
The Conservation and Improvement of Resources: The Grazing Animal [and Discussion]

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The conservation and improvement of resources : the grazing animal

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A comparison of livestock productivity in the arid zones of central Australia and sub-Saharan Africa is used to illustrate the ecological, social and economic factors which together determine the contrasting ways in which animal resources may be developed. Severe ecological restraints necessarily result in fluctuating animal populations and in the need for effective measures to control soil erosion, to prevent serious over-grazing, to vary stocking rates and to maintain the water supply. The aims, attitudes and needs of livestock owners also need to be recognized. Australian cattlemen primarily want to produce meat in order to make money; many African nomadic pastoralists primarily want to produce milk in order to feed their families. Degrees of achieving these aims and, at the same time, of preserving the necessary measure of ecological stability depend also upon a range of structural, economic and fiscal policies and opportunities. The need to coordinate livestock and rangeland research, planning and development on a multi-disciplinary basis is emphasized and the difficulties of doing so discussed.

INTRODUCTION

So much has already been written on this topic, so many experimental investigations have been reported, so many expert committees have made their recommendations, that one can only marvel that so little improvement has so far been achieved in conserving and improving animal resources in the drier parts of the world.

We can all recognize many of the pieces of the jig-saw puzzle which forms a picture of improved animal management in semi-arid zones. Some pieces, which are well-formed and illustrated in definite colours, are labelled: animal health, nutrition and breeding, water development, rangeland management, stratification of livestock industries, and marketing. Others, the shape and colour of which we can identify less clearly, are labelled: land tenure, agricultural credit, livestock taxation and fiscal policies, communications, community motivation, literacy and education. Finally, there are those pieces which we know are essential to the completion of the final picture but the outlines of which are still only vaguely seen and which are labelled: limitations to human and animal populations, social and political change, regional development based on ecological, social and economic criteria, and a reconciliation of national and international aspirations with the fixed and limited extent of the natural resources that are available. Despite our general familiarity with most of the various pieces, in no part of the world can we yet point to a finished picture in which all have been fitted into their correct place and which, as a complete work, supports within us feelings of long-term confidence and satisfaction.

The present paper attempts to contrast two necessarily incomplete pictures of animal management in semi-arid zones, one in Australia and one in sub-Saharan Africa. They are

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pictures of differing shape, texture and colour, yet both serve to illustrate the problems facing those who are trying to complete such pictures in such a way as to give lasting satisfaction to posterity.

It is dangerous to generalize about the characteristics of the semi-arid zones of sub-Saharan Africa and Australia and, particularly, I have no wish to over-emphasize their similarities. Clearly differences in, for example, latitude, altitude, geomorphology, pedology, vegetation and climate are substantial even within these zones, let alone between them. Any inter-continental comparison needs to be hedged around by so many limitations, qualifications and important exceptions that, in most contexts, such an exercise has little point. Moreover, because the movements of grazing animals do not recognize isohyets and the strict definition of ecological zones, it is inevitable that animal management should be considered in relation to what may loosely be called 'the pastoral zone' which, at one extreme, includes areas in which cropping may be practised with a reasonably high probability of success to the other extreme in which no cropping is possible.

Erratic rainfall and disastrous drought are ever-recurring themes over most of both of the vast regions of Africa and Australia under discussion. Annual mean rainfalls of between 200 and 800 mm, with variabilities larger than the world standard values, are characteristic, as are old and nutrient depleted soils, a shortage of surface water, an absence of large concentrations of people, and, with the exception of some mining operations and tourism, there is a dependence upon grazing as the principle industry. The major form of land use in the drier areas of Australia is the grazing of sheep and cattle and in Africa these species are commonly used together with goats, camels and donkeys. The ways in which these pastoral industries have developed and now function in Africa and Australia differ markedly, as do their levels of productivity, technologies and aims. Yet they share certain basic problems and both face an uncertain and difficult future.

AUSTRALIA'S PASTORAL INDUSTRIES

The development of grazing industries in Australia's arid and semi-arid areas is of comparatively recent origin. However, for more than 30 000 years, those recently described by Blainey (1975) as 'the prosperous nomads' had adapted successfully to their dry Australian environment, even though they had not found it possible to change it. The logic of aboriginal nomadism has been described by Thomson (1939) who stressed that it was based upon a traditional understanding of, and intimate relationship with, the climate, the marine and insect life, the maturing of plants and the habits of wild birds and animals. Clearly the 'productivity' of the aboriginal nomads was inevitably low; they did not cultivate crops nor did they tend flocks or herds. Yet Blainey (1975) considers that there was customarily more food available than was needed, so that there was normally that vital margin of surplus which meant that drought was not necessarily associated with famine.

The key to this apparently stable ecosystem, in which man had apparently found his continuing niche, was the fact that aboriginal populations grew slowly if at all. Cultural curbs on population increase, such as infanticide, abortion, abandonment of the sick, aged and feeble, and warfare, were practised regularly by most, if not all, tribes. Occasional plagues or epidemics had an additional, but not an overriding, effect. In other words, the aim of the aborigines was survival and they had evolved a way of life which generally, and in the long term, enabled them to do this successfully by limiting their demands to the resources that were available.

The invasion and settlement of Australia by Europeans after 1788 inevitably led in much of the country to the replacement of the aboriginal cultures with the commercial cultures introduced by the new farmers and graziers. Survival and prosperity were now related to economic strength and their aim was understandably and unashamedly that of making money.

The key to their way of life involved, not population control, but a contrived increase in the supply of food and raw materials. The technological and scientific skills introduced to Australia by 19th century migrants, and later developed within Australia by her own 20th century scientists, resulted in levels of productivity and standards of living much higher than those achieved by Australian or any other nomads.

Much of the arid zone was aggressively occupied by the European settlers, who selected and fenced large tracts of land, often the best land, as individuals, partnerships and companies. Clashes inevitably occurred between these pioneer squatters, bewildered aborigines, and well-meaning but often uncomprehending colonial administrators. These were eventually resolved by a series of legislative measures which included the provision in some parts of Australia of recognized freehold occupation, while in other areas, notably large parts of the arid zones, medium to long-term leasehold arrangements were determined.

During the last 100 years settlement and property development has taken place during periods when market prospects have been good and seasons have been favourable (Barnard 1969). Inevitably, when adverse market and seasonal conditions have prevailed the pastoralists have been driven into debt, into exploitative grazing practices which have degraded range resources, and, in some cases, into selling up and seeking an alternative way of making a living.

Problems of Australian pastoralism

The hardships suffered by the contemporary pastoralists are largely caused by climatic and economic factors outside his or his government's control. They have been minimized by the infrastructure and services which have been built up by a succession of sympathetic governments, which have had the economic strength to translate sympathy into help. To this must be added the individual and concerted efforts of an educated and articulate grazing fraternity who themselves have taken appropriate managerial, economic and political steps to try to obtain whatever they have considered they have needed.

Thus, given the essential prerequisites of common commercial and social aims between live-stock owner and government, and legalized forms of land tenure which have provided security for the pastoralist together with the essential basis for management initiatives, the grazing industries have now developed relatively high levels of productivity.

Livestock owners have introduced exotic species and strains of cattle, both *Bos indicus* and *Bos taurus*, and have developed their own improved breeds, such as the Australian Shorthorn and the Droughtmaster, by judicious crossing and persistent selection. They have developed water points, largely from artesian sources; used vast lengths of barbed wire fence to segregate flocks and herds according to age and sex; controlled pests and predators (particularly rabbits and dingoes); adopted appropriate methods to control animal disease and soil erosion; and have developed improved techniques of grazing management, particularly during drought.

At the same time they have been assisted by government action in, for example, developing communications. The rôle of the traditional cattle drover has now been supplemented by a

network of airways, railways, and roads which facilitate the marketing of livestock and help to minimize the isolation of the people. The flying doctor service is well-developed as are the correspondence schemes for all levels of education. The radio, and more recently television, play a vital part in communications throughout the arid zones and most livestock owners have their own radio transmitter as well as receiver.

Underlying these and other similar developments are two general features of overriding importance.

Stratification and integration

First, there is the way in which the livestock industries of the drier country have been integrated with the Australian economy as a whole. The arid zones are essentially regarded as breeding areas which mainly produce store or immature stock for fattening in locations of higher rainfall. Similarly, during drought, stock are, where possible, agisted in more favoured areas or feed is transported back into the drought locations. Many livestock owners, particularly the grazing partnerships and companies, run properties in more than one climatic zone in order to maximize this flexibility.

In more general ways, also, the livestock owner in the arid zones is supported by the community as a whole. His contribution to the country's development and economy is generally acknowledged and he holds a proud position in much of the folklore and even mythology of Australia's young and largely urbanized society. Add to this his well-organized and successful political influence and one can appreciate the willingness of governments and the community to support the livestock owner with a variety of fiscal, taxation, drought relief and credit measures: measures which have been made possible by the successful economic growth of urbanized and industrial Australia and by her growing mineral and energy wealth and, in many cases, are rationalized by considerations of national security and the need to have an existing knowledge of, and chain of communications throughout, Australia's sparsely populated north and centre.

Research and education

The second important buttress against the uncontrollable vicissitudes of climate and markets (i.e. export markets) is the bank of ecological and economic knowledge and understanding that has been accumulated in Australia by various universities and state and Commonwealth instrumentalities, particularly the Commonwealth Scientific and Industrial Research Organization (C.S.I.R.O.) and the Bureau of Agricultural Economics (B.A.E.).

The extent of this knowledge is reflected in various scientific publications, notably the annual *Arid Zone Newsletters* and the periodic *Studies of the Australian Arid Zone* published by C.S.I.R.O., and various occasional publications and articles in the *Quarterly Review of Agricultural Economics* published by the B.A.E.

A great deal of research, often financed in part by levies raised from cattle and sheep owners, has now been carried out on such topics as the water metabolism, heat tolerance, nutrition, behaviour and reproduction of wild and domesticated herbivores, particularly ruminants, in arid zones (see e.g. Wilson 1974). The results of this work, complementing those of similar studies carried out in various laboratories and institutions in Africa, the U.S.A. and elsewhere, have done much to enlarge our understanding of basic biological principles and processes and have led to improved methods of animal management and breeding. They have also provided an increasingly firm basis of fact with which to resist those superficially attractive notions, which have been proposed from time to time for more than 100 years, that Australia would do well to

abandon cattle and sheep husbandry in favour of kangaroo farming or the production of exotic species, such as the rabbit, llama, deer or some species of African game.

An understanding of physiological mechanisms important in tropical environments has been used successfully by C.S.I.R.O. scientists in evolving systematic breeding plans which have now led to the development of two new breeds of cattle, the Belmont Red (Turner 1975) and the Australian Milking Zebu (Hayman 1974), which have considerable potential both for tropical Australia and similar regions overseas.

The work of veterinary scientists has been remarkably successful in keeping out of Australia many of those diseases, such as rinderpest and foot and mouth disease, which play such a serious and limiting rôle in the cattle industries of many countries. More than this, veterinary research and policy have together eliminated some extremely important diseases, such as contagious bovine pleuro-pneumonia, which had been widespread in parts of the arid zone, and vigorous action has led to successful means of controlling various parasitic, tick-borne, reproductive and other diseases.

Perhaps of widest significance has been the research and survey work led by C.S.I.R.O. ecologists which has mapped and classified the natural resources of Australia's arid zones. Upon this information has been built a system of range inventory and suggestions for rational management which must constitute the basis for long-term conservation and use (see, for example, Perry 1976).

Together the developments and measures which have been mentioned have resulted in an apparently stable grazing industry which yields an annual turnoff rate (for cattle) of from 25 to 30 %, with annual mortality rates varying from 3 to 5 % in normal seasons, although they may be much higher in drought conditions (Haug & Hoy 1970; Reeves & Crellin 1972). The arid and semi-arid zones at present contain more than five million cattle and 30 million sheep and rates of return on capital invested are such as to suggest that these industries will persist in the future (Waring 1973).

However, the story is far from being one of unbridled success or reassuring certainty.

Future problems

The central question concerning the overall effect of development and management on the natural resources of soil, water and vegetation remains tantalizingly unanswered. It has been reported that arid zone vegetation has declined in productivity and stock carrying capacity (Newman & Condon 1969) and the perennial plant populations have been reduced greatly in many locations (Perry 1969). Moreover, it has been pointed out that economic pressures combined with the sheer riskiness of the country, make a pastoralist 'transgress the laws of safe husbandry in fragile semi-arid and arid environments even when he is reasonably aware of the dangers and anxious to implement the appropriate measures to avoid them to the best of his knowledge and ability' (Waring 1973).

The pressures on the arid livestock owner still include some of an institutional type. For example, where land is held under leasehold there is a reduced incentive for capital investment and, as leases have terminated, many properties have been subdivided before the leases have been renegotiated. Even large properties held freehold have been resumed by state governments and broken up for closer settlement by ex-servicemen and others who seem continually to yearn for a grazing property. Increasingly costs of production have gone up but returns have generally remained low and extremely variable. This has meant that adequate net profits cannot

be maintained indefinitely on smaller holdings and pressures for restructuring the industry into fewer and larger ranches are mounting.

Survey results indicate that the financial position of pastoralists has generally declined during the last one or two decades and, for example, net indebtedness on sheep properties in the pastoral zone of Queensland has risen to an estimated \$31 000 per property or \$92 million in aggregate (Bain & Waring 1971). Some 19% of these properties had debts exceeding 60% of their market valuation and, according to another recent report (B.A.E. 1971 *a*), approximately one in eight of woolgrower debtors in pastoral Queensland are unlikely to be able to service their debts at foreseeable prices for wool, mutton and beef cattle.

Because of the marked fluctuations in climate it is inevitable that productivity, and therefore income, must also fluctuate widely. For example, the B.A.E. surveys of the pastoral sheep industry of Queensland have shown that net farm incomes commonly vary in successive years from + \$50 000 to - \$30 000. The effects of such variations need to be minimized by policies which allow the accumulation of sizeable cash reserves or off-farm assets to offset the unfavourable seasons, by appropriately long-term taxation and accounting procedures, and by effective policies for rapid destocking to minimize drought losses and restocking to maximize the potential of good seasons.

Because of the collapse of the beef export market and the low prices which have been paid for cattle during recent years, most cattle producers in the pastoral zone of Australia have been placed in a tight liquidity situation. The average level of capital employed per specialist beef producer in the pastoral zone amounts to over half a million dollars. This means that large amounts of debt have to be serviced and further capital still needs to be invested in herd, plant and fixed improvements if production is to be maintained (I.A.C. 1975).

It has been estimated by the Bureau of Agricultural Economics that of Australia's 35 000 specialist beef producers as many as 17 000 have 'doubtful viability prospects', and the Australian Government was recently advised by its Industries Assistance Commission (I.A.C.) that, as an immediate short-term measure, low interest loans totalling about \$100 million should be made available to those cattle producers whose long-term prospects were thought to be reasonable (I.A.C. 1975).

In recent years increased attention has been focused on the plight of the aborigines and plans have been formulated for the development of aboriginal controlled cattle properties in northern Australia. However, here again the economic outlook is bleak and it was concluded that such enterprises could not be expected to show a sufficient return 'to repay over a 50-year period the costs of development, even if interest was not charged on the capital involved' (B.A.E. 1971 *b*).

An increasingly important problem is that of transporting livestock across the vast distances within Australia and of shipping carcasses across the world to Australia's export markets. Modern methods of transporting, processing and storing cattle and meat involve large inputs of labour and fossil fuels, both of which represent rapidly escalating costs. Unless these costs can be controlled the price of Australian meat on the world market will in time become prohibitive and production in the pastoral zone will necessarily decline.

Although much research has already been done, the present state of knowledge remains woefully inadequate in many vital areas, such as, weather forecasting, the assessment of rangeland status and trend, the regenerative abilities of plant communities under different management practices, the determination of ecologically and economically viable stocking rates for particular locations and the effects of mixed as opposed to single-species grazing.

Moreover, the central economic question of resource allocation in relation to national priorities is unlikely to be decided in favour of the pastoral zone. Even when financial returns in recent years have been generally adequate they have been far from generous and the evidence from B.A.E. surveys indicates that there is little opportunity for intensifying management practices or further utilizing knowledge that is already available concerning nutrition, reproduction and range management. The only modifications to current management policies which are likely to be introduced in the foreseeable future are those requiring little capital or current inputs.

If economic resources are to be allocated to the grazing industries there is greater scope for increased productivity, the use of improved technology, and economic gain in the high rainfall areas rather than in the arid zones. Although, during the period 1961 to 1972, the cattle population of the arid and semi-arid zones increased by approximately 25 % to slightly more than 5 million, in the non-arid zones it increased by over 100 % to 18.7 million. During the same period sheep numbers in the arid and semi-arid zones declined by about 5 million to 30.6 million while in the non-arid zones they increased by some 15.3 million to 132.3 million.

Such is the uncertainty about the best forms of future land use in Australian arid zones that suggestions are still being made that domestic stock should largely be removed and the rangelands used as a vast 'national park' for scientific and tourist purposes. However, the abandonment of such a large part of the country would create considerable social and economic problems and, in any case, the change from pastoral use to a national park would not remove the problems of long-term management. It has been suggested that if the economic viability of the grazing industries becomes doubtful, rather than abandon the range, 'society might be better off to share the cost burden of continued occupation with pastoralists if stable farming patterns could be established' (Waring 1973).

It has also been suggested that increased diversification of resource use is likely so that the vast areas now devoted to cattle and sheep grazing 'will become a spatial mixture of various types of land use including national parks, tourism, beef, carpet wool, sheep meat, and possibly karakul production, with a large part continuing to be devoted to the traditional wool industry' (Perry 1974).

It may be concluded that Australia has enjoyed many advantages in the development of her grazing industries in the pastoral zone.

The aims of pastoralists and governments have been commercially based. Their policies relating to management, marketing, land tenure, credit, taxation, drought relief, research and extension have all been designed, albeit with limited success, to strengthen the profitability of grazing properties and maintain it on a continuing basis. Further, with the advantages of high levels of education, capital investment and managerial skill within the pastoral industry, and the generally sympathetic support of a prosperous and expanding national community, it has so far been possible to maintain the industry on a saw-tooth path of prosperity which, on the whole, has managed to keep itself above the level needed for economic viability.

Yet, nevertheless, the jigsaw puzzle remains far from complete. Major parts of the picture remain to be filled in.

It is not yet certain whether or not the rangelands have been maintained above the level needed for long-term ecological viability. The best forms of land use for the future are still being debated and, although ecological considerations are recognized as vital, most observers regard those of an economic and social type to be even more complex and difficult to solve.

The key to the future conservation and use (i.e. management) of rangeland resources is the determination of appropriately conservative and fluctuating stocking rates. Economic pressures tend to encourage over-stocking, particularly in poor seasons and on smaller properties. No scheme has yet been proposed which ensures the appropriate adjustments of stock numbers and which, at the same time, is economically acceptable.

AFRICA'S PASTORAL INDUSTRIES

Some of Africa's pastoralists are nomadic, while many more are transhumant or seasonally migratory. Unlike the aboriginal nomads, they are traditional herdsmen and shepherds with their own well-developed systems of management, but their basic aim is largely subsistence and, until the last 50 years, their ways of life had survived successfully, in apparent long-term equilibrium with their environment, for centuries (see, for example, Jacobs 1975).

For the most part the African pastoralist regards his cattle as milk rather than meat producers and as such they are the mainstay of his subsistence. However, cattle also represent capital which can be realized if necessary because of their value as meat. Because personal and family security depend on animals the pastoralist is keenly concerned with the maintenance of as high a population of stock as is possible (see, for example, Baker 1968) with sheep and goats being important as sources of meat and cash, and donkeys and camels for transport.

To some extent the African herdsman lives on the fringes of a monetary economy but livestock have a multiple value and can represent variable combinations of wealth, prestige and prerequisites of adulthood, marriage or parenthood, as well as being convertible into money value. In many places he is included in the market at least to the limit which he believes he can safely extract from his herd and, in some cases, to the limit of his immediate needs and desires. However, the vital value of livestock remains subsistence and, in large numbers, as an 'insurance' against the ravages of drought (Gallais 1967). Various observers have stressed the rationality of nomadic behaviour in the light of their basic aim of survival (Monod 1975; Haaland 1975).

A second key feature of the African pastoral tradition is that, although livestock are individually owned, grazing and water resources are not, so that their use tends to be opportunistic, favouring short rather than long-term objectives.

Problems of African pastoralism

The difficulties, and some would say impossibility of introducing more efficient systems of rangeland and animal management under traditional systems of land use have repeatedly been stressed (see, for example, F.A.O. 1967; Schaefer-Kehnert & Brown 1973). The problem has been well described by Jahnke & Ruthenberg (1974) in the following passage:

The pastoralist is highly dependent on milk as a regular source of food for his family. Given the natural environment and the husbandry techniques the milk yield per cow can hardly be increased. As the family grows more cows have to be kept. The pastoral societies too experience a population explosion and there is therefore a constant need to increase cattle numbers. The impact of droughts and epizootics which used to regularly reduce the cattle population has been lessened by water development and veterinary measures so that herds are quickly built up to reach the carrying capacity of the land. The carrying capacity does

not, however, constitute a binding limit for the individual pastoralist since land is common property. As a rational man he will tend to maximize his share from the common land in favour of his private herd. As long as there is still a chance of a cow giving another calf and of a steer putting on another pound of weight it is worthwhile keeping the animals. This, however, means that as long as there is such a discrepancy between the responsibility (and interest) for the grazing and that for the cattle there is an inbuilt mechanism for overstocking and overgrazing with consequent destruction of the environment. This process is the quicker and the more dangerous the lower the natural potential. It assumes disastrous dimensions during abnormally dry years which serve to bring into the open the inherent mechanism of pastoralism for self-destruction.

The solution to this problem will in no case be found in training of the pastoralists unless one deems it possible to teach a man *NOT* to try to survive by maximizing his share from a diminishing resource, nor will the solution lie in any technical progress or innovation alone. Rather the situation calls for a change of the organization of production.

In a few African locations, European settlement during this century has resulted in a change in organization. Ranches have been established, often in areas with high potential, much as they were in Australia and with much the same history of antagonism and misunderstanding between the settlers, the indigenous peoples and the colonial administrators. These ranching areas, as for example in parts of Kenya, have followed much the same pattern as in Australia. Although they have not enjoyed the same benefits of an institutional and infrastructural nature, nor the same support and sympathy from governments and the general community, they have had some relative economic advantages in terms of land prices and labour costs. European ranchers in both Africa and Australia now face economic and ecological problems to which there are no clear or proven answers.

During the last decade, changes in the organization of some indigenous pastoral communities have also taken place, notably in Kenya and Uganda (see, for example, Pratt 1968; Jahnke, Ruthenberg & Thimm 1974; Nsubuga 1975).

Although it is too soon to be certain about their ecological or economic progress and viability, the early indications in Kenya are that, except for individual ranching schemes, these developments (i.e. group, cooperative, company and commercial ranches) are socially viable (Simpson 1973) and 'appear to be one of the economically more successful agricultural projects in Africa south of the Sahara' (Jahnke *et al.* 1974). The Ankole-Masaka ranching scheme in an area of higher potential in Uganda has been judged to be successful economically, socially and technically (Nsubuga 1975).

Techniques used for measuring economic returns from rangeland projects have been criticized because they frequently use parameters which do not fully comprehend the degrees of risk and unpredictability which are inevitably involved. It has recently been proposed that Monte Carlo simulation techniques might appropriately be used to estimate these risks and their consequential effects in rangeland projects (Gunawardena, Simpson & Wynne 1975).

The ecological consequences of ranching projects in Africa are still being studied and no definite conclusions are yet possible. It is certain that a conservatively stocked and well-managed ranch can conserve and even improve the range resources. For example, it was reported that Skylab photographs showed that the Toukounous ranch was the only island of vegetation in the whole of the drought-stricken country of Niger (Catinot 1974). However, there

has never been any doubt that range and animal management is comparatively easy provided that there is no necessity, for economic or subsistence reasons, to maximize stocking rates all the time. Ranches maintained by governments or aid agencies, such as are found in many countries of Africa, have often been technically successful but, although their accounts are not usually made public, their economic viability appears doubtful.

Many of these ranches have served as breeding centres or as demonstrators of improved management. They have benefited from a substantial supply of information produced by the several African research institutions concerned with rangeland management and animal production and health. Much of the older research literature is located in libraries in Belgium, France, the Federal Republic of Germany and the United Kingdom, while F.A.O. publications contribute a valuable source of recent material, especially for the new African states. Among recent reviews and bibliographies which are particularly helpful are those by Barrés (1974), E.C.A. & F.A.O. (1972), E.C.A., F.A.O. & O.A.U. (1973), Reinhold (1971), Deramee (1971), F.A.O. (1972), I.E.M.V.T. (1973), Le Houérou (1973), Meyn (1970), Pagot (1971 *a, b*) and Pratt (1972).

However, for several reasons this accumulation of knowledge has had only a limited impact in practice. Extension services, particularly among nomadic pastoralists, are generally inadequate and, in any case, work in extremely difficult situations, frequently among conservative and illiterate peoples whose aims may be markedly different from those which underly the research that has been carried out.

Where there are communal systems of land use it is extremely difficult to introduce successfully such practices as improved grazing schemes or exotic breeds or crosses which may be readily susceptible to local diseases and infections. The cost of innovation is often beyond the capacity of pastoralists who may have little opportunity for, or understanding of, appropriate lending arrangements. Communal land is unacceptable as a security to credit banks which may also suffer from a lack of administrative control over the borrowers. National exchequers, also, may find it difficult to meet the initial and continuing costs which inevitably arise when changes in the rangelands gather momentum.

In the past, development in the arid and semi-arid zones of Africa has frequently been stimulated by the enthusiasms of particular individuals or organizations, sometimes technical or administrative, often political, who may encourage the introduction of, say, a new stock route, cattle market, field abattoir, grazing scheme, bore hole, dipping scheme, research station or bull breeding ranch. Such isolated and non-integrated proposals have usually failed to achieve their desired impact and sometimes they have even caused serious harm (Baker 1974), partly because of inappropriate technologies and administrative weaknesses, but mainly because of the failure to recognize that development is a continuous and complex process. Improvements may be technical (e.g. diseases control), social (e.g. reform of land tenure), or economic (e.g. credit facilities or improved marketing organization), but they must occur in an appropriate order in relation to one another if they are to have the desired result (F.A.O. 1967; Tribe *et al.* 1970).

Repeatedly, when recommendations have been made by teams of rangeland and animal specialists for the development of the livestock industries throughout sub-Saharan Africa, attention has been drawn to the need for integrated programmes in which steps to improve rangeland management, livestock movement and marketing, the control of stocking rates, and better extension activities should all go hand-in-hand with disease control and water development. However, the more complex developments, many of which involve social change and

continuing high costs, do not have the political or administrative appeal of, say, schemes of water development or animal vaccination. Thus the full recommendations have often been postponed while isolated measures have been adopted because they have been regarded as easy and likely to lead to quick results.

Although such measures may help to gain the pastoralists' interest, and perhaps even their confidence, they do nothing to resolve the central problems of land tenure, credit and management. Indeed, the main consequence of improving animal health and making available more water in isolation has been to increase further the animal populations, the grazing pressures, the overstocking and the degradation of range resources. For example, in 1970 there were about 560 000 users of the pastoral hinterland of the Delta in Mali compared with 200 000 in 1968 (Gallais 1975).

Three factors which have together accelerated the present declining situation in the dry, pastoral zones of Africa are advances in medical services, advances in veterinary services, and water development. The result has been an increase in the human population beyond the level that the land can support (F.A.O. 1974*a*; Le Houérou 1975). In turn this has produced the need to maintain increased numbers of stock to provide subsistence for the greater number of people. The disastrous effects of the Sahelian drought from 1971 to 1974 were the consequence of the unprecedented build up of human and animal populations during the preceding decade. People and livestock used to die of hunger, water deprivation and disease, often soon after birth. The introduction of improved medical and veterinary services, e.g. vaccination programmes, enabled increasing numbers to survive into adulthood when the range resources, limited by serious, although not unprecedented, drought, could no longer provide subsistence for beast and therefore for man.

However, it is a misleading oversimplification to blame the veterinarian and the water engineer for the present problems of overstocking. Their work has afforded a new level of security to pastoralists by eliminating or reducing risks which previously decimated their flocks and regularly threatened their livelihood. This achievement has provided conditions in which pastoralists may now be prepared increasingly to change their traditional attitudes towards their stock, to restrict the size of herds and flocks, to recognize the importance of quality as well as quantity, and to trade stock surplus to their basic needs (Gallais 1967).

The essential problems posed in *Limits to growth* (Meadows, Meadows, Randers & Behrens 1972) are seen in their simplest and most brutal form in such regions as the arid and semi-arid zones and here, more clearly even than elsewhere, *Mankind is at the turning point* (Mesarovic & Pestel 1975).

The urgency of the problem is generally recognized and, during the last two or three years, there has been a spate of surveys, inquiries, committees and conferences to study the situation and recommend appropriate remedial action (e.g. De Wit 1972; F.A.O. 1974*a, b*; Boeckh *et al.* 1974; F.E.D. 1974; Rockefeller Foundation 1975; Ministère de la Coopération, Fonds de l'aide et de coopération, et Organisation pour la Mise en Valeur du Fleuve Sénégal 1975). These reports are valuable because together they provide a detailed and comprehensive coverage of the problems and of the steps that might appropriately be taken to alleviate them. Yet the completeness of their coverage and their detailed thoroughness themselves constitute something of a disadvantage.

Those who have had experience of such committees and conferences, particularly those of an international nature, will understand that their lists of conclusions and recommendations need

to embrace and reflect a broad range of technical, socio-economic, institutional, national, political, disciplinary and, even, personal, considerations. Such comprehension tends to confuse because it is often difficult to identify agreed priorities and consequently 'the thrust and objectives (of livestock development projects) vary considerably and often are contradictory' (I.B.R.D. 1974).

A less complex, even an over-simplified, analysis can lead more directly to the essential core of the problem which is the urgent need to limit the future increase of human and animal populations in the pastoral zones and to encourage the movement of surplus populations to zones of higher potential.

Population control and redistribution

Of the first importance is the control and redistribution of human populations since if this is achieved the subsistence need for higher animal populations is then itself removed. Apart from stressing the need to develop and extend suitable means of birth control, and to urge that the necessary biological and social research and education should be initiated without delay, it is outside the scope of this paper to deal further with this topic.

The redistribution of pastoralist peoples in areas of higher potential has been taking place voluntarily in some locations for several years (Stenning 1974) and the problems of the pastoral areas cannot be solved without accelerating and extending this process (De Wilde 1967; Kraus 1965).

However, the populations in the higher rainfall areas are themselves increasing and, in consequence, areas of cultivation are being pushed further out into the pastoral zone.

Apart from encouraging policies of population control in all climatic zones, there are two other possible ways of accommodating additional numbers of agriculturalists and redistributed pastoralists. The first, for which there appears to be considerable scope, is to increase productivity, crop and animal, by means of improved technology in the high potential country. The second, is to find some means of making habitable, by both man and livestock, the vast areas of potentially good country now infested by the tsetse fly (*Glossina* sp.).

In this connection the work of the recently established International Laboratory for Research on Animal Disease (I.L.R.A.D.), with its headquarters in Kenya, will be of great importance. This laboratory has been established specifically to investigate immunological methods of controlling trypanosomiasis and Theillerial infections. If vaccines can be produced for large-scale use in the field, or if the efficacy of drugs can be improved, a tremendous opportunity will have been opened up for resettling agriculturalists, pastoralists and their animals and so relieving the existing pressures on limited resources.

Exciting though this possibility is, it needs to be remembered that the development of trypanosomiasis controls is likely to be an extremely difficult and lengthy procedure and, even if accomplished successfully, the operations of resettlement in previously uninhabited country involve social, economic and management problems of great complexity. Moreover, in many parts of West Africa, even if trypanosomiasis is brought under control, there remains the important problem of onchocerciasis.

The multi-disciplinary approach

Although further research on many animal and rangeland problems is still needed, the accumulated results already reported from the several national and regional research centres operating in Africa now provide a substantial foundation of technical knowledge on which to

base development projects. The depressing fact is that this knowledge is largely unused because it has not been contained in any overall context of production systems and further disciplinary studies of the traditional type are unlikely to be any more useful. For several years it has been increasingly obvious that there is a need for 'a whole new field of integrated research involving a study of the effect of development and of specific inputs on the social structure and habits of the people, on livestock performance and on vegetation and land use' (Pratt 1968). Phrases such as 'the multi-disciplinary approach to animal production systems', or something similar, crop up again and again in the development literature of recent years (e.g. Tribe, Nestel, Pratt & Thomé 1973) but the meaning is not always clear.

The 'systems approach' can lead to a relatively precise analysis and definition of inputs and parameters, to simulation studies and the building of models which can be expressed mathematically (see, for example, Swartzman & Van Dyne 1972). However, in the context of African pastoralism mathematical precision may be illusory and the integrated study of particular ecological, economic and social systems, such as those of the Tanzanian Masai, the West African Fulani or the Afars of Ethiopia, is likely to be far more empirical yet still extremely useful. An interesting example of the use of a 'descriptive' systems approach has recently been published by Chudleigh (1976) for the small-scale dairy production systems in the high potential areas of Kenya.

The International Livestock Centre for Africa

The need for multi-disciplinary research concerned with the application of knowledge to the immediate and practical processes of development has led to the establishment by the Consultative Group on International Agricultural Research of the International Livestock Centre for Africa (I.L.C.A.), with its headquarters in Ethiopia.

The specific focus of I.L.C.A.'s programme is integrative research centred upon the multi-disciplinary study of existing animal production systems and the formulation of new or amended systems. These studies necessarily involve social anthropologists and economists as well as biologists and seek to:

quantify vital herd statistics, husbandry methods and animal performance in relation to the environment and to the material and cultural needs of particular societies;

establish relationships between the biological, environmental, social and economic components of production systems and identify points in the systems which are sensitive or resistant to change;

identify those specific topics in which a lack of knowledge limits development and in which disciplinary research is therefore a priority need.

In addition I.L.C.A. has given high priority to the establishment of a comprehensive and bilingual (French and English) documentation and information service. Finally, it is developing a capacity to organize seminars and training courses for those engaged in livestock research, extension, planning and production, in order particularly to increase regional competence in the multi-disciplinary 'systems' approach to livestock research and development (see, for example, I.L.C.A. 1976).

It is an ambitious programme and in itself constitutes an interesting experiment. No one should underestimate the difficulties of organizing and managing an international, multi-disciplinary team with pan-African responsibilities. However, the support of the donor members of the Consultative Group on International Agricultural Research and the cooperation and encouragement of African countries has enabled I.L.C.A. to start its work with enthusiasm and confidence.

Nevertheless, the ultimate goal of conserving and improving the animal resources of the semi-arid zones of Africa will not be achieved simply by research activities, however well-planned and executed these may be.

The problems facing African livestock planners are curiously similar to (though of a different order from) those facing planners in Australia – although for different reasons. In both places the ecological and economic limits to production are more closely set than has yet been generally acknowledged. Stability, in every sense, involves a balanced system of management in which the pressures of people and animals are kept in equilibrium with available resources. No matter which part of the world we are thinking about, the prerequisites for achieving such a system are first the knowledge and understanding that result from multi-disciplinary research and second the social and economic changes that result from enlightened community behaviour and courageous political action.

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Discussion

W. E. ORMEROD (*London School of Hygiene, WC1E 7HT*). Professor Tribe has suggested that a possible means of relieving pressure on the Sahel would be to settle the Fulani herdsmen in more humid zones to the south after large-scale tsetse eradication. Contact with tsetse and the losses through trypanosomiasis that result from this contact are, apart from starvation, the main restraint on increases in the Fulani herds. It is possible, if this restraint were removed, such being the demand for meat, that this zone would also become overgrazed without relieving pressure on the Sahel which is so attractive to the Fulani as a breeding area: consequent southward movement of the Sahara could result. This possibility has been considered in greater detail by Ormerod 1976, *Science, N.Y.* **191**, 815 (February 27).

S. SANDFORD (*Overseas Development Institute, 10–11 Percy Street, London W1*). The practice of always using or recommending as an insurance policy ‘conservative’ estimates of livestock carrying capacities in semi-arid areas is unsound. In areas of unreliable rainfall the only truly ‘conservative’ estimate is that no livestock should be carried at all. This, by *reductio ad absurdum*, showed the high cost of this sort of insurance policy in terms of production foregone.

Various speakers had claimed that adequate scientific and technical information already exists to improve productivity in semi-arid areas. But, in estimating livestock carrying capacity of the same area of rangelands in Southern Ethiopia, four of the most well-qualified people to make such estimates had differed by a factor not of 25 % but of 500 %. In the light of this sort of discrepancy, claims that adequate technical knowledge already exists cannot be justified.

E. B. WORTHINGTON (*I.B.P., c/o The Linnean Society, Burlington House, Piccadilly, London W1V 0LQ*). Throughout the symposium there has been very little mention of the indigenous grazing and browsing mammals which evolution has produced in both Australia and Africa, very beautifully adapted to the primary production of plants. How does their competition for food and immunity from local diseases relate to the cattle, sheep and goats, all of which have been introduced from Asia? Is there a place for the indigenous fauna in the food-producing industries of arid and semi-arid lands, comparable, for example, to the place of red deer in the Scottish highlands?

A. B. RAINS (*Land Resources Division, Tolworth Tower, Surbiton*). Professor Tribe has mentioned the harmful results of developing water and providing veterinary prophylaxis in semi-arid areas when these have not been components of comprehensive schemes; he also welcomed tsetse eradication projects in areas of higher rainfall.

Because of a failure to follow up and regulate the subsequent use of many cleared areas, I believe that the results of successful tsetse eradication projects may be as disastrous as the introduction of these other measures has been.

J. SWIFT (*I.S.I.O.*, *Sussex University, Falmer, Brighton*). Professor Tribe's description of increasing indebtedness among Australian cattle and sheep farmers invites comparison with rising indebtedness to village moneylenders and merchants among traditional nomad pastoralist communities in Iran, Afghanistan, Turkey and Greece. This has ecological consequences. People who are getting deeper into debt are likely to exploit the land more intensively, and eventually to overuse it. They are also more susceptible to famine.

This is a good example of the need for a proper understanding between economics and ecology. In particular I suggest we need to identify the economic and social conditions, like rising indebtedness, in which land degradation takes place. In this field information is seriously deficient.

I would suggest that there is evidence that some, not all, traditional societies set up ecologically sophisticated land-use systems. These have recently broken down because, as I suggested yesterday, the land-users are losing control over their economy and over their environment as a result of increasing dependency on outside economic and political processes; rising indebtedness is one example, and there are many others. If this is true generally, in order to reverse the degradation of the land, it is necessary to encourage new economic and social conditions which reduce dependency, and which increase effective power of economic and ecological decision-making at the level of land-users.

This suggests a new set of decentralized and low-level development strategies, very different from the capital-intensive, centralizing, high-technology development currently in vogue. Such new strategies might include simple technical measures like the water conservation and spreading techniques described by Dr Hadley this morning, but should cover the whole economic, social and ecological dimension of development.

D. E. TRIBE (In reply to the discussion). The presence of tsetse frequently has the effect of conserving natural resources such as soils, water and vegetation. The lack of water development also has a similar effect. It is imperative that tsetse eradication and water development should always be seen as only one part of a comprehensive and rational plan for the long term use of natural resources.

There is no doubt that more information is required in the field of rangeland ecology and management. Nevertheless, it is essential that we should try and utilize as effectively as possible the considerable amount of technical information that is already available. It is sensible in our present state of incomplete knowledge to recommend the use of 'conservative' stocking rates and it is not logical to argue that 'the only true "conservative" estimate is that no livestock should be carried at all'.

It has been suggested many times that indigenous fauna, particularly the plains game of East and Central Africa, might be more efficient as producers of meat than introduced species such as cattle, sheep and goats. Unfortunately, every attempt to do this has so far failed. There are many technological problems concerned with wildlife harvesting, processing, transportation and marketing. In addition, the underlying ecological assumption that exotic species are less efficient than indigenous fauna deserves further examination. The present evidence is inadequate

but some of it, at least, indicates that cattle, sheep and goats are in some ways better adapted to fragile environments (e.g. low nitrogen and high roughage intakes, drought, water shortages and climatic extremes) than are many indigenous species. The interaction between ecological and socio-economic factors which press upon pastoral communities deserves much more detailed investigation. I warmly support the views expressed by Dr Swift and assure him that the staff of I.L.C.A. is now studying the range of conditions to which he refers in the hopes of formulating effective new strategies of the type he has in mind.