Chapter III

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SUMMARY

This use of dry grasslands in Africa provides a striking contrast to most uses of U.S. rangelands. In particular, this chapter illustrates:

- attempts to make productive use of degraded grasslands and to prevent their further deterioration by relying on native animal species,
- analogous efforts in the United States which relate to and draw on the African experience, and
- difficulties inherent in developing animal agriculture tailored to long-term resource sustainability.

INTRODUCTION

In years past, the low rainfall grassland plains of Africa, with their immensely rich and varied wild animal populations, formed a major natural resource of the continent. Today these once beautiful and productive areas are in varying degrees of degradation.

Both climatic factors and human exploitation have influenced the condition of these lands. In many instances, wild animal populations have been eliminated or threatened as the land has become degraded and moved increasingly toward arid and semiarid conditions.

Human activity has played a large role in destroying the delicate natural balance between vegetation and wild animals.[1] Desert shrubs have been stripped from the land for use as firewood to the extent that local supplies have virtually disappeared, and charcoal must now be shipped 100 to 200 miles for use in some cities. Such woody ground cover normally served to hinder erosive water runoff and enhance retention of water in the soil. Overgrazing and compaction of the soil by domestic animals, in a region where land is considered common property by stock owners, also has contributed to the degradation. [2]

Commercial production of imported domesticated livestock (primarily cattle, sheep, and goats) continues in the African savanna in spite of the impact on the land. The animals are maintained in African countries with the assistance of much livestock research and social expenditure, in part because they have become an integral part of the local social and economic systems. Owning a large herd is a mark of prestige; it also ensures a constant milk supply despite the low productivity of milking cows and the shortness of their milking period. A herd provides insurance for survival through its meat, dairy, and other products should a calamity such as an outbreak of disease or drought occur. Sheep are retained because mutton is the preferred meat of the region. The consumption of goat meat is generally restricted to the poor. Nevertheless, goat is of particular value in arid lands because it survives when sheep and cattle perish, thus providing a more secure supply of milk, meat, and skins in emergencies.[3] These multiple social benefits have tended to override the fact that the quality of beef is often inferior to that of beef produced in a more favorable climate. Moreover, seasonal variations in water and forage availability are not conducive to the rapid growth of cattle, sheep, or goats.

[1] Southwest Research Laboratories, "The Establishment of Wildlife Ranches in Developing Countries" (Los Alamitos, Calif.: November 1981), p. 1.

[2] L. Chatterton and B. Chatterton, "Combating Desertification in Winter Rainfall Regions of North Africa and the Middle East," *Outlook on Agriculture, vol. 10, No. 8,* p. 397,

[3] *Smithsonian* magazine, vol. 10, No, 5, August 1979, p. 38.

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In contrast, indigenous animals have naturally adapted to the arid and semiarid environment of the African savanna. In one important aspect they are particularly adapted: they require little water. If fresh grass is available, camels, for example, require virtually no water. Even when water is available in such areas as central Sudan, camels are often not given water more than once every couple of months. The Sudan exports tens of thousands of camels to upper Egypt for meat each year. Because of their adaptability, camels in the Sudan are valued more highly for their milk and for transportation than for their meat.[4]

Antelopes, gazelle, oryx, and other game species also are well adapted to life in arid regions. (See table 4 for scientific names of common African game species.) The eland, for example, can endure fairly large variations in body temperature without sweating, so they can reduce water loss. The ostrich can survive a 25 percent loss of body weight, much of which is water that can be replaced in a single drinks Game animals also have potential as an excellent source of high-quality meat. With its higher proportion of protein to fat, some game meat may be nutritionally superior to domestic meats. And if allowed to grow naturally on the range, game meat may contain lower levels of the kinds of chemicals, including growth hormones, commonly used in modern ranching.[6]

Table 4.—Common and Scientific Names of Animals Cited in Text

Since much information about animals is classified by scientific names, this list is provided to help readers locate additional data. There may be cases where disputes in synonomy or regional variation are not reflected.

Domestic and wild cattle and their relatives:	
Domestic cattle	*Bos taurus*
Domestic goats	*Capra hircus*
Domestic sheep	*Ovis aries*
African buffalo	*Syncerus caffer*
American bison (buff ale)	*Bison bison*
Antelopes and their relatives:	
Dik-dik	*Madoqua* spp.
Duiker	*Sylvicapra* spp., *Cephalophus* spp.
Eland	*Taurotragus* spp.
Gerenuk	*Litocranius walleri*
Grant's gazelle	*Gazella granti*
Hartebeest	*Alcelaphus buselaphus*
Kudu	*Tragelaphus* spp.
Impala	*Aepyceros melampus*
oryx	*oryx* spp.
Springbok	*Antidorcus marsupials*
Steenbok	*Raphicerus campestris*
Thomson's gazelle	*Gazella thomsoni*
Wildebeest	*Connochaetes* spp.
Deer and their relatives:	
Axis deer	*Cervus axis*
North American elk	*Cervus canadensis*
White-tailed deer	*Oedicoileus virginiana*
Other animals:	
African camel	*Came/us dromedaries*
Giraffe	*Giraffa camelopardalis*
Zebra	*Equus spp.*
Birds:	
Ostrich	*Struthio came/us*
Ring-necked pheasant	*Phasianus colchicus*

SOURCE: Office of Technology Assessment.

[4]J. L. Cloudsley-Thompson, "Animal Utilization," *Arid Lands in Transition*, Harold E. Dregne (cd,) (Washington, D. C.: American Association for the Advancement of Science, 1970), p. 67.

[5]Ibid., p. 68.

[6]Ibid., p. 58.

EXPERIMENTS IN GAME RANCHING

A growing awareness of the serious impacts domesticated cattle, sheep, and goats are having on the African savanna has spurred interest in game ranching of native species. In the IWO'S a number of ranches in Africa began experimenting with a mixture of domestic and game animals to counter growing land degradation and to boost the economic value of indigenous wildlife species in order to help preserve them.

The feasibility of game farms in several African countries is an area of ongoing research in the more productive use of arid and semiarid lands. On both experimental and commercial ranches, workers are testing the hy-

potheses that indigenous species are better adapted to the savanna environment and thus more easily and profitably raised than common domestic animals. For these reasons, game ranching has been called the use and enhancement of "nature's technology.'" The basic concept is to take economic advantage of the natural balance between vegetation and wild animals.

Major projects at the following ranches were started in the 1970's: Ubizana and Theunis in Natal, South Africa; Doddieburn and Mkwasine in Zimbabwe; Kruger in South Africa; and Athi River in Kenya. The limited data reported on these ranches to date indicate that the most significant costs of game ranching are in capturing and stocking animals, erecting a perimeter fence, and, when necessary, building processing facilities. Stocking costs have ranged from $50,000 at the Ubizana Game Ranch to $146,000 over 3 years at the Theunis Game Ranch in South Africa. Fencing costs were estimated at $1,044 per kilometer in South Africa in the early 1970's. The Mkwasine Game Ranch in Zimbabwe spent over $56,600 to fence 59,304 acres (24,000 hectares). Processing facilities that comply with veterinary and health standards have been found also to be costly. A canning and drying facility in the Kruger National Park in South Africa, for example, cost the equivalent of $1.5 million. However, that facility returned the investment within 3 years. A smaller, less sophisticated facility on the Theunis Game Ranch, which prepared fresh cuts and sausage, cost about $146,000.[8]

One of the largest experimental game ranches in Africa is the Athi River, Kenya ranch, established in the mid-1960's by David Hopcraft. This experiment has attracted interest from both developed and developing countries and is the focus of a major portion of the remainder of this chapter.

[7]David Hopcraft, "Nature's Technology," 19, *Technological Forecasting and Social Change (1980).*

[8]S. Mossman and A. Mossman, "Wildlife Utilization and Game Ranching," IUCN Occasional Paper No. 17 (Merges, Switzerland: International Union for Conservation of Nature and Natural Resources, 1976).

THE HOPCRAFT PROJECT[9]

Athi River, Kenya Demonstration Wildlife Ranch is located about 25 miles from Nairobi. It contains 20,000 acres, some of which are used for cattle ranching. Hopcraft began his project with the help of a 1966 U.S. National Science Foundation research grant for a 3-year comparison of the land effects and the meat and hide yields of cattle and game raised on Kenya grasslands. In the study, he fenced off and halved a uniform 300-acre plot of land. One side was stocked with cattle, the other with gazelle.

Hopcraft found the physical effects of the two species on the land to be substantially different. The cattle significantly reduced grass cover and other types of stable vegetation, created serious tracking problems, and trampled the vegetation on their daily trek to the water hole, compacting the soil. In contrast, according to Hopcraft reports, the gazelle left an area that retained 32 percent more grass cover and 100 percent more self-perpetuating species. The gazelle area did not show either tracking problems or land devastation around the water hole.

Economically, Hopcraft found the gazelle carcass to be more profitable than the cattle carcass. His figures indicated that 47 percent of the gazelle was lean meat, compared to 32 percent in cattle; the cattle in this experiment yielded 7.9 pounds per acre per year, the gazelle produced 14.6 pounds per acre. Cattle raised under traditional stock raising methods, according to Hopcraft, would yield much less lean meat than those on his farm.

[9]David Hopcraft, op. cit.

Income from the gazelle substantially exceeded that from cattle because of the gazelle's higher market price, almost double that of domestic meat, and production of 50 to 100 percent more meat per acre. Hide sales favored the game species as well, the gazelle hides returning a price roughly 25 percent higher than that received for cattle hides. Approximately 10 acres per head and 3 years were needed to produce one cowhide, while Hopcraft estimated that 1 acre could produce eight gazelle hides in only 1 year.

Hopcraft interpreted his findings to indicate that adaptation to the environment is a very important factor. "An indigenous animal spends far less energy than an imported beast in overcoming the harsh environmental conditions such as disease, weather, and vegetation. Thus, more energy becomes available for growth. " The advantage is augmented, he maintains, by the negligible costs of herd maintenance. Gazelle, for example, require no pesticide dippings, inoculations, or night enclosures. Hopcraft estimated that expenses on a cattle ranch consume about 66 percent of income, compared to only 20 percent on a game ranch.

In 1976, Hopcraft received a grant from the Lilly Endowment of Indianapolis for the large-scale application of his findings. This grant was increased in 1977. The funding covered construction of an 8%-foot-high fence around the 31-mile perimeter of his ranch, a project requiring 15 months to complete. This fence enclosed more than 5,000 indigenous animals of 20 different species–giraffes, eland, wildebeest, dik-diks, impala, zebra, hartebeest, and others. About half were from the gazelle family.

According to Hopcraft, this variety of game has helped maximize the productivity of the vegetation. The treetops are forage for the giraffe; the higher bushes are eaten by the eland, kudu, and gerenuk; the lower bushes by the gazelle and impala; and the grasses by buffalo, zebra, wildebeest, and hartebeest. Smaller shoots and leaves serve the duiker, steinbuck, and dik-dik. The seeds are eaten by the ostrich and other game birds. There is some overlap in browsing, but according to one report this arrangement is conducive to helping the vegetation remain in natural balance.[10]

Photo credit: Agency for International Development

The eland of East Africa is the largest of the plains animals that graze across the vast savannas

Photo credit: Agency for International Development

Herds of zebra and wildebeest roam across the grass fields inside Ngorongoro Crater in Tanzania

Erecting the perimeter fence was a major endeavor in the large-scale project. Once operational, the project faced a second hurdle and one of its greatest impediments: securing the Kenyan Government's permission to market the game meat. Hopcraft lobbied for 7 years before obtaining an exemption from gaming and food laws. Cropping game on the Hopcraft ranch began early in 1981. Plans are to crop about one-quarter to one-third of the game population annually. * Now, the ranch's game

[10]Southwest Research Laboratories, op. *cit.,* p. 8.

*Gabriel Von Latham, April 1982, telephone interview. Von Latham and Hopcraft have formed a French-based firm, Wild Indigenous Livestock Development (WILD), to export game ranching to other countries.

meat is sold in hotels and restaurants in Nairobi as a luxury item, and outlets are being sought outside Kenya.

Some of Hopcraft's preliminary findings are:

1. it is possible to live within the natural balance of land and animals in this part of Africa and to use extremely profitably the natural increase of animals for production of meat and hides;
2. ranching indigenous animals requires little input and little imported energy; and
3. far greater production of meat is attained per acre, gaining profits of nearly five times those of traditional livestock rearing, in a sustained multicultural environment.[11]

[11] Southwest Research Laboratories, op. cit., p. 9.

DISCUSSION OF FINDINGS

Some controversy exists over Hopcraft's findings and extrapolation of results obtained on his relatively small plot of land. The advisability of game ranching as an approach to increased economic productivity is under question because of the high capital outlay needed to establish and outfit a fenced range of adequate size.

In general, substantial costs are involved with game ranching where the project must acquire land, construct perimeter fences, stock and harvest the animals, and construct slaughterhouse facilities. Hopcraft was able to avoid many of these costs. Local circumstances, for example, helped Hopcraft minimize stocking costs. In fencing the ranch, several thousand animals were trapped within, saving the time, money, and effort of capturing and transporting them from outside. The weaving of the fencing material onsite from local materials further reduced operating costs. Hopcraft also was able to purchase inexpensively a mobile slaughterhouse from the United Nations Food and Agriculture Organization.

Similar economizing may be possible in other game ranching developments in the African savanna and elsewhere if indigenous species are used. Certain other experiments, however, which must trap and transport game from outside, may find their initial costs much higher. Many game ranchers may have to construct slaughterhouses because of the distance of their operations from commercial facilities.

A group of Cornell University researchers visited Hopcraft's ranch several times to conduct research and to report their findings to the Lilly Endowment. * They have gathered data on range ecology and the digestibility of various plant species by game animals. Co-director Daniel G. Sisler has concentrated his study of the project on the economics of meat production, handling, and marketing. Dr. Sisler raises a number of points about the economics of game ranching:

1. Costs of establishing and operating a game ranch. Although Hopcraft has shown that game meat sales will cover variable operating costs, according to Dr. Sisler, he has not shown that their sales will cover all the fixed costs associated with setting up a ranch. If the fence, slaughterhouse, cooling facilities, vehicle, capture of animals, and labor were all included, the net income might be well below that of a well-managed cattle ranch. The costs of establishing a cattle ranch would have to be compared with those of establishing a game ranch, or the assumption would have to be made that both kinds of ranches are operational at the time of the comparison.

*This section discussing the controversy over Hopcraft's results is based on information from Daniel Sisler and Robert McDowell, Professors of Agricultural Economics, and Robert P. Bauer, graduate student, Cornell University, April 1982, and with McDowell again in August 1982.

Cropping, handling, and marketing game meat are distinctly different from similar operations associated with domestic animals. Table 5 shows some of the characteristics of cropped game animals to consider in handling and marketing. The initial investment in slaughterhouse and refrigeration facilities and their operating expenses may be substantial. The services of a veterinarian maybe needed to meet inspection requirements. These costs are in contrast to cattle ranching, where animals are typically sold live, with slaughter and inspection taking place at a publicly owned slaughterhouse.

In contrast, harvesting at the Hopcraft facility was labor intensive and unusual. Cropping of all animals took place at night, with a crew of three men shooting the animals from a Land Rover. Cropping was reasonably efficient, and dead animals were at the slaughterhouse within 1 hour. During the first year of operation, the game meat was found to be of high quality and accepted by customers. Fat content was low. Statistics relative to cropping indicated that there was no significant seasonal variation in carcass weight of game animals.

Sisler estimates that the establishment costs are roughly equal to those in establishing a cattle ranch. Net operating income may be about equal if the price received for game meat is approximately twice that for cattle (the price ratio in the first year of the Kenya ranch operation).

2. **Game ranch management.** A well-managed game ranch requires highly sophisticated technical knowledge as to rates of growth for each game species, plant food preferred, degree of predation by other species, fawning rates, growth rates, sex composition, compatibility of species, gestation period, and age of sexual maturity of differing species. The availability of this expertise adds cost to the project.

3. **Use of energy.** Although the energy used for a game ranch is less than that for cattle ranching, Sisler estimates imported energy for a game ranch is approximately 40 percent of that required for a comparable cattle ranch. Vehicles use diesel fuel, as does the operation of the slaughterhouse and chilling facilities.

4. **Development of markets.** A ready market existed for all game meat produced from the Hopcraft ranch during 1981 operations. This does not mean that there would necessarily be a consistently adequate market for game meat within Kenya. The absolute quantity of game meat marketed is a small proportion of total red meat consumption in Nairobi. It seems probable that any sizable increase in game meat production could cause prices to decline. The most serious obstacle facing continued efficient marketing of game meat in Kenya is assuring a strong market for all would-be producers. Hopcraft was successful as the only producer operating on a small scale in the capital city of Nairobi.

The majority of Hopcraft's clients were restaurants, although one butchery was a steady client. The meat was sold at 25 shillings per kilo, approximately twice the price of quality beef. The clientele of these restaurants and butcheries has been more than 90 percent expatriate, and wholesale purchasers knew that the high price could be passed onto their customers. When surveyed, clients stated that game meat constituted about 5 percent of total sales. Restauranteurs estimated that the cost of preparing a game meat meal was 20 to 30

Table 5.—Characteristics of Cropped Game Animals

Species	Body length (cm)	Shoulder height (cm)	Dressed weight (kg)	Percent total weight dressed	
				Annual range	Average
Thomson's gazelle	78	67	13	53-55	54
Grant's gazelle	108	91	33	52-61	55
Kongoni	121	119	69	49-52	52
Wildebeest	135	132	125	49-60	53

SOURCE: "An Economic Analysis of Harvesting Techniques, Game Meat Characteristics and Marketing Prospects," tables 1, 2, and 3, paper by Daniel Sisler, Professor of Agricultural Economics, Cornell University, preliminary draft, October 1982.

percent more than that of a beef, poultry, or pork meal. Retail price per plate, however, is usually about the same for game and traditional meats. Table 6 shows the monthly average of kilos of game meat delivered to four or five clients each week and the corresponding revenue from each delivery.

Limited quantities of sausage have been produced from the game meat. The market appears to be strong for this high-value product, which could be marketed at a lower expense than chilled meat. However, equipment for sausage manufacturing is costly, as are some ingredients, notably fat. While sausage production shows signs of profitability, more effort is needed on marketing and promotion of this specialty item.

According to Sisler, game meat will continue to be a high-priced specialty meat if game meat production is to be profitable. Because of its cost, it seems likely that in the foreseeable future game meat will not be a source of low cost animal protein for native peoples.

5. **Price of hides when sold in quantity.** Sisler found hide sales extremely difficult to calculate. If they can be sold at a favorable price, this would be an added source of revenue for game ranching. The development of a market for specialty hides, however, was difficult for Hopcraft's 1981 operations.

6. **Water use.** Theoretically, the expense of drilling wells or installing dams and watering facilities can be considerably less than what is required for cattle. However, a perimeter fence may prevent migration of animals to natural watering points and better range. So any area would need to be large enough to take care of this requirement.

7. **Stocking ranches.** The financial breakeven point for game ranches of Hopcraft's size, calculated by Cornell University reviewers, is roughly 2,000 animals-about twice the current level of Hopcraft's harvest. This figure represents about 40 percent of the 5,000 game that Hopcraft estimated in his 1980 report. More recent estimates from Cornell indicate that the game animals on the ranch number about 2,500 to 2,800. The costs of establishing a similar ranch elsewhere would be extremely high. Also the cost of importing animals would be high. In the first year of operation, only four species of adult males—Thomson's gazelle, Grant's gazelle, wildebeest, and kongonis were harvested. It is unclear what will happen to the ecology when all cattle are removed and game animals expanded.

Other questions remain. What will happen to the off-take rate of game animals when younger animals and a part of the females of each species are harvested? Will the price of game meat be less when it is sold in larger quantities? At present, cropping is completed in accord with what can be sold rather than in a manner to regulate or sustain species composition and number. Achieving a balance between meat production and the natural sustainability of the animals in their local environment will be one of the most critical facets of ranching.

Table 6.—Monthly Deliveries to Nairobi and Revenues (game meat only)

Month	Number of deliveries per month	Total monthly delivery (kg)	Mean weekly delivery (kg)	Monthly revenue Kenyan shillings	U.S. dollars
January	4	954	239.6	23,962	$2,188
February	4	769	192.3	19,227	1,756
March	4	1,008	252.0	25,200	2,301
April	4	857	214.3	21,430	1,957
May	5	1,469	293.8	36,725	3,354
June	4	1,614	403.5	40,345	3,685
July	5	1,481	296.2	37,025	3,381
August	4	1,276	319.0	31,898	2,913

SOURCE: "An Economic Analysis of Harvesting Techniques, Game Meat Characteristics and Marketing Prospects," paper by Daniel Sisler, Professor of Agricultural Economics, Cornell University, preliminary draft, October 1982.

TECHNOLOGY TRANSFER CONSIDERATIONS

Data are not available to make definitive statements about the economic feasibility of expanding game ranching to other parts of Africa. However, because of the optimism for Hopcraft's efforts, the U.S. Agency for International Development (AID) has funded a game ranching feasibility study by Hopcraft for the Department of Wildlife in Botswana. Hopcraft is looking at the possibility of establishing two demonstrations similar to the Kenya ranch, one in a communal area and the other on a private ranch in Botswana. The communal area would involve some 20 farm families living on 5,000 acres, who would be trained to manage the animals. *

Developing international markets for game meat would help assure game ranching profits and increase the desirability of starting such operations. Hopcraft has proposed that Rhodesian and Botswanan game be shipped to Europe through South African ports and airports. The development of widespread markets for these high-priced specialty meats will take a major effort, although some researchers believe that a market is there.[12] Game meats are still an insignificant factor in world food production and world trade. According to U.S. Department of Commerce figures, the United States imported less than $1 million of game meats in 1981. Both the United States and Europe (especially West Germany, Switzerland, and England) could prove to have substantial potential as markets if a reasonably priced, secure supply became available.

Some research on game ranching, parallel to that in Africa, is under way in the Western United States assessing the advisability of a partial shift to native or imported stock. As much as 85 percent of agricultural land in the American West is used as range, and a growing awareness of the problems of overgrazing, reduced water availability, and lower economic return from ranching operations has influenced American ranchers to look into alternative ranching systems. Experimentation with native American bison is under way, and the adaptation of imported African species as a U.S. cash crop is being considered. In light of this American interest in importation, the objectives pursued and results identified by game ranchers in African countries may provide insight for U.S. consideration.

Two types of operations in the United States are similar to the wildlife management schemes in Africa: 1) game ranches that permit hunting of wildlife, and 2) native game farming or herd management of a single indigenous species such as buffalo or elk to produce meat, hides, and other products.

Game Ranches

The Texas Parks and Wildlife Department reports more than 800 game ranches in that State. The Exotic Wildlife Association, a group of game ranches, has 200 members. The State's boom in game ranches has been encouraged, in part, by the promotional efforts of energy companies that provide their top executives with trips to such ranches.[13]

Many ranches have game indigenous to the United States, as well as imported animals. The 50,000-acre Y. O. Ranch in Mountain Home, Tex., for instance, has 10,000 game animals. Half are drawn from native species. The balance are animals culled from 35 African and Asian species. These include antelopes, axis deer, zebras, ostriches, and giraffes.[14]

Game ranches in the United States are almost exclusively focused on sport. They might become more profitable if excess animals could be slaughtered and marketed. A major factor in marketing game meat is Federal and State legislation that bars such sale except under very restrictive conditions. For example, leg-

*Reservations expressed by AID officials in telephone interviews in August 1982 are strongest regarding the economic feasibility of game ranching without a major export market.

[12]Fred Wagner, Associate Dean, College of Natural Resources, Utah State University, June 1982, telephone interview.

[13]Charles Schreiner IV, manager and co-owner of Y. O. Ranch, Mountain Home, Tex., April 1982, telephone interview.

[14]Ibid.

islation requires inspection of wild animals before they are slaughtered for public consumption. Federal laws also require slaughterhouse facilities for game that are separate from those for domestic meat. If game animals have to be first captured and then transported to a specific slaughterhouse for inspection before being killed, the process may make the final product cost prohibitive.[15]

Native Herd Management

One of the principal wild species being managed for commercial exploitation in the Western United States is the American bison (buffalo). Some herds are being raised on semiarid rangeland, particularly on those lands where precipitation for forage production for cattle is inadequate. The National Buffalo Association has some 800 members, of whom approximately 500 have herds. Ironically, the demand for buffalo meat from some supermarkets and restaurants exceeds the available supply, mainly because of the lack of both a centralized marketing system and uniform health inspection regulations.[16]

Experts on game ranching abroad are divided on the feasibility and advisability of introducing foreign (exotic) species to U.S. domestic ranges or expanding native species. Raymond Dasmann, who helped set up one of the pioneering game ranches in Rhodesia, believes that wild ungulates (hoofed mammals), in some settings, are capable of producing more meat than domestic animals.[17] Certain areas of scrub vegetation in California, he estimates, could yield up to 550 kilograms of meat per square kilometer, or more than seven times the average yield from domestic livestock. While the evidence is far from conclusive about the efficiencies of wild ungulates versus cattle in converting biomass to meat, advocates suggest it is sufficient to justify more research on managing ungulates for meat production. Raised in proximity with domestic cattle, they do not necessarily compete with the latter for vegetation but instead actually may assist in maintaining a better balance of forage for both.

To help develop a U.S. market for game meat, Texas Tech University is evaluating mixed ground meats comprised of venison, pork, and beef for palatability and nutrition .18 Generally, landowners with large stocks of wildlife are not yet investing much capital and other resources into its management. They are turning instead to more intensive production of livestock and other primary activities.[19]

Other experts state that imported animals would bring little, if any, ecological benefit. They suggest that such animals usually compete with the range of domestic or native species already competing for forage and may carry parasites that can be transmitted to animals or humans. One expert who holds this view suggested five ecological principles to consider in determining the efficacy of introducing an exotic animal to a new environment:[20]

- **Every habitat tends to be full.** Nature abhors a vacuum and there are few vacant spaces in natural communities. Physical space alone does not constitute a vacancy in the animal community. Sufficient vegetation, preferably not that favored by existing animals, must exist to support new animals.
- **Each species has a specific set of tolerances and must be placed in an environment to which it can adapt.** Ecological homologs are the best candidates for introduction to new lands. These are animals with identical counterparts, frequently found on another continent. They are often look-alikes, have identical habits, and

[15] Ibid.

[16] Judi Hebbring, Executive Director of the National Buffalo Association, July 1982, telephone interview.

[17] R. Dasmann, "Biomass, Yield, and Economic Value of Wild and Domestic Ungulates, " *Transactions of the 6th International Union of Game Biologists* (London: Nature Conservancy), pp. 227-233.

[18] Robert Warren, Assistant Professor, Department of Range and Wildlife Management, Texas Tech University, April 1982, telephone interview.

[19] G. Burger and J. Teer, "Economic and Socioeconomic Issues Influencing Wildlife Management on Private Land" (unpublished paper).

[20] James G. Teer, "Introduction of Exotic Animals, " *Wildlife Conservation Principles* (Washington, D.C.: Wildlife Society, 1979), pp. 173-175.

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occupy similar habitats. The axis deer, for instance, is a homolog to the white-tailed deer.

- **Plastic species have higher probabilities of succeeding.** A plastic species is one that is able to adapt to varying conditions. Such a species often has large variations in its appearance as indicated by large numbers of races. North American ring-necked pheasants, for example, have subtle differences in coloration and other attributes which reflect the underlying genetic variation that makes them successful in a variety of locations.
- **Introduced species in direct competition for resources with closely related animals will fail.** Although dislocations of native species can occur, they usually have the advantage because they evolved in place.
- **Transplanting animals from complex communities, such as their natural habitat, to relatively simple communities, such as farms or game ranches, has been successful.** The significantly decreased presence of other types of life may give exotics an advantage in their new environment.

This same expert suggests that the Sonoran and Chihuahua deserts of the southwestern United States and northwestern Mexico might be suitable for oryx, gazelle, or springbok. But such marginal lands are few in North America, and good rangeland is almost fully used by domestic animals.[21]

Advocates of game ranching believe that the technological and ecological aspects of game ranching are favorable. They believe institutional factors such as encroachment of wildlife on neighboring lands, lack of marketing mechanisms, and health regulations are the main barriers to future development.[22] The long-term potential of game ranching, whether in the United States, Africa, or elsewhere, will depend on economic, social, and ecological conditions of the area.

If the potential exists for eventually marketing low-cost game meat in quantity, game meat could provide a more significant source of protein than now exists. With more secure markets, game ranching operations that fit into the ecology of the area in their use of the water, land, and vegetation also could provide one more means of economic productivity from arid and semiarid lands. As human exploitation destroys the natural habitats of wild animals, their existence as a wild species is threatened. This technology may have the added benefit of helping to preserve them for future generations.

[21] James G. T[illeer], Director, Welder Wildlife Foundation, April 1982, telephone interview.

[22] Raymond F, Dassman, Professor of Ecology, University of California, Santa Cruz, August 1982, telephone interview.