<th>50% of CC</th>
<th>100% of CC</th>
<th>122% of CC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>Cattle (C2)</td>
<td>0.20</td>
<td>0.56</td>
<td>0.30</td>
</tr>
<tr>
<td>Cattle (C4)</td>
<td>0.14</td>
<td>0.50</td>
<td>0.27</td>
</tr>
<tr>
<td>Mixed</td>
<td>0.33</td>
<td>1.45</td>
<td>0.82</td>
</tr>
<tr>
<td>Wildlife</td>
<td>1.20</td>
<td>5.96</td>
<td>5.96</td>
</tr>
</tbody>
</table>

Productivity losses rendering C2 and C4 cattle ranches financially or economically unprofitable were similar but were greater for mixed and especially wildlife ranches. Thus cattle ranches seemed to be using biological capital at a greater rate than mixed or wildlife ranches, particularly if the true carrying capacity was only 50% of the predicted value. This implies that as the susceptibility of range productivity to overstocking increased, the probability that ranches remained economically efficient was greater for mixed and especially wildlife ranches than for cattle ranches because wildlife ranches were less dependent on high stocking rates for economic viability.

Kreuter and Workman (submitted) concluded that government policy was negatively affecting the profitability of cattle and wildlife enterprises. However, when loss in productivity increased, negative financial-economic profit differences (production disincentives) decreased as shown in figure 13.
Figure 13. Financial-economic profit disparities at 50% and 100% of predicted carrying capacity and its upper 95% confidence limit (122%). (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
The C2 intercepts were less (P<0.01) than the C4 intercepts which were less (P<0.05) than the wildlife intercepts. This indicates that with no overstocking cost, policy-related production disincentives of cattle producers were greater than those of wildlife ranchers. But as the productivity loss (included in economic profit only) was increased, the production disincentives faced by cattle and wildlife ranchers changed. Since stocking rates of wildlife ranches did not greatly exceed predicted carrying capacity, wildlife producers faced approximately constant production disincentives. By contrast, increasing overstocking costs rapidly reduced differences between financial and economic profits of cattle ranches. The productivity losses at which financial and economic profits were equal are presented in table 12. These results indicate that, on cattle ranches, policy-related production disincentives were increasingly counter balanced by overproduction incentives (generated by not accounting for negative overstocking effects) as range productivity became more susceptible to overstocking.

Table 12. Productivity loss (Z$ kg$^{-1} ha$^{-1}$ overstocked) at which financial and economic profits were equal (50%, 100% and 122% of predicted carrying capacity).

<table>
<thead>
<tr>
<th>Ranch Type</th>
<th>50% of CC</th>
<th>100% of CC</th>
<th>122% of CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (C2)</td>
<td>0.36</td>
<td>0.53</td>
<td>0.66</td>
</tr>
<tr>
<td>Cattle (C4)</td>
<td>0.36</td>
<td>0.71</td>
<td>1.17</td>
</tr>
<tr>
<td>Mixed</td>
<td>0.47</td>
<td>1.18</td>
<td>2.07</td>
</tr>
<tr>
<td>Wildlife</td>
<td>1.87</td>
<td>9.26</td>
<td>70.12</td>
</tr>
</tbody>
</table>
Discussion and Conclusions

In the Midlands, ranches were initially developed for cattle and relatively few range resources have been released for wildlife as indicated by the substantially heavier stocking rate on cattle ranches than on wildlife ranches.

Since inflation exceeded returns from alternative investments during the survey period (Kreuter and Workman submitted), ranchers had a financial incentive to increase capital investments. This together with foot-and-mouth disease related marketing constraints encouraged overstocking in cattle enterprises which can lead to range degradation and consequently generate social costs such as soil erosion, siltation of rivers, and destruction of wildlife habitat. Since wildlife is not owned by landowners, it cannot represent personal wealth. Furthermore, diverse wildlife communities are more important than large numbers of a few species for hunting or photographic safari operations and trophy sizes are generally inversely related to stocking rates. Therefore, wildlife ranchers had less incentive to overstock than cattle producers whose revenue is a function of stocking rates.

Although cattle ranches were financially and economically more profitable than wildlife ranches when overstocking costs were ignored, this advantage decreased when the productivity loss associated with overstocking increased. Depending on the effect of overstocking on range
productivity, cattle ranches might therefore generate less economic profit than financial profit even when profit-suppressing policy interventions are eliminated.

The effect of internalizing overstocking costs on the allocation of range resources between cattle and wildlife enterprises depends upon the susceptibility of rangeland to overstocking. In areas with sparse wildlife, seasonal waterlogging (resulting from impervious substrata of granitic parent material) appears to have restricted encroachment of woody species into grasslands. These areas may be more resilient to overstocking than the four areas with abundant wildlife (where ranchers reported bush encroachment and the associated loss in range productivity to be widespread). The true carrying capacity might therefore be greater than the predicted value. Internalizing overstocking costs might therefore reduce the profitability of C2 cattle ranches less than predicted. Nevertheless, internalizing overstocking costs is likely to decrease cattle profitability more than wildlife profitability because of the dependence of cattle enterprises on greater animal densities.

Economically efficient resource allocation requires that all benefits and costs of production (including production externalities) be internalized and that the discounted future benefits and costs of competing production systems and interventions (such as rangeland reclamation) be
compared. Internalizing the costs of forage use on future rangeland productivity is facilitated by an economic environment where land prices are set by productive capacity rather than speculation on inflationary trends. This is particularly important in semi-arid savannas, such as those of the Zimbabwe Midlands, where unreliable rainfall and scarcity of supplemental irrigation potential restrict the alternatives to extensive range-based production systems. Furthermore, the effectiveness of range rehabilitation is limited particularly when range degradation is well advanced (Walker, 1988).

The conclusions of this study must be tempered by uncertainty concerning both the true carrying capacity and the effects of grazing on future rangeland productivity. Past herbivory trials seldom included multiple species or comprehensively accounted for long-term rainfall variability, nor have they attempted to identify defoliation thresholds for range degradation. Such information is critical for quantifying the future cost of herbivory and the economic efficiency of alternative production systems and thus promote efficient allocation of range resources.
References


COMPARATIVE ADVANTAGE OF CATTLE AND
WILDLIFE RANCHING IN MID-ZIMBABWE

Introduction

This paper compares the economic efficiency of cattle, wildlife, and mixed ranches in the Zimbabwe Midlands.

It has been argued that game ranching can provide greater profits than beef ranching in semi-arid African savannas (Dasmann and Mossman, 1961; Clarke et al., 1985; Hopcraft, 1986; Child, 1988) because multi-species herbivore communities use heterogeneous vegetation more uniformly than cattle alone (Walker, 1979; Taylor and Walker, 1978). But such claims have been based on market prices which do not ensure economically efficient resource allocation because they do not accurately reflect resource scarcity (Monke and Pearson, 1989). No comprehensive empirical analysis has been conducted to compare the financial and economic efficiency of alternative range-based production systems in Africa.

Market prices of outputs and inputs determine an activity’s financial competitiveness under existing government policies and market structures. Such prices include policy effects but exclude production externalities. Overuse of rangeland can represent a production externality when the associated losses of productivity are borne by future users rather than the present users, or when soil erosion and river siltation affect other producers.
Opportunity costs of resources used in an activity indicate its economic efficiency or comparative advantage from the national perspective. Since efficient production dictates equality between the marginal rates of substitution of production factors in all industries (Laylard and Walters, 1978), each factor should be allocated to where it has a comparative advantage. Trade and specialization guided by comparative advantage of production factors benefits all trading partners (Landsburg, 1989).

Comparing profits (the difference between revenue and production costs including capital opportunity costs) of activities may produce ambiguous conclusions about the relative efficiency of resource use because profit does not specify the production factor levels (Monke and Pearson, 1989). This problem can be circumvented by using the private cost ratio (PCR) to compare systems. PCR is the ratio of domestic factor costs (including a normal return on capital) to net revenue (revenue less tradeable input costs) using financial (market) prices. PCR=1 indicates zero financial profit while PCR<1 indicates a financially viable enterprise since net revenue exceeds the cost of domestic factors. Minimizing PCR is equivalent to maximizing private profits.

When production systems are compared for relative efficiency from the national perspective, the domestic resource cost ratio (DRC) is analogous to the PCR. Minimizing DRC is equivalent to maximizing economic profits.
A DRC<1 indicates that the activity is efficient because the country has a comparative advantage since the domestic factor costs are less than the net foreign earnings.

The Zimbabwe Midlands presented a rare opportunity to directly compare the financial and economic efficiency of commercial cattle and wildlife production systems. There is both a long history of cattle ranching and, since 1975, private land owners have had the authority to manage and utilize wildlife on their property.

Methodology

**Analysis matrix**

A modified policy analysis matrix (PAM - see table 13) was used as the framework for determining the private cost ratio (PCR) and the domestic cost ratio (DRC) of each ranch.

Table 13. Modified policy analysis matrix.

<table>
<thead>
<tr>
<th></th>
<th>Revenue (≥ 0)</th>
<th>Tradeable inputs (≤ 0)</th>
<th>Domestic factors (≤ 0)</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial prices</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D (A+B+C)</td>
</tr>
<tr>
<td>Economic prices</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H (E+F+G)</td>
</tr>
<tr>
<td>Externalities</td>
<td></td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Economic profitability</td>
<td></td>
<td></td>
<td>J (G+I)</td>
<td>K (E+F+J)</td>
</tr>
</tbody>
</table>

Private cost ratio  
Domestic resource cost ratio

\[
\text{PCR} = \frac{-C}{A+B} \\
\text{DRC} = \frac{-J}{E+F}
\]
In table 13 revenue, tradeable inputs, and domestic factors of production (land, labor and capital) are separated by column. Only labor and capital were included in the analysis. Excluding land, due to market volatility did not affect the rankings of ranch profits. The cost of capital (fixed, moveable and livestock assets), was assumed to be 10%, the average nominal savings rate during the study. No capital cost was included for wildlife since it is a fluid resource owned by the state and therefore does not represent personal equity.

Profits in column four are the sums of revenues and costs and represent the net returns to management and land. Furthermore, as this was a cross-sectional analysis, adjustments were made to the net revenues of cattle enterprises to account for profit capitalization or capital liquidation through changes in the livestock inventory. Such adjustments were not made in wildlife enterprises because population fluctuations were as likely to have been due to migration as actual population changes. Only 20% of the wildlife purchase costs were included because breeding stock purchases were irregular and associated benefits were assumed to accrue over five years.

In table 13, the first row represents revenues, costs and profits in actual market prices. Market values of outputs and all production inputs were obtained through personal interviews using a standardized questionnaire from
the 1989/90 financial records of the ranches surveyed. The PCR (financial efficiency) of each ranch was estimated from the parameters in row 1, table 13 as defined in row five.

The second row provides hypothetical economic (policy neutral) prices of the same output and input components of production. Since world prices may approximate economic prices of tradeable commodities (Monke and Pearson 1989), economic price estimates were obtained from free-on-board export prices, cost-insurance-freight import prices, and free-market exchange rates as described by Kreuter and Workman (submitted). By contrast, the economic prices of domestic factors were valued at their domestic opportunity cost, the value of the factor in its next best use, since domestic factor prices are determined mainly in domestic markets (Monke and Pearson, 1989). Differences between financial and economic prices represent estimated policy effects (Kreuter and Workman, submitted).

Policy-neutral economic prices represented in row two are insufficient to guarantee efficient resource use because they do not account for the costs of foregone future production. In semi-arid savanna production systems, overstocking can lead to decreased future range productivity (Walker, 1976; Walker et al., 1981). Since vegetation is a domestic production factor, the cost of overstocking is represented by column three of row three. But quantifying herbivory effects on semi-arid savannas is problematic
because biotic and abiotic interactions occur intermittently (Walker, 1988; Westoby et al., 1989). A method for comparing the overstocking costs in the study’s four ranch categories was described by Kreuter and Workman (in preparation).

Economic profitability which excludes policy effects but includes overstocking costs is represented in the last column of the fourth row. The DRC (economic efficiency) of each ranch was therefore estimated by combining the cells of row two and three as defined at the bottom of table 13.

A limitation of the PAM approach is that the accounting indices in the matrix are average parameters. This theoretically renders the PAM inappropriate for assessing economic efficiency, which is defined by the equality of value of marginal products (Masters, 1989). However, in agriculture, where there are many producers with relatively constant short-term returns to scale, marginal costs and returns can be approximated by average prices.

Data analyses

The absolute values of the opportunity cost of capital, overvaluation of the Zimbabwe dollar (Z$), the financial/economic price ratio for cattle revenue, and the opportunity cost of overstocking were uncertain. A sensitivity analysis was therefore used to determine the effects of changing the value of each parameter on the financial and economic efficiency of each ranching operation included in the study.
The inevitably small sample size of each ranch category and differences in sample variances required the use of non-parametric statistics to analyze the data. Differences were considered statistically significant at P<0.10. Tests used to compare sample means were the Wilcoxon matched pair, the Mann-Whitney two sample and the Kruskal-Wallis tests (Hollander and Wolfe, 1973). Differences between pairs of regressions, generated to determine the increasing cost of overstocking, were analyzed with the abridged Chow test using dummy variables (Gudjarati, 1988).

**Data presentation**

Financial and economic efficiency (estimated by PCR and DRC) are represented by frequency distributions and sample means. The frequency distribution categories used were 0-1, 1-2, 2-5, and >5 or <0. These represent efficient, nearly efficient, inefficient and highly inefficient ranches, respectively. Since the relationship between PCR or DRC and tradeable input costs is a rectangular hyperbola, ranches whose tradeable input costs approximated their revenue (i.e., near zero net revenue) greatly skewed the PCR and DRC distributions. To statistically test differences between ranch categories, negative values and outliers beyond the 95th percentile were therefore excluded from the analysis.
Results

Results are presented in two parts: (1) economic efficiency excluding overstocking costs, using two capital interest rates, two Z$ exchange rates, and two cattle-revenue price ratios; (2) sensitivity analysis of costs of overstocking on the economic efficiency using fixed capital interest, Z$ overvaluation, and cattle-revenue price ratio.

Efficiency excluding overstocking

Capital opportunity costs of 0% and 10% were used. The first rate excluded interest on capital from efficiency estimates while the second rate was the average nominal savings rate during the period of the study.

The Z$ overvaluation rates used were 50% and 100%. The second rate was the excess of the black-market rate over the official exchange rate including the risk premium. The first rate excluded an assumed 50% risk premium from the black-market rate and provided an estimate of the free-market exchange rate. Since PCR is unaffected by this parameter, only the effects on DRC are discussed.

Ratios used to convert cattle revenues from financial to economic prices were 1.25 and 1.35. The 1.25 factor, which represents a 25% tax on beef-producer prices, was obtained from the national beef sales realization/producer price ratio weighted for export and local sales in 1990. The 1.35 conversion was obtained from the same data except
that the full European Community export quota was used to eliminate the effects of 1989/90 foot-and-mouth disease epidemic on exports. DRC but not PCR is affected by the cattle-revenue conversion, so only the DRC’s are presented.

The impact of the capital opportunity cost on the financial and economic efficiency of ranches, assuming 50% Z$ overvaluation and 25% implicit tax on cattle revenue, is presented in figure 14. Panels (a) and (b) represent the PCR distribution using 0% and 10% capital interest, respectively, while panels (c) and (d) represent the DRC distribution using the same capital interest rates.

Financial efficiency

Most operations were financially efficient (0<PCR<1) when capital opportunity costs were not charged. The lowest proportion of efficiency occurred among wildlife ranches (71.4%, 5 ranches). The frequency of financially highly inefficient ranches (0>PCR>5) was less than 15% in all ranch categories. With the inclusion of 10% interest on capital, the financial efficiency of all ranches, but particularly cattle ranches, was reduced. Only one C2 cattle ranch still had a 0<PCR<1 but 43% (3) wildlife and 31% (4) mixed ranches remained financially efficient. The greater effect of including capital interest on cattle than on mixed and particularly on wildlife ranches is due to the greater capital requirement for cattle ranches.
Figure 14. Frequency distributions of financial efficiency (PCR) and economic efficiency (DRC) using 0% [(a) and (c), respectively] and 10% [(b) and (d), respectively] capital opportunity cost, and four frequency categories (0-1, 1-2, 2-5, and >5<0). (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
Economic efficiency

More ranches were economically than financially efficient. In excess of 80% of ranches in each category were economically efficient when no opportunity cost was charged for capital. When 10% interest on capital was used the proportion of economically efficient ranches decreased. Whereas only one cattle ranch was financially efficient, 67% of C2 and 47% of C4 cattle ranches were economically efficient compared with 71% of wildlife and 62% of mixed ranches. This was because government policy negatively affected cattle revenue to a greater degree than wildlife revenue or input cost (Kreuter and Workman, submitted).

Figure 15 illustrates the effects of varying the Z$ overvaluation rate and the cattle-revenue conversion factor on economic efficiency estimates. The upper panels represent the frequency distributions and the lower panels the corresponding average DRC (excluding outliers).

Figure 15, panel (a) is identical to figure 14, panel (d) and shows that 67%, 47%, 71%, and 62% of C2, C4, wildlife and mixed ranches, respectively, were economically efficient when 10% capital interest, 50% Z$ overvaluation and 25% taxation on cattle revenue were specified. The corresponding mean DRC’s (figure 15, panel d) were not significantly different from 1.0 and only the DRC’s of C4 and wildlife ranches were significantly different (P<0.10). Statistically no ranch type was economically inefficient.
When the Z$ overvaluation was increased from 50% to 100% (i.e., the real exchange rate was assumed to equal the black-market rate), (panels b and e), the proportion of economically efficient cattle ranches increased (C2 from 67% (10) to 87% (13); C4 from 47% (7) to 73% (11)). The number of economically efficient wildlife ranches remained the same while there was little change among mixed ranches. All corresponding DRC's were less than one (C2 ranches P<0.01; wildlife and mixed ranches P<0.05) but the DRC of C4 ranches was significantly greater (P<0.10) than wildlife ranches.

The decrease between corresponding DRC's in figure 15 panels (d) and (e) was significant (wildlife P<0.05, others P<0.01) but greater (P<0.05) among cattle than wildlife ranches. This implies that as overvaluation of the Z$ increases, the disparity between the estimated economic efficiency of cattle and wildlife producers decreases. In general overvalued currencies create implicit taxes on exports and subsidies on imports (Monke and Pearson, 1989). However, converting financial to economic prices affected cattle revenue to a greater extent than wildlife revenue or input costs (Kreuter and Workman, submitted).

Increasing the cattle-revenue conversion factor from 1.25 to 1.34 (to eliminate the effects of export constraints due to foot-and-mouth disease), while maintaining capital interest and Z$ overvaluation at 10% and 50%, respectively, resulted in a significant (P<0.01) increase in the economic
Figure 15. Frequency distribution (panels a-c) and mean value of estimated economic efficiency (panels d-f) using a 10% capital interest (i), 50% and 100% Z$ overvaluation rates (f), and 1.25 and 1.34 cattle-revenue conversion factor (c). (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
efficiency of cattle (C2 more (P<0.05) than C4) and mixed ranches (panels c and f). The average DRC of C4 ranches was slightly greater than 1.0 while those of the other ranch types were less than 1.0. C2 ranches were economically more efficient (P<0.05) than C4 ranches. These results imply that the government policy of taxing beef producers to subsidize low-income urban meat consumers and the veterinary constraints on beef exports negatively impacted the financial efficiency of cattle ranches particularly those in the C2 category.

**Efficiency including overstocking**

The following values were specified in the sensitivity analysis of overstocking costs: (1) capital opportunity cost = 10%, (2) Z$ overvaluation rate = 50%, (3) cattle-revenue price ratio = 1.25. The carrying capacity for herbivore communities in the Midlands was predicted by Kreuter and Workman (in preparation), using a modification of the Coe, Cumming and Phillipson (1976) model. Because of uncertainty about rangeland sensitivity to overstocking, values of lost productivity ranging from Z$0.00 to Z$0.50 kg\(^{-1}\) of herbivore overstocked were used.

The effects of increasing the cost of overstocking on the economic efficiency (DRC) of each ranch category are presented in figure 16. The intercept values are identical to the mean DRC’s in figure 15 panel (d). As previously stated, the only significant difference (P<0.10) is between
Figure 16. Effect of increasing the cost of overstocking on the mean economic efficiency (DRC) of four ranch categories. (C2 and C4 are cattle ranches in areas with sparse and abundant wildlife, respectively).
the C2 cattle and wildlife ranch intercepts. Due to the small sample sizes and the large variability within samples only the C2 slope was significantly positive (P<0.01) but none of the slopes of the regressions were statistically different. Thus no concrete conclusions can be drawn about the effects of stocking rate differences on the economic efficiency of the four ranch categories.

Although statistically insignificant, variations among the four regressions suggest that cattle ranches (especially C4 ranches) are more likely to be economically inefficient than mixed and particularly wildlife ranches when costs are charged for overstocking and if rangeland productivity in the Midlands is sensitive to overstocking. This is because stocking rates on wildlife ranches were lower (P<0.05) than on cattle ranches (Kreuter and Workman, in preparation).

Discussion and Conclusions

Few ranches were financially efficient when a 10% capital interest rate was specified. However, the prevailing rate of inflation was greater than the controlled savings rates (Kreuter and Workman, submitted). In real terms capital investments therefore probably represented a hedge against inflation and not a liability so ranchers had a financial incentive to overstock with cattle. While cattle investments can be capitalized by ranchers, wildlife does not represent personal wealth, thus there was no incentive
to overstock with wildlife. However, wildlife presented an opportunity to earn foreign currency directly and, with restricted access to foreign currency, this generated an incentive to utilize the wildlife resource. Since there is a trade-off between increasing cattle stocking rates, as a hedge against inflation, and increasing foreign currency earnings by promoting wildlife populations, ranchers faced conflicting financial incentives. Both cattle and wildlife enterprises faced risks because beef production was constrained by veterinary-related marketing regulations and revenue from wildlife was dependent on socio-political stability. Where wildlife was abundant, mixed ranching operations provided opportunities to hedge against inflation through capital investments in livestock, generate foreign currency earnings, and spread risk.

While few ranches were financially efficient, the majority of C2, wildlife and mixed ranches were economically efficient. The financial-economic efficiency differences were magnified in all operations (especially cattle enterprises) by higher Z$ overvaluation rates and higher cattle-revenue conversion factors. Without charging overstocking costs, beef cattle production (in areas with sparse wildlife) and mixed and wildlife operations (in areas with abundant wildlife) would have a comparative advantage in a policy-neutral environment and would not require government subsidies for survival. However, prevailing
government policy provided production disincentives and did not enhance economically efficient range use.

The same conclusions might not be reached when the possible cost of overstocking is included. Regressions relating economic efficiency and overstocking costs did not differ significantly despite large stocking rate differences among the four ranch categories. Nevertheless, with increasing sensitivity of rangeland productivity to overstocking, the probability of economic inefficiency appeared to be greater for cattle ranches (particularly those in areas without wildlife) than mixed or wildlife ranches. This supports the contention that in the areas with abundant wildlife, cattle-only operations are likely to be economically inefficient.

Since this was a cross-sectional rather than a time-series study, the preceding conclusions do not include discounted future benefits and costs of potential range rehabilitation nor alternative production systems. However, reduced vegetation production trends in semi-arid savannas may not be readily reversed (Walker, 1988) and production intensification is limited by erratic precipitation patterns. Thus there are few alternatives to extensive cattle and wildlife production systems and confidence can be placed on the general applicability of the conclusions.

In a parallel study in southern and western Zimbabwe it was concluded that cattle, wildlife and mixed ranches may
each have a comparative advantage depending on management, source of revenue, and policy effects on individual producers (Jansen et al., 1992). This study indicates that, if promoting production systems with a comparative advantage enhances human welfare among trading partners, then cattle ranches in areas with sparse wildlife and mixed and wildlife ranches in areas with abundant wildlife should, on average, be promoted in the Zimbabwe Midlands. This does not support earlier claims that game ranching is generally superior to beef ranching in semi-arid African savannas.
References


SUMMARY AND CONCLUSION

The economics of commercial ranches in the Zimbabwe Midlands, which generated income from cattle, or wildlife, or both, were compared during 1989/90 to test the claim that wildlife ranching generates greater profits than cattle ranching on semi-arid African savannas. Financial (market) prices and estimated economic prices (opportunity cost) for inputs and outputs were used to test four hypotheses: (1) Ranch financial profits were the same; (2) Government policy effects on ranch profits were the same; (3) There were no inter-ranch differences in overstocking costs; (4) There were no inter-ranch differences in the economic efficiency.

A survey of independent ranches exceeding 1,200 ha in area was conducted. Data were obtained through personal interviews using a standardized survey questionnaire from 15 cattle, 7 wildlife and 13 mixed ranches in four contiguous areas with abundant wildlife and from 15 cattle ranches in two separate areas with sparse wildlife. Data to convert financial to economic prices were obtained from official sources. Results of the study are presented in four papers.

In the first paper, the gross revenues, costs, net revenues (adjusted for changes in cattle herd sizes), and capital investments associated with each ranch type were compared. Cattle enterprises derived revenue primarily from the sale of beef cattle and wildlife enterprises from the sale of hunting opportunities to foreign clients.
Under the prevailing economic conditions, cattle ranches in the areas with sparse wildlife provided the greatest net revenues per ha (due to greater grass cover) while only mixed ranches were financially profitable in areas with abundant wildlife. In the latter areas cattle ranches were surviving financially by living off depreciation or liquidating their livestock assets while wildlife ranches were surviving financially by deriving revenue from external wildlife sources or by living off depreciation. Since wildlife ranches had the least capital investments, they may have presented less of an investment risk in an uncertain economic climate while at the same time providing an opportunity to earn foreign currency.

In the second paper a policy analysis matrix was used to compare the financial and economic profitability of cattle, wildlife and mixed ranches. Border price estimates were used as proxies for policy-neutral (economic) prices of tradeable commodities and opportunity costs were estimated for domestic production factors. Sensitivity analyses were used to determine the effects of changing the capital opportunity cost, the Z$ overvaluation rate and the cattle-revenue conversion ratio on economic profitability.

Cattle ranches in areas with sparse wildlife were estimated to be most profitable when the government policy effects (such as implicit taxes on beef-producer prices, high interest and inflation rates, and overvalued currency)
were removed. In the areas with wildlife, differences between the economic profits of cattle, wildlife and mixed ranches were generally not statistically significant. When access to extra-ranch wildlife resources was eliminated, changing from purely cattle to purely wildlife ranching did therefore not appear to be economically rational. Mixed ranching provided at least equivalent economic profits to cattle ranches while at the same time spreading operational risks by providing two income sources. Financial-economic profitability differences showed that all ranch types were negatively affected by policy interventions but that these effects were greatest for cattle ranches. Thus all producers faced production disincentives and the Zimbabwe government’s objectives of maximizing net foreign currency earnings and providing sufficient protein for an expanding population were not being realized in the Midlands.

In the third paper an attempt was made to quantify the cost of lost rangeland productivity due to overstocking. Carrying capacities, based on mean annual precipitation, and the stocking rates of cattle and the grazing fraction of wild herbivores were estimated. Since the productivity loss due to stocking above carrying capacity was uncertain, a sensitivity analysis was conducted to determine the effects of various overstocking costs on ranch profitability.

The financial incentives for cattle ranchers to retain stock during inflationary periods and the restrictions on
cattle sales, due to the foot-and-mouth disease epidemic, resulted in considerable overstocking in cattle enterprises. Wildlife ranchers had less incentive to overstock since species diversity was more important for safari operations than large numbers of a few species. As a result of these differences, the larger economic profitability of cattle versus wildlife ranches decreased when productivity loss associated with overstocking increased.

The last paper compared the relative efficiencies of cattle, wildlife and mixed ranches both from the private perspective (financial efficiency, measured by the private cost ratio: PCR) and from the national perspective (comparative advantage, measured by the domestic resource cost ratio: DRC). The PCR included policy effects but excluded overstocking costs while the DRC excluded estimated policy effects and was calculated both with and without estimated overstocking costs. A sensitivity analysis was used to determine the effects of changing the capital opportunity cost, the Z$ overvaluation factor and the cattle-revenue conversion ratio on DRC estimates.

While few ranches were financially efficient, when overstocking costs were not charged, beef cattle production (in areas with sparse wildlife) and mixed and wildlife operations (in areas with abundant wildlife) were found to be economically efficient. But this conclusion did not necessarily hold when overstocking costs were included. With
With increasing sensitivity of rangeland productivity to overstocking, the probability of economic inefficiency increased more for cattle ranches than mixed or wildlife ranches. This supports the contention that in the areas with abundant wildlife, cattle-only operations are unlikely to be economically efficient.

In conclusion, this study did not support the claim that wildlife generates greater profits than cattle ranching in semi-arid African savannas. Profitability of range-based production systems was area specific depending on vegetation composition, carrying capacity and management capability.

However, these conclusions must be tempered with uncertainty concerning both the true carrying capacity and the effects of grazing on future rangeland productivity in the Midlands. Furthermore, since this was a cross-sectional rather than a time-series study, discounted future benefits and costs of potential range rehabilitation were not included. Thus the study has limited predictive power due to seasonal changes in both rangeland productivity and the profitability of range-based production systems. It is therefore strongly recommended that estimates of carrying capacities be rigorously determined and that both changes in range productivity and operational profitability be monitored over time. Furthermore, if government intervention continues, the potential economic efficiency of cattle and wildlife enterprises will not be realized.
APPENDICES
Appendix A

Scientific Names of Wildlife Occurring in the Zimbabwe Midlands
Table A1. Names used in text and common and scientific names of wild animals in the Zimbabwe Midlands by fauna family.

<table>
<thead>
<tr>
<th>Text name</th>
<th>Common name</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elephantidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elephant</td>
<td>African elephant</td>
<td>Loxodonta africana</td>
</tr>
<tr>
<td><strong>Rhinocerotidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rhino</td>
<td>Black rhinoceros</td>
<td>Diceros bicornis</td>
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<td></td>
<td>White rhinoceros</td>
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<td><strong>Hippopotamidae</strong></td>
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<td></td>
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<td>Hippo</td>
<td>Hippopotamus</td>
<td>Hippopotamus amphibius</td>
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<tr>
<td><strong>Giraffidae</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giraffe</td>
<td>Giraffe</td>
<td>Giraffa camelopardalis</td>
</tr>
<tr>
<td><strong>Bovidae</strong></td>
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<td></td>
</tr>
<tr>
<td>Buffalo</td>
<td>African buffalo</td>
<td>Syncerus caffer</td>
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<tr>
<td>Bushbuck</td>
<td>Bushbuck</td>
<td>Tragelaphus scriptus</td>
</tr>
<tr>
<td>Duiker</td>
<td>Common duiker</td>
<td>Sylvicapra grimmia</td>
</tr>
<tr>
<td>Eland</td>
<td>Eland</td>
<td>Taurotragus oryx</td>
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<tr>
<td>Grysbok</td>
<td>Grysbok</td>
<td>Raphicerus melanotis</td>
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<td>Impala</td>
<td>Impala</td>
<td>Aepyceros melampus</td>
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<td>Oribi</td>
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<tr>
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<td>Reedbuck</td>
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<tr>
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<td>Tsessebe</td>
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<td>Waterbuck</td>
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<td>Bushpig</td>
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<td><strong>Cercopithecidae</strong></td>
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<td>Papio ursinus</td>
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<td><strong>Felidae</strong></td>
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<td></td>
</tr>
<tr>
<td>Leopard</td>
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<td>Cheetah</td>
<td>Acinonyx jubatus</td>
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<tr>
<td><strong>Hyaenidae</strong></td>
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<td>Hyaena</td>
<td>Spotted hyaena</td>
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<tr>
<td><strong>Canidae</strong></td>
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<td></td>
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<td>Jackal</td>
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<td><strong>Crocodilidae</strong></td>
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<tr>
<td>Crocodile</td>
<td>Nile crocodile</td>
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Appendix B

Survey Questionnaire
PART A: DESCRIPTIVE INFORMATION

GENERAL INFORMATION

A101 Ranch name(s) ___________________________

A102 Company name(s) ___________________________

A103 Owner/operator name ___________________________

A104 Manager ___________________________

A105 Interviewee(s) ___________________________

A106 District/ICA ___________________________

A107 Mailing address ___________________________

A108 Telephones (_____) (_____) ___________________________

A109 Financial year begin ______ end ______

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<th>Question</th>
<th>Description</th>
<th>Options</th>
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<tr>
<td>Q1</td>
<td>How long have you been ranching here?</td>
<td>___________________________</td>
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<tr>
<td>Q2</td>
<td>What do you do on your ranch?</td>
<td>___________________________</td>
</tr>
<tr>
<td>Q3</td>
<td>From what do you earn most of your money?</td>
<td>___________________________</td>
</tr>
<tr>
<td>Q4</td>
<td>What are your plans for the future?</td>
<td>___________________________</td>
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<th>Description</th>
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<td>Total area ranch unit</td>
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<td>A202</td>
<td>Arable total</td>
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<td>A203</td>
<td>Veld/animals total</td>
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<td>A204</td>
<td>Other</td>
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Comments ___________________________
ENVIRONMENT

Q5 WHAT HAS BEEN THE AVERAGE RAINFALL IN THE LAST 10 TO 20 YEARS?
A301 Precipitation
1 mm years
2 mm years

Q6 WHAT NATURAL REGION ARE YOU IN?
A302 Natural region(s)

Q7 WHAT KINDS OF SOIL DO YOU HAVE?
A303 Soils
1 Sandy
2 Sandy loams
3 Clay loams (red)
4 Basaltic clays (black)
5 Rocky (<150mm/6")
6 Saline
7 Other

Q8 WHAT KIND OF VEGETATION DO YOU HAVE?
A304 Vegetation
1 Brachystegia woodland
2 mopane woodland
3 Acacia domin. savanna
4 Combretum/acacia
5 Kalahari savanna
6 Jesse bush
7 Alluvial savanna
8 Vleis
9 Rock outcrops
10 Other

Q9 WHAT CONDITION DO YOU THINK YOUR VELD IS IN?
A305 Veld condition (ask and assess)
1 Grass cover
2 Litter cover
3 Bush encroach.
4 Sheet erosion
5 Gully erosion

Q10 DO YOU THINK THAT VELD CONDITION AFFECTS YOUR PROFITS?
A307

CATTLE SYSTEM

Q11 DO YOU HAVE BEEF CATTLE?
Q12 IF NOT WHY NOT? (Go to Q21)

Q13 WHAT BREEDS AND CROSSES DO YOU HAVE?
A401 Main breeds/crosses
1 2 3

Q14 HOW WOULD YOU DESCRIBE YOUR PRODUCTION SYSTEM(S)?
A402

Circle production system(s) Head or % Comment
1 Breeding/slaughter/veld @ ... yr
2 Breeding/pen finished @ ... yr
3 Breeding/sale weaners
4 Breeding/sale ... yr feeders
5 Purchase weaners/pen finishing
6 Purchase ... yr feeders/pen fin.
7 Stud breeding
8 Speculative buying/selling
9 Other

Q15 WHAT ARE YOUR BREEDING AND CALVING SYSTEMS AND PRACTICES?
A403

Breeding/calving systems Season (mths/days) /comment
1 All year
2 Summer breeding/spring calving
3 Winter breeding/autumn calving
4 Early heifer breeding

Breeding practices

Q16 WHAT IS YOUR CALVING RATE?
A404 Calves/ mature cows + heifers bred
Q17 HOW MANY CATTLE AND WHAT KIND OF GRAZING SYSTEMS DO YOU HAVE?

A405 Cattle numbers total

<table>
<thead>
<tr>
<th>Tot. head</th>
<th># herds</th>
<th>Head/herd</th>
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</thead>
</table>

A406 Grazing systems

<table>
<thead>
<tr>
<th>Number paddocks/herd</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4-5</th>
<th>6-7</th>
<th>8+</th>
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</thead>
<tbody>
<tr>
<td>Number of each type</td>
<td></td>
<td></td>
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<tr>
<td>Average paddock size</td>
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Q18 WHAT IS YOUR STOCKING RATE AND HOW DO YOU DECIDE ON IT?

A407 Actual stocking rate

<table>
<thead>
<tr>
<th>ha/head</th>
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</table>

2 Recommended stocking rate

3 Selection criteria

Q19 HOW DO YOU MARKET YOUR CATTLE?

A408 Circle markets used

<table>
<thead>
<tr>
<th>Head or %</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 On ranch</td>
<td></td>
</tr>
<tr>
<td>2 Cold Storage Comm.</td>
<td></td>
</tr>
<tr>
<td>3 Private abattoirs</td>
<td></td>
</tr>
<tr>
<td>4 Live sales</td>
<td></td>
</tr>
<tr>
<td>5 Other</td>
<td></td>
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</table>

Q20 WHAT IS YOUR OPINION ON CURRENT CATTLE MARKETING ARRANGEMENTS?

A409

General comments on cattle

WILDLIFE SYSTEM

Q21 DO YOU HAVE ANY GAME?

Q22 IF NOT WHY NOT? (Go to Q33)

A501

Reason for wildlife

<table>
<thead>
<tr>
<th>Major/minor/nill/negative/uncert Rank</th>
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<tbody>
<tr>
<td>1 None</td>
</tr>
<tr>
<td>2 Aesthetic</td>
</tr>
<tr>
<td>3 Ecological</td>
</tr>
<tr>
<td>4 Personal hunting</td>
</tr>
<tr>
<td>5 Economic</td>
</tr>
<tr>
<td>6 Other</td>
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</table>

If yes: Maj/min/since If no: planned

A502 Sources of revenue

<table>
<thead>
<tr>
<th>Safari hunting</th>
<th>Non-consumptive safari</th>
<th>Meat sales</th>
<th>Hide sales</th>
<th>Live animal sales</th>
<th>Lease game user rights</th>
<th>Other</th>
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Q23 WHAT ROLE DOES GAME PLAY ON YOUR RANCH?

A503 Hunting

<table>
<thead>
<tr>
<th>Campsite</th>
<th>Camp</th>
<th>Board</th>
<th>Guides</th>
<th>Vehicles</th>
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</thead>
<tbody>
<tr>
<td>Number</td>
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<tr>
<td>Comment</td>
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</table>

A504 Non-consumptive

<table>
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<tr>
<th>Campsite</th>
<th>Camp</th>
<th>Board</th>
<th>Guides</th>
<th>Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
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<tr>
<td>Comment</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Q25 WHAT TYPES OF HUNTING ARE PROVIDED ON YOUR RANCH?
A505 Type hunting safaris
1 Plains game
2 Lion/leopard
3 Buffalo
4 Big game
5 Other

Q26 HOW DO YOU PROVIDE HUNTING OPPORTUNITIES?
A506 Provide hunts through/to:
1 Own safari operation
2 Self catering clubs
3 Concessionaires
4 Other

Q27 IF YOU HAVE YOUR OWN OPERATION, WHAT AREAS DO YOU USE?
A507 Areas used for safaris
1 Owned private land
2 Leased private land
3 Communal land
4 State land

Q28 HOW DO YOU MARKET YOUR HUNTING AND NON-CONSUMPTIVE SAFARIS?
A508 Advertising
1 Word of mouth
2 Commodity assoc.
3 Local/internat. agent
4 Newspaper/magazines
5 Own brochures
6 Other

A509 Market(s) used
1 Zimbabwe
2 South Africa
3 Europe
4 North America
5 Other

Q29 WHAT PROBLEMS DO YOU HAVE MARKETING SAFARIS?
A510

Q30 WHAT DO YOU THINK OF THE FUTURE OF THE SAFARI INDUSTRY?
A511

Q31 TO WHOM DO YOU SELL LIVE ANIMALS, MEAT AND HIDES AND WHAT PROBLEMS DO YOU FACE?
A512 Live animals

A513 Game meat

A514 Game hides

Q32 WHAT GAME MANAGEMENT DO YOU PRACTICE?
A515 Census animals
1 Casual counts
2 Spot counts
3 Strip counts
4 Sex/age ratios
5 Other

A516 Adjustment animal numbers
1 Adjust trophy sales
2 Culling/contractor
3 Other

A517 General comments on wildlife

YEARLONG/BEFORE HUNTING SEASON

OTHER
### COMMON MANAGEMENT PRACTICES

**Q33 HOW DO YOU MANAGE YOUR VEGETATION?**

<table>
<thead>
<tr>
<th>A601 Management practice</th>
<th>Cattle</th>
<th>Game</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Perimeter fencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Internal fencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Estimate forage avail.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Veld burning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Bush eradication</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Other</td>
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</table>

**Q34 WHAT WATERING FACILITIES DO YOU HAVE?**

<table>
<thead>
<tr>
<th>A602 Watering facilities</th>
<th>Cattle</th>
<th>Game</th>
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<tbody>
<tr>
<td>1 Natural sources</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Dams/weirs/canals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Boreholes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 Watering points</td>
<td></td>
<td></td>
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<tr>
<td>5 Ave. distance to water</td>
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</table>

**Q35 WHAT TYPE OF SUPPLEMENTARY FEEDING DO YOU DO?**

<table>
<thead>
<tr>
<th>A603 Type feeding</th>
<th>Cattle</th>
<th>Game</th>
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<tbody>
<tr>
<td>1 Protein supplements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Salt licks</td>
<td></td>
<td></td>
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<tr>
<td>3 Fodder</td>
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</table>

**Q36 WHAT TYPE OF DISEASE AND PARASITE CONTROLS DO YOU USE?**

<table>
<thead>
<tr>
<th>A604</th>
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<tbody>
<tr>
<td>Botulism.(BL)</td>
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<tr>
<td>Brucellosis.(CA)</td>
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<tr>
<td>Heartwater.(HW)</td>
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<tr>
<td>Lumpyskin(LS)</td>
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<tr>
<td>Quarter-evil.(QE)</td>
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<tr>
<td>Rift-Valley-Fever.(RVF)</td>
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</tr>
<tr>
<td>Vibrio/lepto.(VL)</td>
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</table>

**Q37 DO YOU HAVE PREDATOR PROBLEMS AND DO YOU CONTROL PREDATORS?**

<table>
<thead>
<tr>
<th>A605</th>
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</table>

**Q38 WHAT STOCK THEFT AND POACHING PROBLEMS DO YOU HAVE?**

<table>
<thead>
<tr>
<th>A606</th>
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<tbody>
<tr>
<td>(Quantity/value)</td>
</tr>
<tr>
<td>1 Theft/poaching</td>
</tr>
<tr>
<td>2 Control measures</td>
</tr>
<tr>
<td>1 Foot patrols</td>
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<tr>
<td>2 Vehicle patrols</td>
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### Part B: Financial and Statistical Information

#### B1 Domestic Livestock Reconciliation Statement

<table>
<thead>
<tr>
<th>Type</th>
<th>Ave Mass</th>
<th>Open Stock</th>
<th>Purch # / $</th>
<th>Sales # / $</th>
<th>Farm Use</th>
<th>Birth</th>
<th>Death/lose</th>
<th>Re-class</th>
<th>Close Stock</th>
</tr>
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<tbody>
<tr>
<td><strong>Females</strong></td>
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<td>1-2 year</td>
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<td><strong>Small Total</strong></td>
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</table>

### Q39 Can You Provide Your Total Stock Counts for Previous Years?

<table>
<thead>
<tr>
<th>Year</th>
<th>Number</th>
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</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

### Q40 Could You Provide Accurate Details of Cattle Breeding Performance?

<table>
<thead>
<tr>
<th>Indicator Description</th>
<th>Number Cattle</th>
<th>Cows</th>
<th>Heifers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Females bulled last year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calves produced/weaned</td>
<td>/</td>
<td>/</td>
<td>/</td>
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</tbody>
</table>

### Q41 What Domestic Stock Were Not Fed Directly Off Your Own Veld?

<table>
<thead>
<tr>
<th>Class of Livestock</th>
<th>Number Cattle</th>
<th>Days</th>
</tr>
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<tbody>
<tr>
<td>Pen Feeding</td>
<td></td>
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<tr>
<td>Leased Grazing</td>
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</table>

### B2 Income from Livestock

#### Q42 Do You Have Sales Sheets?

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
<th>Mass live</th>
<th>CDM</th>
<th>Price $/kg live</th>
<th>CDM</th>
<th>Income</th>
<th>Market</th>
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</thead>
<tbody>
<tr>
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<td><strong>Subtotal</strong></td>
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<td>Other income from beef cattle</td>
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<tr>
<td><strong>Total Cattle Revenue</strong></td>
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<td>Sheep</td>
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<tr>
<td>Goats</td>
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<td>Other</td>
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<td><strong>Total Revenue from Livestock</strong></td>
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<tr>
<td>Species</td>
<td>Numbers</td>
<td>Trend</td>
<td>Live Anim Purch</td>
<td>Live Anim Sold</td>
<td>Trophy On R.</td>
<td>Trophy Off R.</td>
<td>Non-Trophy</td>
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<td>Grysbok</td>
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</tbody>
</table>
### B3b WILDLIFE NUMBERS - BIG GAME, CARNIVORES, PROTECTED ANTELOPE, OTHER

<table>
<thead>
<tr>
<th>Species</th>
<th>Numbers</th>
<th>Trend</th>
<th>Live Anim Purch</th>
<th>Live Anim Sold</th>
<th>Trophy On R.</th>
<th>Trophy Off R.</th>
<th>Non-Trophy</th>
<th>Average Hide Price</th>
<th>Average Meat Price</th>
<th>Comments</th>
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<tbody>
<tr>
<td></td>
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## B4 Wildlife Income (On and Off Ranch)

### 1 Hunting Safaris

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<th>Days</th>
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### 2 Non-Consumptive Safaris

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<td>Type</td>
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### 3 Other sources of income from wildlife

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<tr>
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<tr>
<td>Lease of hunting camp</td>
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<tr>
<td>Sale of trophy animals</td>
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<td>Sale of live game</td>
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<td>Meat sales</td>
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<td>Sale of processed products and hides</td>
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**TOTAL INCOME FROM WILDLIFE (sum B4 1,2,3)**

## B5 Direct Costs (All Operations)

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<td>Veterinary/dips</td>
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<td><strong>TOTAL COSTS</strong></td>
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## B6 Inventory Adjustment

**Q43 What did you use this year not in costs, what did you buy but not use?**

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## Ranch Overheads

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<td>Other</td>
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<td>Repairs, maintenance</td>
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### Financial:

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### Consumables goods:

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### TOTAL

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Comment:

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156
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<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL CAPITAL ASSETS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Domestic livestock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildlife</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL LIVESTOCK ASSETS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

Life Times Used for Calculating Straight-Line Depreciation of Capital Assets
Table C1. Life times assumed for capital items to calculate straight-line depreciation.

<table>
<thead>
<tr>
<th>Capital item</th>
<th>Life time (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed assets</strong></td>
<td></td>
</tr>
<tr>
<td>Structures:</td>
<td></td>
</tr>
<tr>
<td>1. Management housing</td>
<td>40</td>
</tr>
<tr>
<td>2. Labor housing</td>
<td>30</td>
</tr>
<tr>
<td>3. Other ranch buildings</td>
<td>30</td>
</tr>
<tr>
<td>4. Handling facilities and dips</td>
<td>20</td>
</tr>
<tr>
<td>5. Safari camp</td>
<td>15</td>
</tr>
<tr>
<td>Fencing:</td>
<td></td>
</tr>
<tr>
<td>6. Cattle and game fences</td>
<td>25</td>
</tr>
<tr>
<td>7. Electrical fences</td>
<td>15</td>
</tr>
<tr>
<td>Water facilities:</td>
<td></td>
</tr>
<tr>
<td>8. Dams and weirs</td>
<td>40</td>
</tr>
<tr>
<td>9. Concrete reservoirs</td>
<td>20</td>
</tr>
<tr>
<td>10. Boreholes, pipelines and water points</td>
<td>15</td>
</tr>
<tr>
<td>Electrical facilities:</td>
<td></td>
</tr>
<tr>
<td>11. Power supply</td>
<td>40</td>
</tr>
<tr>
<td>13. Lighting plant and refrigeration</td>
<td>15</td>
</tr>
<tr>
<td>14. Other</td>
<td>15</td>
</tr>
<tr>
<td><strong>Moveable assets</strong></td>
<td></td>
</tr>
<tr>
<td>Vehicles and equipment:</td>
<td></td>
</tr>
<tr>
<td>15. Tractors and trailers</td>
<td>15</td>
</tr>
<tr>
<td>16. Agricultural implements, engines and pumps</td>
<td>15</td>
</tr>
<tr>
<td>17. Cars, trucks and motorbikes</td>
<td>10</td>
</tr>
<tr>
<td>Contents:</td>
<td></td>
</tr>
<tr>
<td>18. Office and workshop equipment</td>
<td>15</td>
</tr>
<tr>
<td>19. Safari camp furnishings</td>
<td>15</td>
</tr>
<tr>
<td>20. Other</td>
<td>15</td>
</tr>
</tbody>
</table>
Appendix D

Price Conversion Ratios and Foreign Currency Component
of Revenue and Cost Items
Table D1. Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: cattle and wildlife products and direct inputs.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price ratio</th>
<th>Foreign content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cattle Products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Slaughter sales</td>
<td>1.1, 1.25, 1.34</td>
<td>87%</td>
</tr>
<tr>
<td>2. Live sales</td>
<td>1.1, 1.25, 1.34</td>
<td>87%</td>
</tr>
<tr>
<td>3. Private sales</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>4. Hides</td>
<td>1.00</td>
<td>50%</td>
</tr>
<tr>
<td>5. Small stock sales</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Wildlife Products</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Daily rates</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>7. Trophy fees</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>8. Live game sales</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>9. Hides and skins</td>
<td>1.00</td>
<td>50%</td>
</tr>
<tr>
<td>10. Game meat sales</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>11. Hunting lease</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td><strong>Cattle Related Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Cattle purchases</td>
<td>1.1, 1.25, 1.34</td>
<td>87%</td>
</tr>
<tr>
<td>13. Cattle feeds</td>
<td>1.19</td>
<td>8%</td>
</tr>
<tr>
<td>14. Veterinary</td>
<td>1.19</td>
<td>48%</td>
</tr>
<tr>
<td><strong>Wildlife Related Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Wildlife purchases</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>16. Trophy purchases</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>17. Game capture</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>18. Game feeds</td>
<td>0.90</td>
<td>45%</td>
</tr>
<tr>
<td>19. Safari consumables</td>
<td>1.00</td>
<td>10%</td>
</tr>
<tr>
<td>20. Trophy handling</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>21. Ammunition</td>
<td>1.00</td>
<td>100%</td>
</tr>
<tr>
<td>22. Agent commissions</td>
<td>1.00</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table D2. Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: general inputs.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price ratio</th>
<th>Foreign content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Seed</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>24. Fertilizer</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>25. Chemicals</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>26. Diesel</td>
<td>0.93</td>
<td>78%</td>
</tr>
<tr>
<td>27. Gasoline</td>
<td>0.54</td>
<td>42%</td>
</tr>
<tr>
<td>28. Lubricants</td>
<td>0.70</td>
<td>60%</td>
</tr>
<tr>
<td>29. Electricity</td>
<td>1.43</td>
<td>45%</td>
</tr>
<tr>
<td>30. Water</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>31. Consumable stores</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>32. Building rep/maint</td>
<td>1.00</td>
<td>5%</td>
</tr>
<tr>
<td>33. Fencing rep/maint</td>
<td>1.35</td>
<td>14%</td>
</tr>
<tr>
<td>34. Water supply rep/maint</td>
<td>1.00</td>
<td>30%</td>
</tr>
<tr>
<td>35. Road rep/maint</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>36. Vehicle rep/maint</td>
<td>0.50</td>
<td>45%</td>
</tr>
<tr>
<td>37. Tractor rep/maint</td>
<td>0.75</td>
<td>50%</td>
</tr>
<tr>
<td>38. Machinery rep/maint</td>
<td>0.70</td>
<td>35%</td>
</tr>
<tr>
<td>39. Rent/leases</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>40. Hired transport</td>
<td>0.95</td>
<td>20%</td>
</tr>
<tr>
<td>41. Local travel</td>
<td>0.90</td>
<td>20%</td>
</tr>
<tr>
<td>42. Foreign travel</td>
<td>0.90</td>
<td>90%</td>
</tr>
<tr>
<td>43. Postal/telecomm</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>44. Accountancy/legal</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>45. Bank charges/insurance</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>46. Levies/licenses</td>
<td>1.00</td>
<td>0%</td>
</tr>
<tr>
<td>47. Other</td>
<td>1.00</td>
<td>20%</td>
</tr>
</tbody>
</table>
Table D3. Financial/economic price ratios, and estimated foreign currency components of tradeable commodities: capital items.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price ratio</th>
<th>Foreign content</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed Capital Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48. Buildings/structures</td>
<td>1.00</td>
<td>10%</td>
</tr>
<tr>
<td>49. Cattle/game fencing</td>
<td>1.40</td>
<td>14%</td>
</tr>
<tr>
<td>50. Electric fencing</td>
<td>1.06</td>
<td>14%</td>
</tr>
<tr>
<td>51. Dams/weirs/reservoirs</td>
<td>1.00</td>
<td>10%</td>
</tr>
<tr>
<td>52. Water points</td>
<td>1.00</td>
<td>10%</td>
</tr>
<tr>
<td>53. Boreholes</td>
<td>1.00</td>
<td>5%</td>
</tr>
<tr>
<td>54. Pipelines</td>
<td>0.85</td>
<td>22%</td>
</tr>
<tr>
<td>55. Power supply</td>
<td>0.62</td>
<td>60%</td>
</tr>
<tr>
<td>56. Lighting plant</td>
<td>0.83</td>
<td>60%</td>
</tr>
<tr>
<td>57. Cold room refrigeration</td>
<td>0.80</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Moveable Capital Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>58. Large trucks</td>
<td>0.68</td>
<td>68%</td>
</tr>
<tr>
<td>59. Pickup trucks</td>
<td>0.39</td>
<td>25%</td>
</tr>
<tr>
<td>60. Cars</td>
<td>0.35</td>
<td>29%</td>
</tr>
<tr>
<td>61. Tractors</td>
<td>0.90</td>
<td>67%</td>
</tr>
<tr>
<td>62. Motorbikes</td>
<td>0.73</td>
<td>40%</td>
</tr>
<tr>
<td>63. Trailers</td>
<td>1.00</td>
<td>10%</td>
</tr>
<tr>
<td>64. Agricultural machinery</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>65. Engines and pumps</td>
<td>0.80</td>
<td>55%</td>
</tr>
<tr>
<td>66. Workshop equipment</td>
<td>0.55</td>
<td>50%</td>
</tr>
<tr>
<td>67. Office equipment</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>68. Fire arms</td>
<td>0.70</td>
<td>70%</td>
</tr>
<tr>
<td>69. Safari camp furnishings</td>
<td>1.00</td>
<td>20%</td>
</tr>
<tr>
<td>70. Other</td>
<td>1.00</td>
<td>20%</td>
</tr>
</tbody>
</table>
VITA

Urs Peter Kreuter

Candidate for the Degree of

Doctor of Philosophy

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