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| 9. ABSTRACT This paper considers tsetse fly eradication and its implications in a broad context. Tsetse fly control is discussed in terms of both the problems it poses which are specific to tsetse flies and trypanosomiasis and those which pertain to larger issues such as new lands development and resource protection of which tsetse fly control is but an aspect. The author attempts to draw together many diverse strains of thought from a wide range of sources and to present in succinct form the major issues raised by the possible development of cheap and effective eradication technologies. There are thirty some species and sub-species of tsetse fly each with a preferred habitat and well defined behavior patterns. Thus in a given area, plans for the eradication of tsetse flies must be targeted for the species of fly present. Modern eradication technologies can effectively clear tsetse flies from the control area. The ease, effectiveness and relative low cost with which tsetse can be controlled raise the question of the land use implications of tsetse fly eradication. This paper addresses itself to these secondary impacts. Tsetse fly eradication projects must be part of a broader development effort attacking all relevant constraints. Failure to manage any one may limit the success of the whole program. For an eradication project to succeed, a land use scheme for the entire area must be ready to be put in place immediately. The maintenance of fly barrier zones around control areas must be guaranteed until habitat modification and game displacement have rendered them unacceptable to tsetse fly. Without concurrent population control efforts, tsetse fly eradication will be only a short-term palliative. Limited alternatives to tsetse fly control exist for the development of the fly belt. Further research is needed and more consideration should be given to such options as tourism. | | | | | |
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TSETSE FLY ERADICATION AND ITS IMPLICATIONS

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PREFACE

In the following paper an effort will be made to consider tsetse fly eradication and its implications 'in the round', placing the question in a broad context. Tsetse fly control will be discussed in terms of both the problems it poses which are specific to tsetse flies and trypanosomiasis and those which pertain to larger issues such as new lands development and resource protection of which tsetse fly control is but an aspect. This paper is intended to be neither definitive nor to add substantively to the debate. Rather, it is an attempt to draw together many diverse strands of thought from a wide range of sources and to present in succinct form the major issues raised by the possible development of cheap and effective eradication technologies.

INTRODUCTION

Tsetse Flies, Trypanosomes and the Fly Belt

Those portions of Africa infested with the tsetse fly are referred to as the 'fly belt' or 'fly lands.' Taken as a whole, the fly belt is an impressive area. It lies roughly between 12° N and 20° S (with exceptions in East Africa) and covers some four million square miles or 2.5 billion acres. Of this vast area it is estimated that approximately one fifth -- more than five hundred million acres -- are suitable for extensive grazing or range management practices. This is double the present grazing lands of the Sahel, West, Central and East Africa combined. In comparison to the carrying capacity of the semi-arid zones which is one animal unit (AU) to 16 hectares, the average carrying capacity of fly belt grazing lands is one AU to 4 hectares.

(45, p. 5) Cleared and seeded Guinean Zone areas of the fly belt promise to support as many as one AU per hectare. (19, p. 1)

Because of higher and relatively more reliable rainfall and generally better soils, the lands of the fly belt also have high potential for agricultural development.

The simple label 'fly lands' obscures the complexity of the distribution of tsetse and trypanosomiasis in Africa. There are, in fact, thirty some species and sub-species of Glossina or tsetse fly of which the three main sub-groups are *G. Fusca*, *G. Palpalis*

and G. Morsitans. Each of the major sub-groups has a preferred habitat and well defined behavior patterns.* There also exist several strains of trypanosomes, each of which is highly specific in the species it attacks and the type of tsetse fly which serves as its vector. Thus in a given area, plans for the eradication of tsetse fly must be targeted for the species of fly present. (45, p. 6-7). However, because the subject of this paper is the long-term impact of successful tsetse fly eradication, the diversity of tsetse fly species and habitats will be ignored.

In the same regard, this paper will not discuss the available methods of eliminating tsetse. Eradication techniques have come a long way since bicycle riders wearing tar-coated suits combed range lands for flies or blanket sprayings with residual insecticides were used to free areas. If properly handled, modern eradication technologies can effectively clear tsetse fly from the control area. The development of ultra low volume (ULV) spraying, the hoped for success of the sterile insect release method (SIRM) and the future possibility of the development of a trypanosomiasis vaccine also promise to reduce the primary ecological impacts of tsetse fly eradication to almost nothing. The ease, effectiveness and relative low cost with which tsetse can be controlled raise

* See Appendix B for maps of the distribution of the major tsetse fly species.

the question of the land use implications of tsetse fly eradication. It is to these secondary impacts of tsetse control that this paper is addressed.

The Problem

Livestock production and to a lesser extent human habitation in tsetse fly must be targeted. The species of tsetse fly are restricted in those areas of Africa infested with the tsetse fly (p. 67). However, because the subject of this paper is tsetse fly, until quite recently the restriction on use of these lands did not pose a serious problem, although as early as 1920 reports began to appear of the tremendous potential for meat and agricultural pro-

duction that might be realized if only the fly could be eradicated. There existed sufficient fly-free land to support the animal and human populations under traditional 'slash and burn' agriculture and nomadic cattle herding. The continuing, rapid growth of population, the lack of incentives to intensify agricultural and livestock production and the resultant land pressure, however, have created a new situation.

Systems of production have not been improved and in many places existing land use patterns are causing a reduction in the natural productivity of the land. Staple food production has not kept pace with rising population and in several countries has actually declined. Many governments have been forced to purchase larger and larger quantities of grain abroad. Development programs and social services have broken down under the weight of persons fleeing the countryside.

for urban centers ill-equipped to deal with them and lacking employment alternatives. National planning priorities which once largely ignored rural areas and envisioned industrialization as the 'engine of development' have had to be abandoned. New development schemes have replaced them, intended to endow countries with the capacity to feed themselves, to provide new employment opportunities in agriculture that will hold rural populations in place and to raise rural incomes.

The Sahelian drought and the international food crisis which accompanied it brought these issues into sharp focus. In the late 1950's or early 1960's livestock numbers reached and exceeded the maximum carrying capacity of the semi-arid Sahel in West Africa and its East African equivalent given current levels of management and the declining condition of the range. The combination of a strong demand for meat, improved animal health measures, unusually good rainfall and the construction of a number of unmanaged water resources drove cattle and small ruminant populations far beyond safe stocking rates. A.I.D. experts estimate the maximum, safe carrying capacity of the Sahel in the 1960's to have been 6.7 million animal units. In 1972 the Sahelian range held 14.7 million animal units. (16, p. 1) Simultaneously, population and land pressure, coupled with the unusually favorable and regular rainfall, led to the encroachment of agriculture on grazing lands and the bringing under cultivation of many sub-marginal areas. Overgrazing, erosio

a reduction of the land's productivity and eventually desertification in some areas followed.

When the rains failed in the late 60's nature restored the balance. Five to six million animals died and the range lands failed to produce. As a result of relatively effective international relief efforts, losses among the human population of the Sahel were negligible. The land resource, however, suffered a serious decline in productivity.

This deterioration of the productive potential of the land base in much of the semi-arid zone, coupled with excessive and rapidly rising populations of both humans and animals, present crucial development problems. Ways must be found to produce high, sustained yields from the land without destroying it. Unfortunately, the Sahel and other semi-arid areas cannot "support the presently attempted level of activity, let alone that required for increased production."

(45, p.3) Moreover, unless much of the most severely overgrazed land is either temporarily taken out of use or allowed to recover under careful management, it may suffer an irreversible loss of productivity. As one expert states, "the only feasible means of stopping the deterioration of the Sahel range and achieving any measure of development and recovery is to reduce the grazing pressure and to implement a seasonal grazing rotation program over much of the area. The alternative appears to be certain desertification of the Sahel and the loss of livelihood of four to five million people." (16, p. 1)

but the people of the region are already among the poorest in the world and, as one commentor asks, "If they are putting too much pressure on the land now just to maintain their present standard of living, how are you going to set any of it aside and prevent its use?"

(48, p. 25). "The only realistic solution," writes Lloyd Clyburn, "to the problem of excess pressure on the Sahel is in alternative opportunities or endeavors elsewhere for those forced out and those who would willingly choose to leave the areas." (19, p. 1) Facilitated migration into the fly belt seems to offer one of the major options for achieving this end.

A wide ranging debate is underway over these issues of African development in general and the opening of new lands by tsetse fly eradication in particular. Although there seems to be little doubt that eventually the lands infested by the tsetse fly will be brought into production, the problems of how and when this shall be done, and to what end the new lands will be employed afterward are being hotly contested.

The debate over tsetse fly eradication involves entymologists, agronomists, livestock experts, economists, rural sociologists, environmentalists, conservationists, development planners and, of course, politicians. It is a debate over the costs and benefits of opening new lands to human exploitation. Increased production, relief of land pressure and the possibility of long-term changes in regional

land use patterns are being weighed against the risk of environmental degradation, destruction of wildlife and the disruption of traditional societies. At the heart of the debate are the questions of the capacity of planners and politicians to conceive, implement and manage successful, large-scale development programs in areas of tsetse and their priorities in doing so.

Tsetse fly and trypanosomiasis have long been recognized as primary obstacles to the development of large areas of Africa. Efforts to eliminate the fly and to bring new lands into use have often failed, however, because insufficient weight was given to the multitude of other constraints to the full exploitation of those areas. "Diseases like trypanosomiasis, malaria, East Coast fever, but also problems of human and animal nutrition, of poor husbandry standards, erosion and others are all aspects of the complex reality of Africa. For analytical purposes it may be necessary to single out a problem like tsetse and trypanosomiasis. The danger, however, is that one then loses sight of the context, of the relative importance of other problems and of ... overall development objectives..

(38, p. 109)

Tsetse fly eradication, unlike the construction of access roads and fire breaks, can be considered neither a 'discrete entity' nor 'terminal by nature.' (16, p.7) Its costs must be assumed to include those of all subsequent development necessary to make a newly opened area productive, since "the full benefits of tsetse fly eradication ca

only be obtained within a system in which all other constraints have been eliminated or are at least brought within manageable limits." (7, p. 24) Otherwise, the effort will have been wasted.

Full account must also be taken of the risks involved in opening new lands through tsetse fly eradication or the circumvention of the trypanosomiasis constraint by some other means. As one observer asks of the possible environmental impacts of clearing tsetse fly from an

If opened to grazing only, what are the chances of overgrazing the environment, effects on wildlife, destruction of ground cover, wind and water erosion? If an increase in human habitation follows, what effects might this have? (burning fields, pollution of streams and lakes, destruction of trees for fuel, erosion due to gardening or trail making, increased human population, eviction or destruction of wildlife, construction of new roads, homes, schools, etc.). (53, p.4)

Consideration must be given to the risk that tsetse control efforts will set up conditions for an epizootic, and possibly an epidemic of trypanosomiasis. Settlers may also run the risk of contacting or spreading other diseases.

Proponents of tsetse fly eradication efforts cite a number of reasons for clearing tsetse fly infested areas for human and animal use. The opening of new and often fertile lands would immediately add badly needed food production potential. The fly belt is underutilized while the naturally less productive and less reliable semi-arid areas nearby are not only overpopulated and overstocked given current levels of management, but are declining in productivity. This pressure for land resources has also led to the piecemeal

exploitation and degradation of portions of the fly belt, the disease risk notwithstanding. These lands could be developed with range management programs, modern husbandry and agricultural techniques, and improved animal and human health services that would increase productivity without threat to the environment or humans. Those urging eradication hold that sufficient technical know-how exists to plan development schemes for reclaimed areas beneficial enough to counterbalance the risks of such interventions.

Those forces opposing tsetse fly eradication or urging extreme caution in its use do not fail to recognize the seriousness of the situation in the Sahel and portions of East Africa. They believe, however, that tsetse fly eradication is neither a necessary nor a desirable tool for overcoming it because of the serious risks involved. Few, if any, of these people are 'development Ludites' counseling the preservation of vast, pristine stretches of wildlands at the expense of people. Nor do they believe that inaction and the tsetse fly will preserve the fly belt intact for future generations. Most, however, would agree with Rene Dubos that,

he survival, let alone growth, of (man's) complex societies implies that he will continue to exploit and therefore to upset nature. The real problem, herefore, is not how to maintain the balance of nature, but rather how to change it in such a manner that the overall result is favorable for the human species. (33, p. 70)

The objections most opponents of tsetse fly eradication raise stem from the failure of such projects to meet this final criterion. The past sixty years hold few examples of successful eradication efforts and worse, as an A.I.D. report laments, "the intended results of many earlier development programs are being eroded with the landscape." (3, p. 21)

Those counseling caution in tsetse fly eradication argue that for the time being development should aim to tap the great potential for increased production through improved or alternative means in already utilized areas. The risks to the environment, to wildlife, to people and ultimately to the productivity of the fly lands are such that even the present situation does not justify major eradication efforts. They doubt the capacity of development planners to design and manage large, integrated projects involving the total transformation of areas and peoples. All agree that it will be difficult for African governments to make and enforce the hard political decisions necessary to implement the policies and controls required if such projects are not to become the 'poisonous gifts' so many others have been.

Tsetse Fly Eradication as a Land Use Problem

Tsetse fly eradication is at bottom a land use problem. Habitats modified by man's use whether cultivation or grazing are generally unacceptable to the fly. In a stable situation man and fly remain in balance, neither encroaching upon the other's preserve. The serious

disruption of human settlement, however, can bring about the infestation of hitherto fly free zones. Conversely, cultivation, tree clearing, game displacement and the other aspects of human settlement may result in the 'natural' reclamation of portions of the fly belt.

Since the late nineteenth century this pattern of disruption and reclamation has been repeated on numerous occasions around Africa. In the final decades of the last century a series of traumas disrupted much of Africa. Slaving reached its peak in the 1860's and the wars it touched off as well as others resulting from a general shift in political power throughout the continent left many areas depopulated or in a state of confusion. Then in the 1890's a rinderpest epizootic decimated cattle herds and left huge tracts of grazing land empty. Game herds filled the vacuum and the tsetse fly followed, sparking terrible epidemics of sleeping sickness. In one district of Uganda 200,000 people died from sleeping sickness out of a total population of 300,000. (40, p. 728)

Fly control efforts and the consolidation of colonial rule helped stabilize the situation. Slowly domestic animal and human populations began to increase and as they did the fly retreated. In Sukumaland, Tanzania, for example, between 1938 and 1947 the fly belt receded 1000 square miles to the west and 2500 square miles

to the east as a result of an increase of the human population of the area by 300,000 and of the herd (cattle and small stock) by 750,000.* (28, p. 232-233) Similarly, the removal of tsetse flies from much of southern Busoga, Uganda can be attributed to a change in population density from 63 people per square kilometer in 1952 to 101 per square kilometer in 1962. (38, p. 120)

It is not enough, however, simply to reclaim land from the tsetse fly, for unplanned land use may quickly destroy the new resource as has often been the case in the past. From the economic point of view, Hans Jahnke suggests that "this implies that it is not so much the cost of controlling tsetse flies and trypanosomiasis which are of interest but the economics of putting land in which the problem prevails to productive use." (38, p. 24) The success or failure of any given reclamation project will turn on the capacity of those planning the area's subsequent use to bring the entire control zone into production in an environmentally sound way.

Disease Control

Early tsetse fly and trypanosomiasis control measures aimed at protecting areas where flies were invading in the wake of the disruption of human settlement. With increasing population pressure habitat modification practically eliminated the need for these types of control efforts. Today fly control measures focus on those areas

*See Appendix C for detailed account.

where land and grazing pressure are destroying the natural productivity and dangerously forcing people to exploit land still heavily infested with tsetse.

Ironically, disease and fly control measures designed to open new areas bring with them the serious task of trypanosomiasis epizootics and epidemics among settlers and their herds. Unless sufficient settlement and land clearing take place to permanently alter the habitat so that the fly and game cannot return, a system of shear cleared barrier zone must be maintained and periodic respraying may be required. The disruption or even reduction of barrier maintenance efforts may result in fly reinfestation with serious loss of livestock and possibly human lives.

John Ford, author of The Role of Trypanosomes in African Ecology considers this risk one of the most serious posed by tsetse eradication programs.

In some countries ... control services have survived in full or even greater vigour the end of colonization. In them the application of tsetse elimination techniques at very high costs creates situations which promise to be even more dangerous than the almost total lack of services to be seen elsewhere. In the latter case the mechanism for natural readjustment to infection, both ecological and physiological, still exists. Where a policy of extensive elimination of *Glossina* (tsetse) or of the trypanosomes is pursued, often with the use of external financial aid on a scale unrelated to the potential of the country for economic growth both these mechanisms cease to operate. (28, p. 490)

The threat of reinfestation remains, however, and as he concludes, "the reduction of expenditure or relaxation of effort must be followed by catastrophic losses of cattle." The same is true for people as is made clear, for example, by the sleeping sickness epidemic which swept Zaire following the collapse of an extensive control program after independence in 1963.

The focus on tsetse fly and trypanosomiasis, indeed even the label 'fly belt', ignores numerous other disease constraints to the use of these areas. A CGIAR pamphlet claims that, "it is estimated that a land area even greater than the continental United States is not optimally utilized for cattle production because of a single disease -- trypanosomiasis." (CGIAR, New York, 1976) The pamphlet, however, fails to note that an ecology favorable to tsetse may also harbor the vectors for malaria, schistosomiasis and onchocerciasis in humans, and East Coast fever, hoof and mouth, anthrax, fly and tick worry, and streptothricosis in animals. All the problems related to the control or management of these diseases must be considered in framing development plans for tsetse fly eradication projects in areas which may contain them. Failure to do so may result in still another contribution of 'development' to the spread of disease.*

*For a good discussion of this problem, see Charles C. Hughes and John M. Hunter, "The Role of Technological Development in Promoting Disease in Africa," in The Careless Technology, eds., Taghi M. Farvar and John P. Milton (Garden City: The Natural History Press, 1972), pp. 69-101.

The Relief of Land and Population Pressure

A basic tenet of the argument in favor of tsetse fly eradication is that the lands of the fly belt are virtually empty and so provide a potential home for people and animals moved off damaged areas.

An important corollary is the assumption that the tsetse fly is in large part responsible for the overuse of the fly free zones.

Insofar as the latter contention is concerned, in many areas large tracts of useable, fly free lands exist. Hans Jahnke notes, "In an analysis of land use in Uganda I have shown that going by present average size of holdings and by the estimated grazing requirements of the livestock, the 'unused' agricultural area is almost twice as large as the area presently infested by tsetse flies." (38, p.114-5)

He concludes that "the general claim that tsetse fly infestation caused over-utilization of surrounding areas cannot be maintained" and that "the reasons for high population densities and land pressure in certain parts of Uganda do not lie in land scarcity caused by tsetse infestations." * To determine whether or not th:

* Jahnke also cites the Chief Tsetse Officer's Handing Over Report from 1971 which is studded with such comments as "The major problem was that there were not even enough people to settle the barrier area, not to speak of the whole control area" and "Land use intensity within the control areas is so low that the tsetse habitat remains unaltered, ready to accommodate the fly again at any time." Of the Ankole area where A.I.D. assisted in tsetse eradication efforts, the Chief Tsetse Officer's report notes,

In Ankole a huge barrier is to be constructed along the Tanzania border in order to prevent re-infestation from the south. The prospects of settling cultivators within the barrier zone are poor. Thus regular re-slashing of the vegetation or burning with flame throwers will be necessary. Hunters have to be stationed permanently along the barrier to prevent game movement and pickets have to be operated along the roads, both to prevent passive transport of flies into the reclaimed area. Whether Tanzania will eradicate tsetse on their side of the border is not clear and cooperation between the two countries cannot be anticipated in the near future. (37, p. 46-48)

same situation exists elsewhere in East Africa or in the Sahel will require further research. It does suggest, however, that attention must be given to other factors contributing to the skewing of population distribution.

In response to the basic contention that the fly zones contain large areas capable of absorbing the excess human and animal populations of the arid and semi-arid range lands, it must be pointed out that there is considerable local variability in the availability and quality of land in the belt. In East Africa as well as parts of the West African savanna where high population densities exist, the fly belt has been reduced to those areas which are otherwise unuseable. In the Zambezi Valley, for example, by 1949 the fly belt contained 60% of those lands considered totally unuseable while very low quality or unuseable land comprised fully 76% of the fly belt. (27, p. 667) Jahnke's analysis of the tsetse infested areas of Uganda reveals that 25% of this land is unuseable and that an additional 15% is already in use, leaving only 60% available for more intensive productive use. A look at the Mali Range Survey analysis of the Kita Project Area (the most promising of three) indicates similar figures. Of the entire project area, 30% is already under cultivation and an undetermined amount is either being grazed or is unfit for use. (24, p. 3/10-3/22)

Considering the high carrying capacity and soil fertility of these areas, the remaining lands are not insignificant and could undoubtedly absorb a large number of people and animals. As Jahnke points out, however, the cost of clearing the entire area and of maintaining it fly free must be borne by the subsequent productivity of the useable new lands. In the case of cattle production, he argues that this will not be possible unless at least 75% of the cleared land is suitable for productive use and has a carrying capacity of at least one AU per four hectares. (38, p. 123)

These areas, particularly those where natural fly barriers exist, are quite a small portion of the fly belt as a whole. In the case of Kita in Mali, for example, in order to control the fly within the area, substantial infested areas outside it will have to be cleared or an extensive fly barrier created.

The presence of cultivators in and near the fly belt also reduces the likelihood that tsetse eradication will provide significant relief for population pressure in the Sahelian ecological zone. Experience indicates that in areas of high land and population pressure it will be extremely difficult to contain local populations and 'save room' for people to be resettled from the outside. This is especially true of the situation in West Africa where ethnic groups are stratified by climatic zones. Local people will be better prepared to exploit new lands than outsiders from entirely different ethno-environmental backgrounds. Under such circumstances, the only

likely role for the Sahelian nomad will be that of mercenary
order. (17, p. 2-3) The very ethnic difference of the
settlers is also likely to arouse the hostility of local peoples
when competition for new lands occurs. Further, "because
livestock, particularly the unimproved African breed types, are
inefficient in their conversion of fodder into useable product,...
livestock production tends to give way to food and cash crop
production -- more intensive uses of land -- as soon as population
pressure or price relationships dictate." (29, p. 32) This, too,
tends to favor the agriculturalists of the fly belt.

It is equally unlikely that the mere opening of the fly lands
will have a marked impact on the livestock situation in the Sahel
and other arid and semi-arid areas unless accompanied by successful
livestock control measures. As Lloyd Clyburn comments on a pressure
relief project,

In 1973 or 1974 the World Bank suggested a scheme
that would draw some 638,000 steers off the Sahel
annually for growing and fattening in the Sudan
and Guinea Zones, thus relieving the grazing
pressure by that much. I now doubt that this
necessarily follows. If national herd numbers had
remained constant since say 1953, yes, we could
predict a certain decline. But this has not been
the case. It seems to follow that the 'vacancies'
created by the extraction of immature steers would
soon be filled through the expansion of the number
of females. (14, p. 1-2)

in other words, it is likely that because of the lack of controls on herd numbers and grazing patterns the Sahel would be overstocked regardless of the progressive reduction of the tsetse fly belt.

More importantly, even if sizeable numbers of animals are taken off the land and moved south, without the imposition of stocking controls the Sahel will remain overstocked and the land will continue its downward trend. The settlement of the fly belt in the absence of controls on stocking rates, grazing patterns and cultivation, necessarily raises the possibility of the accelerated environmental degradation of those Sudanian zones of modest to very low human settlement.

Control Measures for Post-eradication Development

The question of control measures raises the problem of tsetse fly eradication's place in national development schemes. As was stated earlier, tsetse eradication makes sense only when undertaken as one aspect of an integrated scheme which includes attacks on other constraints and provides control measures to limit animal and human populations to the carrying capacity of the land. The governments, donor agencies and local leaders must be willing and able, both technically and politically, to manage the entire integrated program. Past experience, however, indicates the magnitude of the obstacles which must be overcome if this is to be possible.

Proposed fly eradication projects must be viewed against a back drop of failed development schemes associated with tsetse fly control and other attacks against single environmental constraints which did not succeed in maintaining the ecological balance. These failures have generally stemmed from the technical and political inability of those responsible to replace the environmental constraint with effective control measures and to enforce those changes in land use necessary to protect the newly opened lands. The problem, as one expert puts it, is that, "(u)nfortunately, such measures...tend to increase herd size without directly addressing sustained ecosystem capacity."

(17, p. 1) Examples can be found almost anywhere in Africa. The final report of the Range Management Advisor of the Ilkisongo Grazing Scheme in Masailand reads, for instance,

Politically it was not possible to enforce the stringent regulations. The range was over-stocked at the time the Ilkisongo scheme was established. Direct destocking was not acceptable to the people of Ilkisongo Section and had destocking been insisted upon, it would have meant no scheme at all. It was hoped that through improved management practices there would be sufficient increase in forage production to absorb that of the excess cattle and destocking could be accomplished over a period of years.

A special stock market was established for the Ilkisongo Scheme to provide a destocking outlet. Approximately 750 head of cattle passed through the market monthly. Records, however, indicate that during the operation of the scheme the livestock numbers actually increased rather than decreased.

The drought accomplished what administration was unable to do -- it destocked the range, although disastrously and wastefully.

In establishing the schemes every consideration was given to features that would conform as nearly as possible to traditional grazing use. An aggressive water development program was initiated, which unfortunately contributed to the depletion of the range resources, because the livestock population was not controlled. During the drought the schemes ceased to function and to date have not been reactivated.

In their failure the grazing schemes clearly demonstrate the futility of water development and management measures without control of livestock population. The danger of water development and range improvement projects in general without adequate management provisions cannot be too strongly stressed for almost invariably the result is the deterioration or destruction of the range resource involved. (51, p. 705-6)

Some experts fear that similar disasters may occur in the future as one comments, "If you look at the livestock development proposals under consideration for the Sahel right now, not a single one deals in a comprehensive way with this problem of how to control livestock numbers." (48, p. 24)

While considering control measures, it is also necessary to point out that the tsetse fly's 'control' of land use in the fly belt is breaking down rapidly. In fact, the tsetse fly belt is subject to significant forces of change. Because of pressure in many non-infested areas, the lands of the fly belt, so long held 'in escrow' by the tsetse fly, are now threatened with piecemeal and short-sighted exploitation. This promises to damage seriously the productive capacity of the fly belt and to establish land utilization and tenure patterns that will thwart future development efforts. Herders forced by the drought to enter the fly belt have destroyed the vegetation surrounding

many watering places and cultivators have extended destructive 'slash and burn' agriculture into those areas adjacent to their present lands. Moreover, the pressing need for fuel has resulted in serious deforestation in some areas. (45, p. 9-10) For this reason some form of planned development must be undertaken to compensate for the failing effectiveness of the fly as a land protector at least in areas most open to indiscriminant encroachment such as those along rivers and roads, near heavily grazed or cultivated lands, or possessing easily exploited forests.

Tsetse Fly Eradication and Population Control

Neither overstocking nor land pressure can be dealt with in isolation; both are symptoms of a deeper and more serious problem, over-population. Over-population is not an absolute, but indicates a population which has outstripped its capacity to exploit the environment successfully, i.e., without reducing the land's productivity. Four alternatives exist in such a situation: Either 1) new, non-agricultural opportunities are found for those unable to live on the land; 2) new technologies are developed to improve returns while maintaining the environment; 3) new areas are opened relieving pressure on over-used land or; 4) the degradation of the environment continues until the natural controls of starvation and disease begin to correct the balance.

A successful tsetse fly eradication program can relieve land pressure and overstocking for a short period, but unless a major effort is made to limit population growth and to improve yields through intensification, these symptoms will quickly return on a larger scale. Given current population growth trends in Africa, there is a risk that the latter will occur if major tsetse eradication efforts are attempted. Estimates of population in the countries of Sahel, for example, indicate rates of growth averaging 2.5% and reaching 3.5% in some instances. The seriousness of the situation is aggravated by the extremely high proportion -- nowhere less than 40% -- of the population under 15 years of age. (2, p. 35)

In and of itself, rapid population growth does not constitute a reason for restricting the use of new areas. Many African leaders, however, apparently refuse to accept population as a serious factor in development and prefer to view overstocking and land pressure as problems of population distribution and not absolute numbers.*

*This argument appears also in the UNEP collection Environment and Development. For example,

The E.C.A. report on the population of Africa concludes: "The present rate of population growth in Africa is about twice as high as that in industrial Europe in the nineteenth century." This is not in our opinion warranted, in view of the very low density of the population in large areas of the continent. The danger of infertility and, indeed, extermination has to be faced. Africa needs labor for development, and the continent, by and large, has not yet been developed. (30, p. 269)

(Personal communication, Carol Ulinski, Sahel Development Program, June 23, 1977) The likely result of such an attitude, coupled with major fly eradication projects aimed at achieving the desired population distribution, will be the extension of overgrazing, land pressure and all the accompanying ill-effects. If this is to be prevented, efforts must be undertaken along with tsetse fly eradication to increase the intensity of land use and to absorb those for whom there is no space on the land in non-agricultural occupations. Experience indicates, however, that such efforts are made far more difficult and eventually become impossible without concurrent population control.

The Human Factor in Post-Eradication Development

The inability of development planners to manage tradition... pastoralists successfully has regularly contributed to the failure of development schemes associated with tsetse fly and similar environmental constraint removal projects. There are reasons to doubt that in the near future large scale efforts to transform traditional peoples as part of new lands projects will be any more successful. The problems are of two sorts. On the one hand, projects have failed for 'practical' reasons; they did not sufficiently minimize risk, provide beneficial enough returns to encourage change or overcome land tenure problems. On the other hand, such projects failed because they could not change the valued place of cattle in pastoralists societies.

The management of risk and the provision of incentives are the crucial factors in the success or failure of all projects. As an FAO/UNEP report notes,

Many of the traditional forms of land use practiced by pastoral societies are well adapted to the risks imposed by the low productivity and regular major fluctuation in rainfall that characterize range ecosystems. Strategies, motivations and behavior of pastoralists need therefore to be analyzed in this light as a preliminary to development efforts; otherwise proposed changes may be resisted on the rational grounds that they increase risk, either in the short or long-term. (25, p. 52)

Development schemes which hope to reach these people must include well conceived marketing facilities, animal health services, improved credit.

A major factor in the risk calculations of pastoralists (and other subsistence populations) is the extreme unreliability of government services. Demonstration ranches notwithstanding, they have often preferred their 'four-footed social security' to government reassurances. Government unreliability also operates as a general disincentive to commercial production. For example, pastoralists trade livestock for grain and other needed commodities, but as one report notes, "The shortage or the exorbitant cost of such commodities has often proved as much a disincentive to livestock sales as any other factor, particularly in West Africa." (25, p. 21)

Land tenure modification also plays an important part in the transformation of traditional societies and the protection of the environment. It has major consequences which must at least be considered. As one expert notes,

Without land adjudication there is no general consciousness of the limited absorptive capacity of rangeland for people. Differences in cattle ownership are considerable, but income and status differentials are not so important since income consists of subsistence mainly and the 'rich' man observes the custom of sharing subsistence with the poor man. Poverty is thus generalized and the diminishing environment in relation to the increasing population is a curse affecting the whole population. With land adjudication the situation changes dramatically. If it is to achieve its objective of limiting stocking to the long term capacity of the land, the number of people who can be expected to live off the land has to be defined and part of the present or future population will have to be denied the right to stay on the land. Irrespective of the method of selecting land owners, the selected ones are given the basis for improvement and commercialization of production which reduces the portion of subsistence which can be shared with others. Those who have not been selected are deprived of their basic subsistence and are turned into a landless proletariat. (38, p. 87-88)

Apart from the employment problems suggested above, development planners must consider the short and long term impact of traditional societies of the changes in the distribution of wealth and power, both social and political, that such land adjudication will bring about. In the case of development projects for tsetse fly eradication areas, resistance to land tenure reforms must be weighed when considering the risks to which new lands may be subjected.

As far as the resettlement of pastoralists in cleared areas is concerned, the question of the adaptation to the new environment must be considered. Proponents of resettlement argue that the removal of the pastoralist from a known micro-environment will make him accept new range management advice more easily. Opponents argue that the opposite is likely to be true, especially if the resettlement scheme is a large one with limited staff. They doubt sufficiently detailed micro-environmental information exists to allow range management specialists from outside to substitute their judgement for that of the pastoralist.

For example, there is no study which details with any useful precision the distribution of the constituent population of a Sahelian ecosystem over time. That is, we do not know the precise relationships among the various populations of humans, domesticated animals, wild animals, domesticated and cultivated plants, water, markets, villages, etc., of a single local area for as much as one year! (32, p. 58)

They hold that stripped of his detailed knowledge of the environment upon which he has always depended for his survival, the pastoralist will feel threatened and resort to herd build-up as a defense.

Such rationalistic explanations fail, however, to take into consideration the pastoralist's special relationship to his cattle. All the logic of incentives and differential price values do not answer the Matheniko herder from Uganda who says, "You see, my cows are like flowers. I like to sit here and see them grow. When they are happy, I am happy, and, the more there are, the happier I am."

(11, p. 1) As Michael Horowitz points out, before such attitudes can be managed in development projects,

We need to know why specific choices are made, how the strategies respond to and how they affect the physical and social environment. We need to understand how innovations in technology, in settlement, in material culture, in economic relationships, etc. can be based upon existing values; that is, we need to explore the incentives which could facilitate change. (32, p. 58)

It is not enough to remove environmental constraints to increased production or to provide improved marketing facilities, for until a cultural mechanism exists to limit livestock numbers or a change in attitude toward cattle can be affected, these efforts will be wasted. It may only be a matter of time before these changes take place, but since tsetse fly eradication can be carried out very rapidly, the time lag is crucial.

Political Constraints to Post-eradication Development

Tsetse fly eradication and its consequences are as much problems of politics as they are of development. For African governments the management of large scale development projects on lands cleared of tsetse fly poses a serious challenge on several fronts. First, African countries do not possess the trained manpower, whether field technicians or ministerial planners, necessary to undertake integrated development projects without outside assistance. Of the professionals they do have, few, particularly at the higher levels, possess an environmental perspective or appreciate the complexity

of the environmental issues involved in new lands development. Second, government bureaucracies lack the flexibility and inter-ministerial linkages required to coordinate the many aspects of such multifaceted efforts. Third, past development priorities and present political realities may lead African governments to use tsetse fly eradication to achieve short-term political ends and to ignore long-term consequences.

The development of policies and projects which will protect new lands resources from degradation includes a large educational component. At the field level, African governments have by and large maintained the disproportionate emphasis on animal health services and personnel which characterized colonial livestock policy. As a result, they lack both trained range managers and other livestock production specialists to carry out environmentally sound projects and the data necessary to formulate them. At the national level, governments do not possess the professionals necessary to conceive, for example, tax and price policies which will encourage intensification of production. Since it is both politically and practically difficult to circumvent these problems with outsiders, African governments must be assisted in training the needed personnel before they assume the responsibility of managing large, hitherto unexploited land resources.

Another aspect of the educational problem is the notable lack or environmental awareness from which African policy makers suffer. For example, at a recent meeting of the Environmental Assessment Working Group of the Club des Amis du Sahel, a respected and influential African participant insisted that Africa has no environmental problem. In another case the Ford Foundation rejected a proposal for an environmental training school in Nigeria because there seemed to be insufficient interest on the part of the government to guarantee its support after initial outside funding and because it appeared the graduates would have little impact on policy.

The consensus among African leaders seems to be that something must be done immediately about development. The environment should be monitored, but cannot be allowed to stand in the way. Such a short-sighted approach is likely to have negative consequences. By the time an environmental problem is detected, the effects may already be serious. Once projects are fully underway, it is also very hard to stop them, regardless of the reason. Short-term gains may be paid for in long-term damage to the land's capacity to produce sustained yields.

Bureaucratic management of large scale development projects on lands cleared of the tsetse fly is a complex effort and one likely to tax the capacity of African governments. For example, a list of government bodies with an interest in a fly land

reclamation project might include those for agriculture, animal husbandry, cooperatives, economic planning, education; family planning, finance, forestry, highways, land reform, livestock marketing, various local administrations, medical services, range management, tourism, veterinary services, water development and wildlife. Even where an obvious need for coordination between divisions exists -- such as between the divisions for crops and livestock or animal health and range services -- there is little or none. Similar problems hamper the collection, coordination and distribution of information. Bureaucracies suffer vertical communication difficulties as well, limiting liaison between policy makers and extension workers. For various reasons it is also very difficult to provide sufficient numbers of competent local administrators to manage complex projects.

Politically tsetse fly eradication efforts are understandably difficult for government leaders to control. Tsetse fly eradication has the 'advantage' of showing immediate returns and gives governments something they can actually 'do' for their people.

Investment in training range managers, for example, has no such instantaneous pay-off, whatever the long-term benefits may be. Destocking measures are extremely unpopular and to be effective require expensive investments in other inputs. The intensification of agriculture and the improvement of land use techniques are also costly. Tsetse fly eradication seems an inexpensive solution to

the land pressure that the failure to make these investments has created. High land pressure, however, also makes it both practically and politically very difficult to 'quarantine' cleared areas while controlled development projects are put in place.

Past and present government planning and investment priorities favoring industry and large scale commercial agriculture and cattle ranching have important implications for development planning in relation to the fly lands. Indeed, the failure of governments to invest in the subsistence sector and the decision to exploit it to generate capital for investment in other sectors must be considered prime causes of the present need for the tsetse lands. A glance at the statistics reveals this clearly. In case of the six Sahelian countries, agriculture and livestock production occupy 90% of the population. They account for an average 49% of the GNP and contribute 88% of national exports (excluding Mauritania's iron). However, in Mauritania, for instance, the first four year plan allocated only 10% of total investment to agriculture and livestock while during the second, although 14% was allocated, only 4.8% was actually invested. (50, p. 82-84)

Traditionally, the subsistence agriculture and livestock sectors have been heavily taxed as well. In Upper Volta, for example, direct taxes on farmers rose 100% between 1960 and 1970. Between 1965 and 1970 when the drought had severely depressed farm incomes, direct taxes rose 30% and subsidies for pesticides, fertilizer and farm implements were abolished. (50, p. 82-84)

During roughly the same period, 1961 to 1970, average staple food production in rural areas throughout the Sahel dropped by more than 17%. (5, p. 14) A portion of this reduction must be attributed to the drought. The drop, however, would certainly not have been so substantial nor would the environmental damage have been so great had sufficient investments been made in improving land use among subsistence farmers and herders. Without a reversal of these investment priorities and tax policies as well as the development of schemes aimed specifically at the subsistence sector such as price policies and credit programs which encourage intensification, new lands will suffer the same fate as the old.

The past bias of government planning priorities against the subsistence sectors suggests that alternatives may exist to tsetse fly eradication and that care should be exercised to ensure that eradication, if undertaken, does not delay efforts to realign these priorities. First, the virtually complete absence of past investment in the subsistence sectors indicates that within the limits now imposed by population and resource degradation considerable room for improvement exists in already occupied areas. Second, because tsetse fly eradication will have the immediate effect of reducing pressure on governments to attend to the subsistence sector, there is a risk it will serve to postpone needed adjustments in national priorities until the situation worsens again. Third, the political weight of commercial, large scale, export oriented agriculture and cattle

ranching relative to that of the subsistence sectors makes it likely that such schemes will receive a disproportionate share of investments made in lands reclaimed from the tsetse fly.

Such development would have little long-term impact. Investment in large scale commercial operations does not address the need of the majority in these countries whose inability to exploit the environment without destroying it is at the root of the problem. It would contribute to GNP, serve other political ends and help satisfy the demands of an elite meat market, but would not have a general effect on employment, nutrition or income. This need not necessarily be the case, since investment in lucrative, export oriented, commercial beef ranching might, for instance, generate foreign exchange which could in turn be invested in the subsistence sector. Given political and institutional limitations, however, such 'strategic' planning is unlikely to succeed at present. In view of the new A.I.D. mandate, this is of particular significance when considering development schemes for lands reclaimed from the tsetse fly.

Tsetse Fly Eradication and the Food Crisis

The issue of food is central to the debate over whether to invest in tsetse land reclamation projects. A basic agreement underlies the entire debate: sustained increases in production can be achieved only through intensification, and not through mere expansion of the area under cultivation. As the United Nations Study on the Future of the World Economy (1976) noted,

the major thrust of food supply in the developing regions will have to come from and increase in their own agricultural output (however) even after mobilizing available excess arable land resources, the land productivity (including crop yields and cattle productivity) (will) have to be increased by at least three fold...if the five percent annual target is to be realized. (6, p. 1)

It is in this regard that "it has to be asked whether tsetse reclamation is the best or the only solution to the problem."

(38, p. 116) Will investment in tsetse fly eradication and related projects have as large an impact on the food crisis as some other effort?

Proponents of tsetse fly eradication argue that investment in fly land reclamation is more cost effective than investment in already occupied areas. Economically, the problem is that,

the land in zones where the more serious income problems are found are, from the standpoint of natural fertility and land use potential, generally marginal. The only way to prevent disaster in some areas is through extensive conservation and dramatically altered resource management techniques... Modifying the land use system will require inputs in private and public management which in the least advantaged and most fragile or damaged areas may not be justified by short-term economic or financial returns, especially if the capacity of the host government to deliver a coordinated program to the field is low. (1, p. 24)

The fly lands, on the other hand, promise a far better return

In their report "Utilization of Grazing Areas in Sahelian

Countries of Africa: An Analysis of Development Costs and Impacts

for Alternative Systems of Utilization," Arnold Moeller and Frank Abercrombie conclude,

development inputs into the higher rainfall zones (unutilized but tsetse infested) have a clear advantage over equal inputs into the low and intermediate zones. This is true whether management systems utilize development in the high rainfall zone only or in some combination in one or both of the other zones. (46, p. 11)

According to their figures* the cost per animal unit of clearing the fly belt might be as little as one fifth to one eighth those of clearing the low and intermediate rainfall zones. These figures, however, apply only to tsetse eradication.

Besides costs, there are other advantages. As Moeller points out in his paper "Tsetse Land Utilization -- An Overview," "Much of the area is highly susceptible to planned development and controlled utilization in a manner beneficial to overall production not possible on land now heavily occupied and often under questionable utilization." (45, p. 5)

*Moeller and Abercrombie figure tsetse belt carrying capacity at four hectares per AU for year around grazing and three hectares per AU for dry season grazing only. For the intermediate zone they calculate fifteen hectares per AU, and four hectares per AU for wet season grazing of four months in the low rainfall zone. The cost of clearing a hectare they figure to be \$7.61 for the fly belt, \$3.30 for the intermediate zone and \$3.56 for the Sahel. This gives clearing costs per AU of \$33.44 in the fly belt, \$79.50 in the intermediate zone and \$14.24 in the Sahel for the wet season alone. (46, p. 8)

The actual tsetse fly control projects under contemplation vary in size from quite small to very large and contain a variety of proposed uses for the cleared lands. At the small end of the scale are a number of special projects not intended to change the land use patterns of an area radically, but rather to relieve particular bottlenecks. Such projects include, for example, the control of tsetse flies along cattle marketing corridors or the clearing of areas for cattle rest stops along marketing routes in order to prevent weight and animal loss.

Most development schemes proposed for the lands freed of the tsetse fly form a part of still larger plans for the transformation of the regional livestock industry through stratification of production by climatic zone. The primary aim of all such projects will be the transformation from traditional subsistence, dairy herd livestocking to modern, beef production; for, as the "Mali Livestock Design Study" notes, "The traditional system of migratory cattle production is rapidly reaching its yield limit, while demand for meat is growing at a rapid rate, with the prospect that prices will rise in the future." (4, p. 2)

Since the semi-arid zones have little potential for anything but extensive livestock grazing, it is proposed that they be used as breeding grounds. Herd productivity will be improved through the provision of mineral and salt supplements, proper range management and veterinary services. In the cleared areas of the higher rainfall

zones, where the forage is both more abundant and more nutritious, fattening operations will be established to bring to market weight immatures and culled cows from the Sahelian herds. Such a system promises to reduce the time required to get an animal to market, increase the number of animals slaughtered and improve carcass weight and quality.

Opponents of tsetse fly eradication projects believe that investment in reclamation schemes intended for grazing to be a misallocation of funds, since it fails to address directly the needs of the victims of the food crisis, the very poor. Among the prime factors contributing to Africa's "low productivity both absolute and relative to the rest of the world" has been lack of attention to the rural, subsistence sector. (1, p. 7) It is here, however, that the African food crisis exists and here that land use patterns have to be changed. The easiest and environmentally safest development projects for the cleared fly belt -- large, possibly expatriate managed, commercial ranches -- do not answer the needs of these people. Nor is it likely, given political and institutional limitations, that revenues generated by such operations would be reinvested in the subsistence sector. Moreover, a stratification of production by climatic zone would institutionalize the poverty of the primary producer in the low rainfall zones, since the real profits of livestock production in such a system would be earned by the fattening operations in the savanna.

It is argued that even in the short-term the returns from investment in intensification of land use in occupied areas are higher, particularly for the very poor, than are those for the expansion of agricultural lands. In terms of increasing the productivity of peasant farmers and poor herders, there is great potential for improvement of yields and land use through water management, training in husbandry and agricultural techniques, provision of fertilizer, improved seeds and simple technology, applied and basic research, and other agricultural intensification methods. None of these requires the high overhead of tsetse control, nor carries the risks associated with opening new lands for exploitation.

Opponents of tsetse eradication also dispute the contention that tsetse fly eradication is an appropriate tool for improving protein availability. Jahnke puts the problem neatly.

A number of authors see the main problem of tsetse infestation in the fact that it prevents the keeping of cattle and thus the production of urgently needed protein. It is erroneous, however, to conclude that tsetse and trypanosomiasis control are suitable measures to relieve a protein deficiency. If a protein deficiency exists, it exists among the poorer sections of the population. It is therefore necessary to find cheap sources of protein. Beef and milk produced in outlying areas after expensive tsetse control or under expensive drug protection are likely to be the most expensive sources of protein in any country. It is unrealistic to assume that the poor population groups benefit from this expensive program except the pastoral producers who enjoy a luxury consumption of protein anyway. It is therefore strongly recommended to discard the protein argument in the development of a tsetse and trypanosomiasis strategy. (38, p. 110)

Meat production on cleared lands may generate foreign exchange to purchase food abroad, but without other major development efforts this will not significantly improve the lot of the poorest portions of the population.

Jahnke's argument touches the heart of the relationship of tsetse fly eradication to the food crisis. The food crisis exists for the very poor, those who lack the means, technical, economic and educational, to feed themselves. These people may be aided by tsetse fly control, but if such expensive undertakings divert capital from direct investment in efforts to improve their capacity to use the land well, it will be misallocated, at least in terms of combatting the food crisis.

Alternatives to Tsetse Fly Eradication

At the present time three major alternatives to the eradication of tsetse fly exist for circumventing the trypanosomiasis constraint: the raising of trypano-tolerant cattle, the use of prophylactic and curative drugs, and game ranching. In the proper circumstances, all three are viable alternatives to tsetse fly eradication, but if improperly handled (as, for instance, drug treatments have been) they also present many of the same land use difficulties as eradication. In each case, the elimination of the trypanosomiasis constraint poses a threat to range and soil resources unless accompanied by control measures which limit human and animal populations to the carrying capacity of the land.

Under certain conditions the use of prophylactic and curative drug treatments is an important alternative to fly eradication. In areas with low carrying capacities or low infestation rates, it is often less expensive and less risky to employ drugs than to attempt fly clearance. The use of drug treatments avoids the high capital costs of clearing and maintaining barrier zones. Moreover, the use of drugs allows limited access to lands needed for dry season grazing which eradication might open to uncontrolled use and overgrazing. Such control gives governments a powerful tool for limiting livestock numbers and movements, a tool they relinquish with blanket eradication, a policy of injection on demand, or any other indiscriminant circumvention of the trypanosomiasis constraint.

Game ranching promises to be a feasible and environmentally safe means of bringing wild portions of the fly belt into production. Its proponents argue that it is superior to cattle ranching for a number of reasons. They claim that it will be cheaper, since it requires neither tsetse control nor any other major capital expenditures apart from limited infrastructure development. It will also not result in any harm to the environment; it will in effect protect wildlife where a cattle ranch would displace it and, unlike cattle which graze selectively, mixed game herds consume the whole spectrum of available forages, hence maintaining their balance.

Trypano-tolerant cattle such as the N'Dama or Baole also represent a real alternative to eradication in areas of the savanna and particularly in the Guinea Zone where *G. morsitans* is not prevalent. Unlike the first two alternatives, however, the risks involved in using trypano-tolerant breeds are essentially as high as for eradication. The N'Dama and other trypano-tolerant cattle are better adapted for the wetter areas of the fly belt than the northern Zebu and show a greater resistance to other fly belt diseases such as streptothricosis and those borne by ticks. (16, p. 3) Raised under medium management on lands with carrying capacities of 2-4 hectares per AU, herds of trypano-tolerant cattle can reach a 70% calf drop (5-8% calf mortality). They can produce 500 lb. grass fattened steers in two to two and a half years and achieve a 15% take-off rate. This is roughly equivalent to the Zebu. (43, p. 4) N'Dama also shows great potential as a work animal. As far as the widespread use of trypano-tolerant cattle is concerned, however, it must be borne in mind that without the same control measures necessary to avoid overgrazing and resource degradation following tsetse fly eradication, the use of this alternative to fly clearance will be an expensive one.

Conclusion

There are no simple lessons to be drawn from the above discussion of the pros and cons of tsetse fly eradication. The issue is a complex one and the stakes are high. The lives and livelihoods of millions of people are being weighed against possible risks to the land's capacity to sustain their children. As with all development issues there is an air of crisis about this one, but the time element is not the crucial one. Crisis management merely begets more crisis. The African environment can hardly bear another.

A number of authors suggest checklists against which to measure proposed tsetse eradication projects. All recognize the need for the lands now infested with tsetse, but all urge caution in making the decision to attempt opening the lands. Hans Jahnke's checklist consists of four questions.

- 1) What are the costs of different control methods and what are the benefits to be achieved for the country as a whole?
- 2) How can the economic desirability of control schemes be increased by lowering the costs or raising the benefits of tsetse or trypanosomiasis control?
- 3) Are there more profitable investment opportunities for scarce public funds than tsetse and trypanosomiasis control?
- 4) How does tsetse and trypanosomiasis control fit into a general agricultural development policy? (38, p. 15)

A group of experts suggests considering the following three items prerequisites for assistance to tsetse control efforts:

- 1) the development of a national range policy incorporating ecological guidelines; 2) the establishment of an executive agency, with the mandate to control and coordinate all departmental activities touching on range areas, operate extension services and to pass all required legislation and; 3) the preparation of project plans based on adequate ecological and socio-economic studies. (25, p. 4)

John Ford calls for 'efficient control' by which he means "control that 1) keeps the disease at a tolerable level in relation to the competence of medical and veterinary services and at the same time does not impede the economic process of the societies affected and 2) ensures that the beneficial effects of trypanosomiasis in maintaining the ecological balance between the natural resources of the continent and the energy expenditure of its inhabitants are retained until they can be replaced by new social and economic controls which are integrated into the local cultures of the people." (27, p. 880)

In the end, the debate over tsetse fly eradication comes down to a series of judgements about the seriousness of the situation, the ends to be achieved and the ability to gain them. The following is a summary list of questions raised in this paper for which answers must be found before a control project is begun. It is meant to suggest the issues which must be considered part of any judgement concerning tsetse fly eradication.

1) Environment:

What are the potential risks to the environment of eradication

-- From the eradication method?

-- From human activities?

-- From domestic animals?

What will eradication mean for wildlife?

What are the risks to the environment of occupied areas if eradication is not carried out?

Does sufficient information exist to make these judgements?

2) Technical:

It is technically unfeasible to achieve the same ends in already occupied areas?

Are control technologies advanced enough to limit primary impacts to acceptable levels?

Does the technical capacity exist to plan and execute environmentally sound land use schemes in cleared areas?

Do sufficient technical personnel exist in project countries to carry on the work? If not, can they be trained in time?

Does sufficient data about the environment exist to plan projects suited to a specific area?

3) Sociological:

Is a sufficient amount known about the target populations to design projects for them?

Will it be possible to enforce control measures?

What are the likely long-term impacts of resettling populations or altering their traditional life style through changes in land tenure, material culture, their relationship to cattle, etc.?

4) Economic:

Is tsetse fly eradication the best use for scarce funds?

Will the returns of the project be sufficient to justify major outside assistance?

Are planners capable of controlling price, tax and investment policies in order to encourage development in new lands?

5) Political:

Does the government have the capacity to manage eradication projects?

-- Bureaucratically?

-- Administratively?

-- Does it have the trained personnel?

-- Does it appreciate the environmental issue?

To what end does the government intend to use the new lands?

Summary Conclusions

- 1) **Tsetse fly eradication projects must be part of a broader development effort attacking all relevant constraints.**
Failure to manage any one may limit the success of the whole program.
- 2) **Tsetse control projects must be tailored for specific areas.**
For various reasons many areas of the fly belt do not merit eradication.
- 3) **For an eradication project to succeed, a land use scheme for the entire area must be ready to be put in place immediately.**
- 4) **The maintenance of fly barrier zones around control areas must be guaranteed until habitat modification and game displacement have rendered them unacceptable to tsetse fly. Failure to do so will result in reinfestation followed by an epizootic and possibly an epidemic of trypanosomiasis.**
- 5) **Other diseases in tsetse eradication areas besides trypanosomiasis must be controlled as well to avoid risk to settlers and their animals.**
- 6) **Tsetse fly eradication will not relieve population pressure in Sahel or comparable areas of East Africa. The likely beneficiaries will be the residents of the fly belt.**

- 7) Without effective livestock control measures, tsetse fly eradication will not relieve over-stocking on the semi-arid and grid range lands.
- 8) Unless development schemes in lands reclaimed from the tsetse fly include effective livestock and land use measures, eradication of the fly will contribute to a spread of environmental destruction.
- 9) Without concurrent population control efforts, tsetse fly eradication will be only a short-term palliative.
- 10) In many places the tsetse fly is no longer enough to prevent expansion of existing, environmentally damaging land use patterns into the fly belt. Some form of planned development must take place in these areas or the land resource will be lost.
- 11) Unless development schemes on lands reclaimed from the tsetse fly can manage the transformation of the traditional farmers and herders who settle the new lands, environmental destruction will result.
- 12) Development planners should consider the possible, long-term impacts on traditional societies of changes which upset existing distributions of social and political power and wealth.

- 13) African governments are not yet prepared to manage integrated development schemes for new lands. They lack the personnel, the bureaucratic capability and in many cases the will to follow up tsetse eradication with programs capable of protecting new lands' resources.
- 14) The likely beneficiaries of post-eradication investment are large scale commercial agriculture and cattle ranching. This will have little impact on the source of the problem, the inability of subsistence farmers and herders to exploit the land without destroying it.
- 15) Tsetse fly eradication is unlikely to have more than a short-term impact on the food crisis unless accompanied by major efforts to improve land use. Control projects may also divert capital from direct investment in improving the capacity of the poor to feed themselves.
- 16) Limited alternatives to tsetse fly control exist for the development of the fly belt. Further research is needed and more consideration should be given to such options as tourism.

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Review of Work Underway at Other Organizations
Concerning the Implications of Tsetse Fly Eradication

Introduction

A.I.D. is not alone in its concern for the future of the land now held 'in escrow' by the tsetse fly. The Ford and Rockefeller Foundations, the Rockefeller Brothers Fund and the United Nations Development and Environmental Programs have all committed resources to the study of the implications of the eradication of either the tsetse fly or similar issues. UNDP, in conjunction with FAO and WHO, has recently launched a study of the technical, economic and environmental aspects of tsetse control. This fall or early next year the Rockefeller Foundation, with ILCA and ILRAD, will sponsor a conference on the implication of the discovery of a trypanosomiasis vaccine. Both the Ford and Rockefeller Brothers Fund are sponsoring research on alternatives to new lands development and the Fund is also training wildlife managers and environmentalists.

Although the special concerns of their organizations led the people interviewed to stress different points, all agreed that African governments do not yet possess the capacity to undertake major tsetse eradication programs successfully. From the technical point of view, African governments lack the trained environmentalists, range managers, rural sociologists and other personnel to design and implement environmentally sound projects in reclaimed areas. They also lack

the economists, planners and trained administrators necessary to reorient national priorities to provide a positive context for rural development. Those interviewed felt that an important aspect of the demand for tsetse fly eradication was the desire for short-term political returns and that if eradication took place governments would be unable or unwilling to control the use of the cleared lands. They also doubted the willingness of governments to orient development in cleared areas toward the poorest sectors of the population.

A second major point of agreement was that at the present time the technical and sociological expertise does not exist to undertake successfully the massive interventions which would be called for if the fly lands are opened by eradication or other means. All felt that considerable research on subjects ranging from anthropology to soil science is needed before it will be possible to implement environmentally sound projects. From their point of view a necessary corollary of all tsetse fly research should be further intensive study of alternatives to opening the fly belt, particularly methods of intensifying land use and increasing land yields.

Rockefeller Bro....., Program Associate 101

International Programs.....

The Rockefeller Brothers Fund is not at present involved in tsetse fly control nor is it contemplating any future involvement. In general, the Fund considers tsetse fly eradication too environmentally risky to be undertaken now and feels that there exist

important alternatives with greater potential returns, particularly to the rural poor. It is, however, deeply interested in many of the issues related to tsetse eradication. The Fund's International Program for Developing Countries is focused on improving the quality of life of the poorest populations, primarily through projects aimed at increasing food production and incomes in rural areas. The Fund's work in developing countries has two themes, environmental management to increase and sustain food yields and diversification of employment opportunity.

As far as tsetse fly eradication is concerned, the Fund feels that for the time being African governments possess neither the awareness of environmental issues nor the trained personnel necessary to design, implement or follow up on the complex schemes needed to develop the cleared fly belt without risking its destruction. In order to help African governments develop their capacity to undertake environmentally sound development, the Fund is deeply involved in the training of wildlife specialists at the Wildlife Training Center in Botswana and the School for the Training of Wildlife Specialists in Cameroon.

The Fund is also interested in alternatives to tsetse fly eradication for the development of the fly belt. It is currently involved in the planning of the Nazinga Game Ranch Project in Upper Volta and supports the research of the African Wildlife Leadership Foundation, Inc. of Washington, D. C. The Nazinga Game Ranch project will involve the management and controlled culling with local hunters of a game herd specifically to supply a local market with a noted

preference for game meat. The Fund believes that the project should prove far less expensive than an FED sponsored commercial ranch in the same area. Moreover, the environmental risks of the project are far less and the local impact far greater than those for the FED scheme.

Ford Foundation: Joseph V. Remenyi, Assistant Program Officer,
Office of the Vice President, International Division

The Ford Foundation does not contemplate any involvement in tsetse fly eradication. The Foundation considers the risk of resource degradation and wildlife destruction as well as the costs, both economic and social, so high that the eradication of the tsetse even from limited areas cannot be justified. It feels that African governments lack both the capacity and the interest in environmental issues necessary to make such projects succeed.* Ford prefers to fund environmentally safe projects involving, for instance, soil fertility, agronomic practices, water management and such research as is being carried out now by IITA in Mali and the Kenya Grains and Legumes Project. Moreover, the Foundation has little interest in livestock projects in general, the prime beneficiaries of tsetse

*The Ford Foundation, for example, recently decided against an environmental training center in Nigeria because it felt government interest was too low to sustain the project after initial outside funding and because it appeared that graduates of the school would have little or no impact on policy decisions.

control efforts, since the potential for agricultural intensification is so high and the potential for an effective livestock policy so low. Like the Rockefeller Brothers Fund, the Ford Foundation is concerned about the impact of tsetse eradication on wildlife.

United Nations Development Program: Dr. Frank Vandemaele, Technical
Advisory Division

The United Nations and particularly FAO are very interested in the possibility of eradicating the tsetse fly throughout Africa; they are also concerned about the possible impacts of such widespread eradication. Dr. Finelle, FAO's tsetse fly expert, has declared tsetse fly eradication a 'major weapon' in the struggle for food self-sufficiency in Africa. The FAO seems to be seriously considering undertaking at least part of the two billion dollar, forty year effort they estimate it will require to completely eradicate the fly. The Technical Advisory Division, however, has expressed concern that if massive clearing takes place, "there is a danger that these areas will suffer from overgrazing and erosion in a manner which has already occurred in the Sahel ." (Technical Advisory Division memo, April 29, 1975) As a result of this concern, Assessment Panels have been established to consider the possible impacts of individual projects. In the light of the availability of some \$150 million from the Arab oil states for tsetse fly eradication and the subsequent development of the fly belt, the UN has recently undertaken a

four year and four month study entitled Animal Trypanosomiasis Control: Economic Assessment and Applied Research on Glossina Control in the Dry Savanna Zones (RAF-75/001). A copy of the abstract for this study is appended to this report.

As far as tsetse control is concerned, UNDP has two interests, development of tsetse specific control measures and the design and safeguarding of land use schemes for cleared areas. SIRM and ULV spraying notwithstanding, the Technical Advisory Division considers the primary impacts of large scale eradication still unacceptably high. UNDP also worries that the land use schemes associated with proposed eradication projects are unlikely both to have a major, positive long-term effect on the poorest sectors of the population of target areas and to guard sufficiently against the destruction of the environment.*

*UNDP's last experience with tsetse fly eradication was not successful and as a result it is hesitant to become involved in others. In 1965 UNDP funded the spraying of a large valley in Luo country, Western Kenya. A land use scheme for the cleared area was insisted on, but never materialized. The project was associated with Luo politician Tom Mboya from the start and when he was assassinated shortly after the project's completion funds for maintaining the barrier zone and for development within the control area dried up. The area was quickly reinfested and all the cattle died.

UNITED NATIONS
DEVELOPMENT
PROGRAMME



Distr.
GENERAL
DP/PROJECTS/1181
(RAF/75/001)
27 August 1976
ORIGINAL : ENGLISH

APPROVAL OF LARGE-SCALE UNDP ASSISTANCE TO A PROJECT OF THE GOVERNMENTS OF BENIN, BOTSWANA, BURUNDI, CENTRAL AFRICAN REPUBLIC, CHAD, CONGO, EQUATORIAL GUINEA, ETHIOPIA, GABON, GAMBIA, GHANA, GUINEA, GUINEA-BISSAU, IVORY COAST, KENYA, LIBERIA, MALAWI, MALI, MOZAMBIQUE, NIGER, NIGERIA, RWANDA, SENEGAL, SIERRA LEONE, SOMALIA, SUDAN, TOGO, UGANDA, UNITED REPUBLIC OF CAMEROON, UNITED REPUBLIC OF TANZANIA, UPPER VOLTA, ZAIRE AND ZAMBIA

Project title and number: Animal Trypanosomiasis Control: Economic Assessment and Applied Research on Glossina Control in the Dry Savannah Zones (RAF/75/001)

Executing Agency: Food and Agriculture Organization of the United Nations (FAO)

Government co-operating agencies: Ministries of Agriculture

Date of approval: July 1975

Starting date for project operations: September 1975^{1/}

Duration: Four years and four months^{1/}

Estimated value of the Government inputs expressed in US dollars: \$1 096 000 (in kind)

Estimated UNDP additional contribution: \$1 543 500

Source of UNDP financing: Indicative Planning Figure (IPF)

I. Background

1. African animal trypanosomiasis, a disease borne by the tsetse fly (*Glossina*) occurs in tropical Africa over an extension of about 10 million square kilometres. It is one of the chief causes of the underexploitation of hydro-pastoral resources of this region and a major limiting factor to rural development in general and animal production in particular in a large number of African countries.
2. Tsetse flies are also the vectors of human trypanosomiasis (sleeping sickness), a major problem for human health in tropical Africa. In some countries, sleeping sickness continues to be a potentially serious problem with the threat of an epidemic situation. The control of the tsetse fly would consequently not only have

^{1/} Excluding a preparatory mission in May 1975

an economically beneficial effect so far as animal production is concerned, but would also reduce the occurrence of sleeping sickness and lessen human death and suffering.

3. It is estimated that, if trypanosomiasis were brought under control; the African Continent could carry a supplementary cattle population of about 120 million with a production of 1,500,000 tons of meat per year, representing a value of at least US\$750 million. Large areas unexploited at present would become open for cattle production, and provide feed for enlarged herds as well as produce food for human consumption. Above all, it would progressively enable the people of these areas to attain higher levels of prosperity and well-being.

II. The project

4. The general long-range objective of the project is to contribute to the elimination of animal trypanosomiasis as an obstacle to the socio-economic development of tropical Africa. It will also contribute to the control of human sleeping sickness.

5. The immediate objectives of the project are to: in the field of the economic assessment of animal trypanosomiasis and its control (a) Assess the economic impact of animal trypanosomiasis, taking into account the direct losses (mortality, morbidity, cost of control) and the indirect losses (consequences on human health and economy); (b) Estimate the cost of the methods of tsetse fly and disease control both available at present and still experimental and potential; and (c) Evaluate the long-term results of previous actions and advise on the implementation of each method. Land use after clearing of the disease will be included as part of the survey. In the field of Glossina control assist in developing a suitable tsetse control methodology applicable to dry savannah species of socio-economic importance, such as Glossina morsitans, G. submorsitans, and G. pallidipes. The main target is to guarantee the safe and effective human settlement and agricultural development of the dry savannah zones through the control of tsetse flies by application of biodegradable insecticides (with ample safety margin for man and domestic animals). However, any economically promising control methodology will be investigated.

6. The expenditure components of the UNDP contribution are as follows:

| | Previously approved | | Present approval | | Total approved | |
|--|---------------------|---------------|------------------|------------------|----------------|------------------|
| | m/m | \$ | m/m | \$ | m/m | \$ |
| Experts and administrative support personnel and mission costs | 2 | 12 000 | 168 | 705 000 | 170 | 717 000 |
| Subcontracts | | | | 248 000 | | 248 000 |
| Training | | | | 82 000 | | 82 000 |
| Equipment | | 40 000 | | 203 500 | | 243 500 |
| Miscellaneous | | 25 000 | | 305 000 | | 330 000 |
| | | <u>77 000</u> | | <u>1 543 500</u> | | <u>1 620 500</u> |

7. Of the total amount approved it is planned that \$682 000 will be expended beyond the current IPF period.

UNITED NATIONS

Press Section
Office of Public Information
United Nations, N.Y.

NER/

(FOR USE OF INFORMATION MEDIA — NOT AN OFFICIAL RECORD)

Press Release FAO/2553
20 January 1975

FAO AGREES ON JOINT PROGRAMME TO BATTLE TSETSE FLY IN AFRICA

(The following is reproduced as received from FAO, Rome.)

A new joint programme to battle the tsetse fly in Africa and tick-borne diseases of livestock in many parts of the world has been agreed on by the Food and Agriculture Organization (FAO) and private industry.

The campaign against the tsetse, announced in Rome today by the FAO, represents part of the follow-up to the United Nations' World Food Conference, held in November. The Conference called for the launching of a long-term programme for the control of tsetse-borne African animal trypanosomiasis "as a matter of urgency". The disease also strikes at humans and is commonly called sleeping sickness.

A successful campaign could make more than 7 million square kilometres of tropical Africa fit for cattle production, the FAO estimates. The zone, which includes part of all tropical African countries, could carry an additional 120 million head of cattle, producing 1.5 million tons of meat per year representing a value of at least \$750 million.

The animals could browse on rangeland instead of consuming costly feed-grains.

A campaign in Nigeria offers evidence that the tsetse fly can be controlled. According to Dr. Pierre Finelle, a specialist in the FAO's Animal Production and Health Division, 150,000 square kilometres — equivalent to more than one-third of Italy — have been recovered for agricultural purposes.

The Animal Production and Health Division plans to budget \$700,000 in seed money for the drive against trypanosomiasis. The FAO estimates that more than \$2,000 million from all sources would be needed over a period of 40 years to clear the 7-million square kilometres zone.

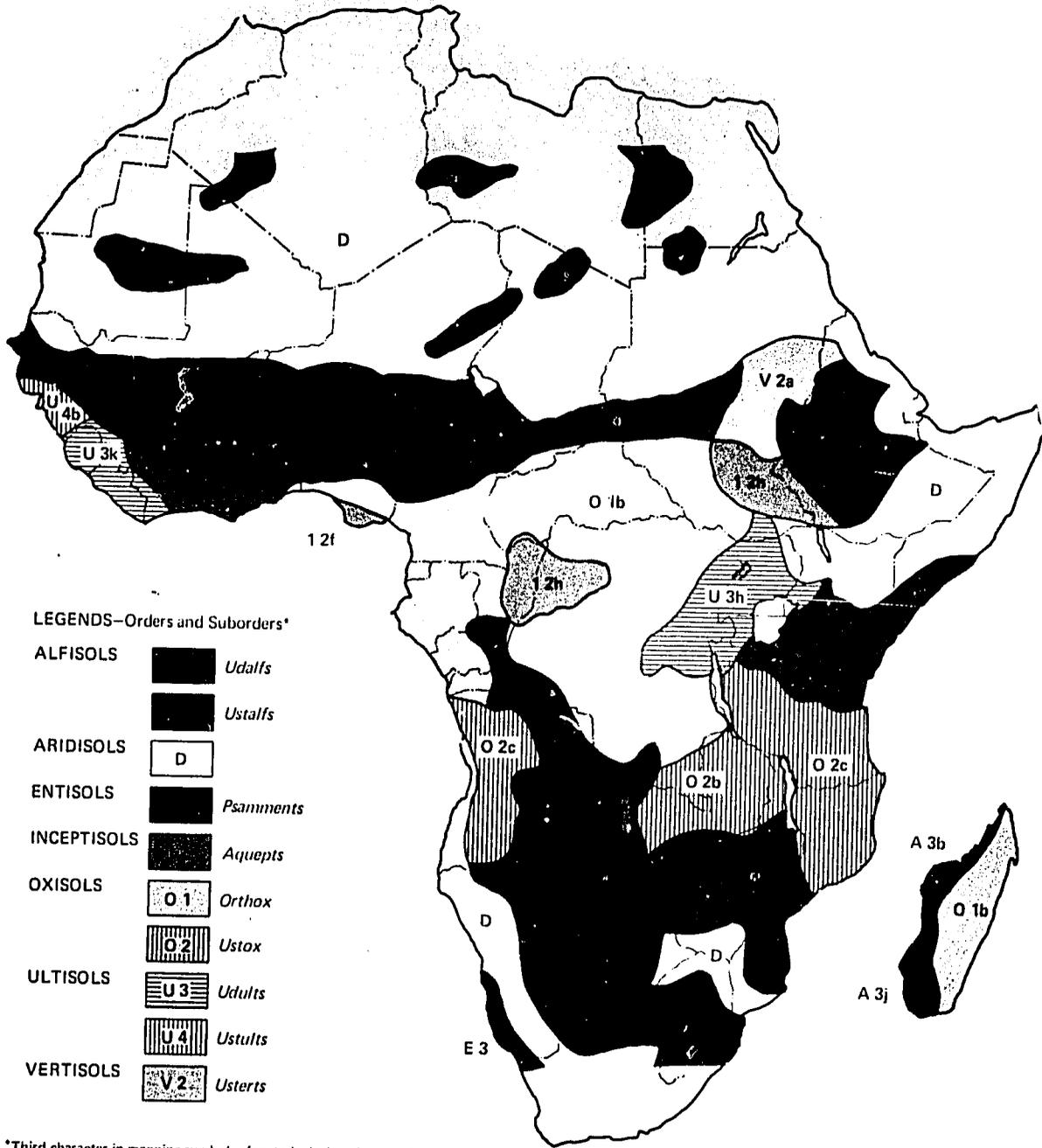
Representatives of 15 firms specializing in pesticide compounds and veterinary drugs met in Rome on Friday, 17 January, to form a task force with specialists from the FAO's Industry Co-operative Programme and the Animal Production and Health Division. The task force noted that diseases borne by ticks account for extensive livestock losses in Africa, South America, Asia and Australia. A complicating problem is that many ticks have developed resistance to pesticides, and the FAO proposed the establishment of a global resistance-monitoring programme.

Elected Co-Chairmen of the task force were Dr. Fritz Bauer of Hoechst Ltd., Federal Republic of Germany, and Dr. R.B. Griffiths, Chief of the FAO's Animal Health Services.

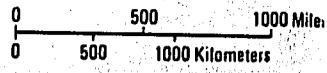
Rockefeller Foundation: John Pino, Director for Agricultural Services

The Rockefeller Foundation is very interested in the implications of tsetse fly eradication and the development of a trypanosomiasis vaccine. Indeed, with ILCA and ILRAD, the Foundation plans to help sponsor a conference on this subject this fall or early next year. Rockefeller feels that there is serious need for two related efforts in this regard, the intensification of research on the lands of the fly belt to make possible environmentally sound use and a major effort on the part of all concerned to design true long-term development programs for the new lands to avoid the reoccurrence of the problems now faced in occupied area. Like the other major organizations involved in the issue of tsetse fly eradication, the Rockefeller Foundation is interested in protecting the environment's productivity. However, contrary to the others, Rockefeller stresses first that without opening the fly belt there is no way of arresting the decline of the semi-arid zones and that unless planned development of some sort can be started soon, the fly belt will suffer serious degradation through short-sighted, piecemeal exploitation.

Map 5
SOILS OF TROPICAL AFRICA



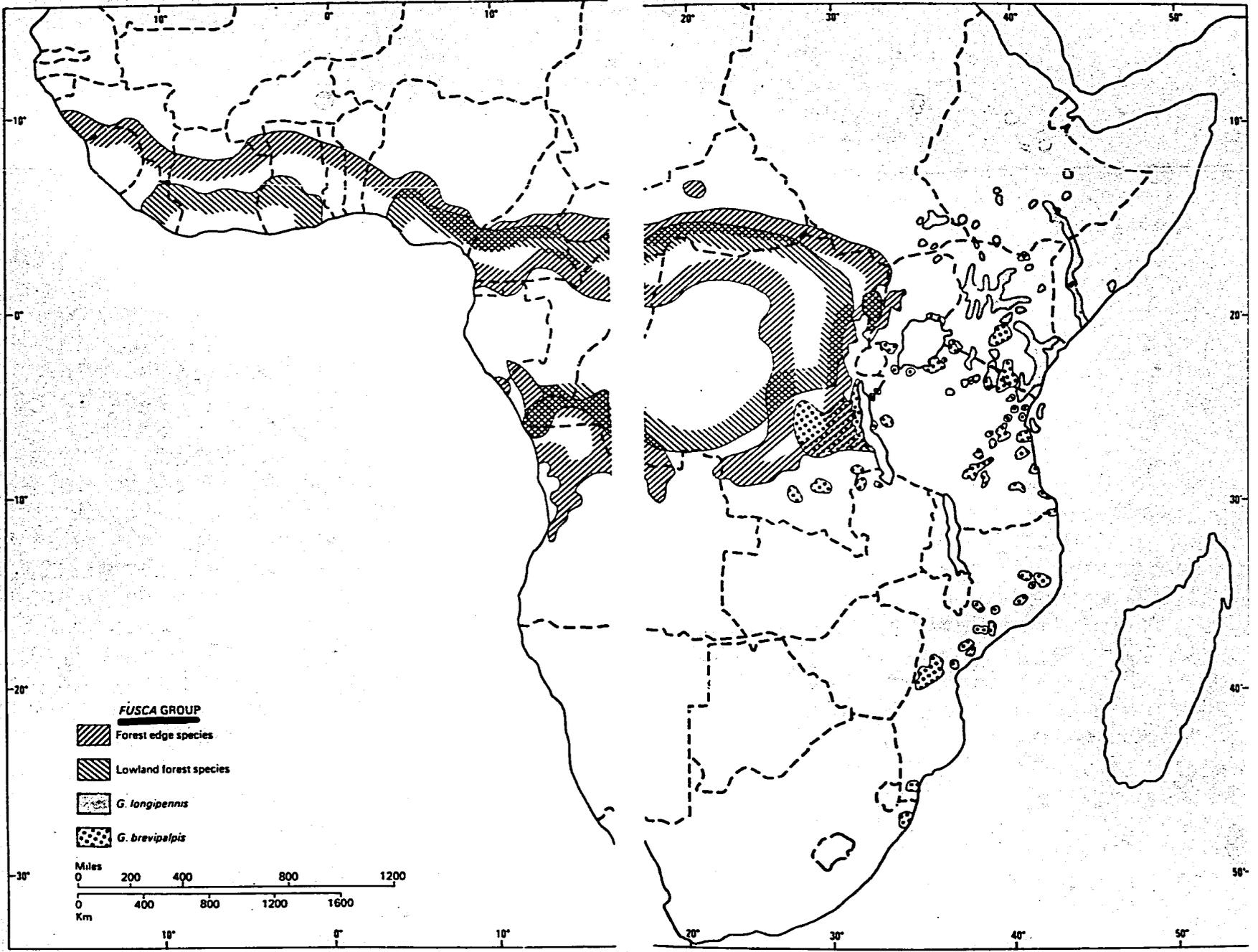
*Third character in mapping symbol refers to inclusions in the suborders, which are identified in the accompanying legend. The representation of international boundaries on this map is not necessarily authoritative.



From Arnold Moeller, "Tsetse Land - An Overview"

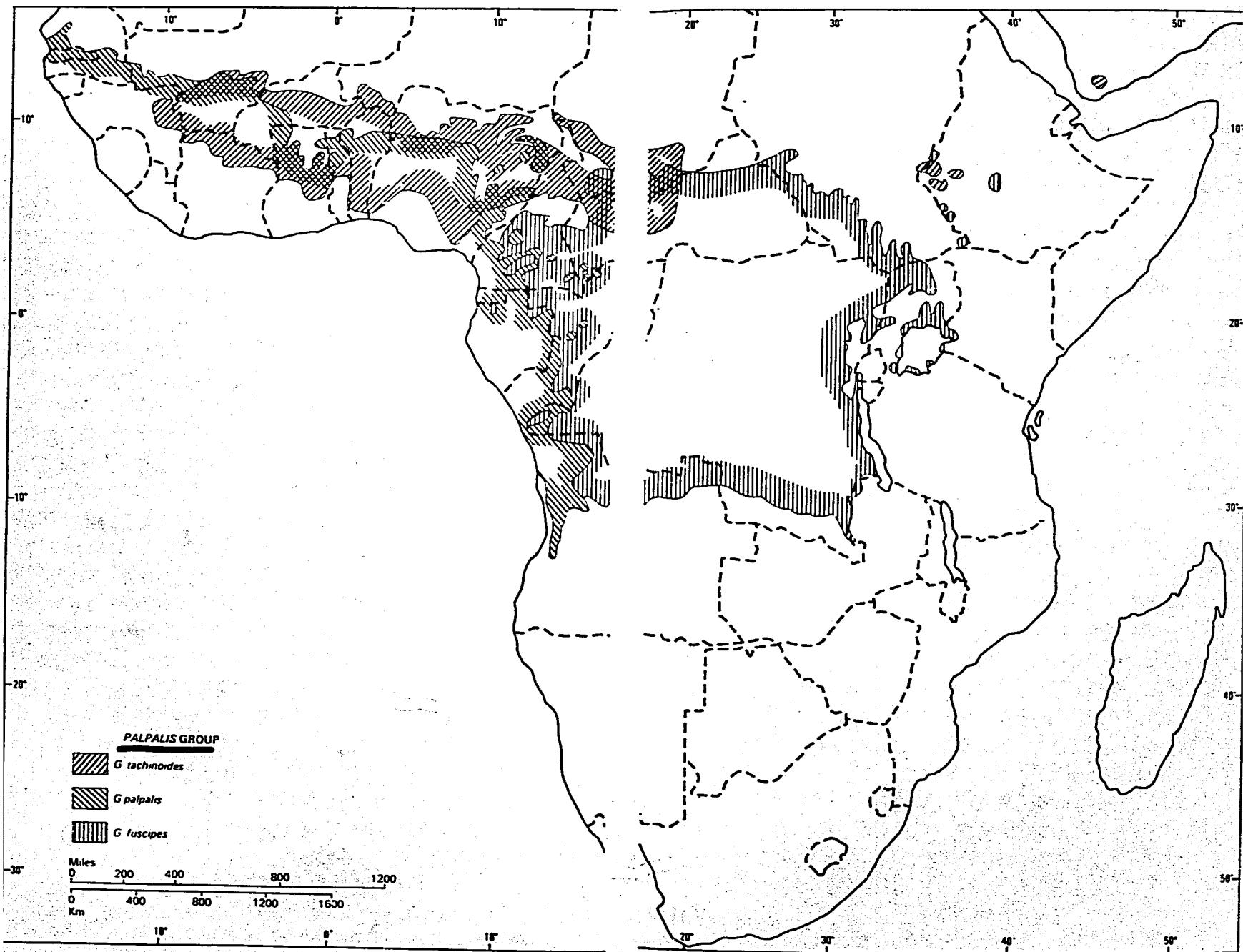
From John Ford, "The Role of Trypanosomes"

B-2



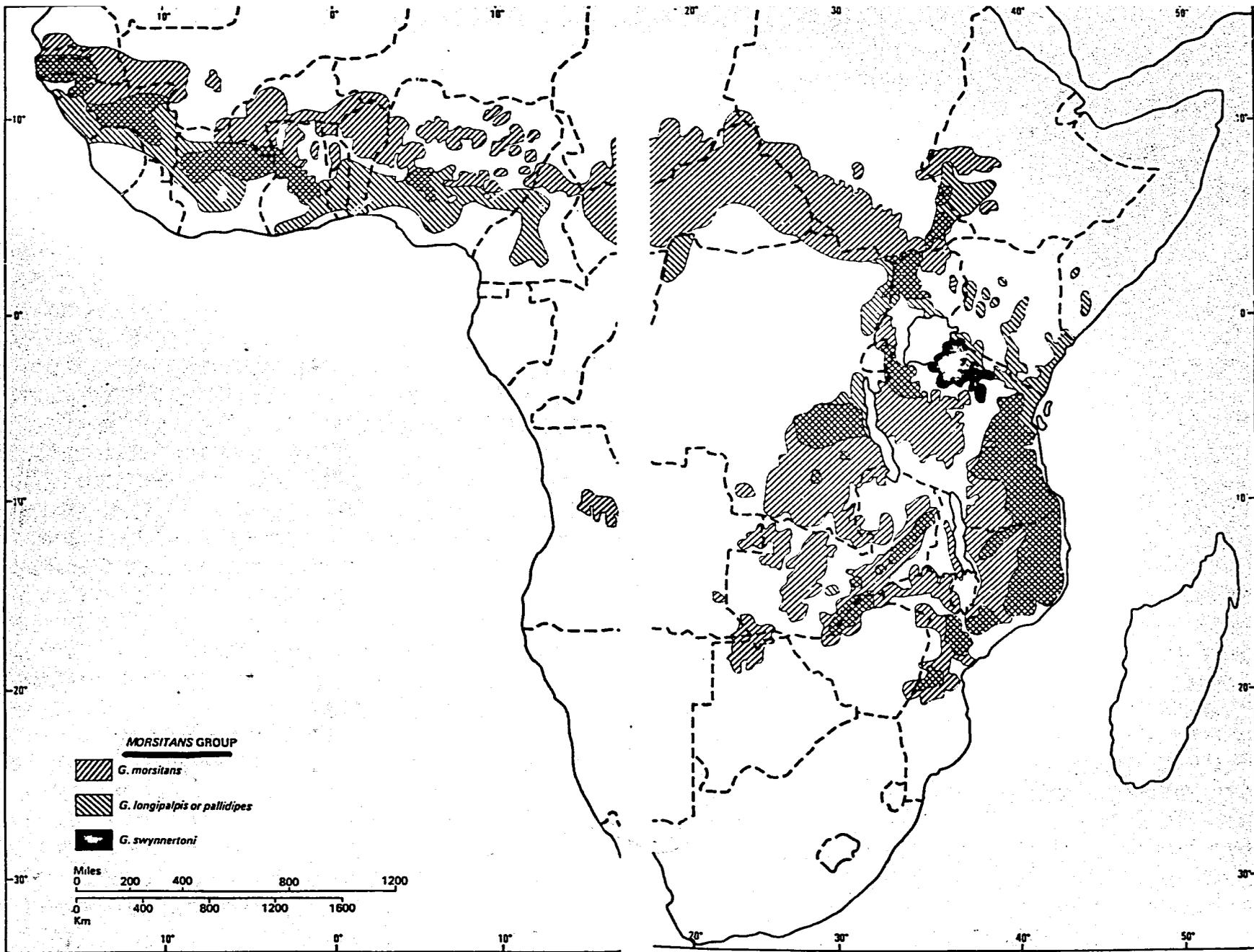
THE RANGE OF *RYPAROSOMES*

B-3



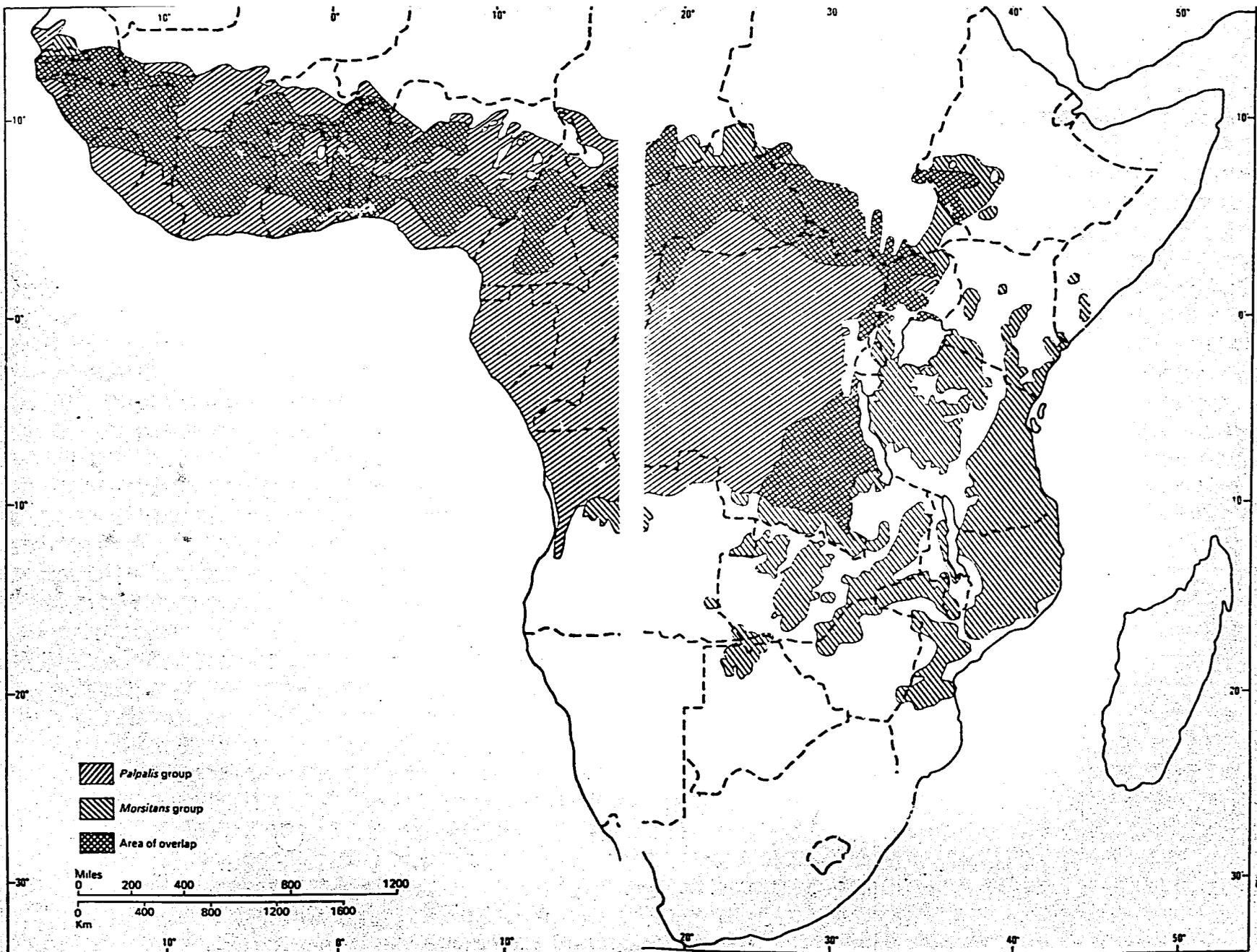
from John Ford, "The Role of Tridanosomes"

B-4



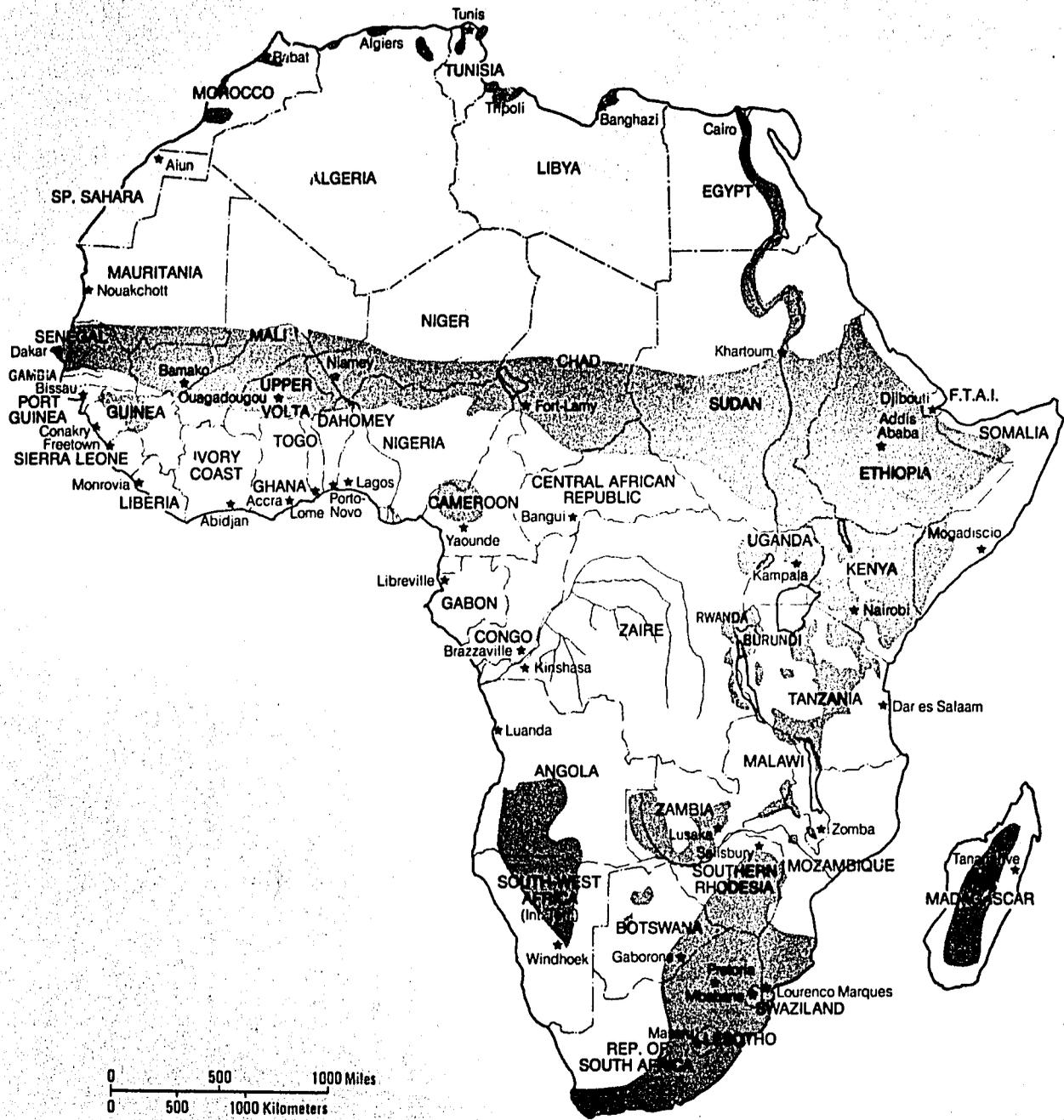
From JOHN FOUD, "THE HOME OF IGYRANOSOMES"

R-5



**Map 2
MAIN CATTLE PRODUCING AREAS**

16



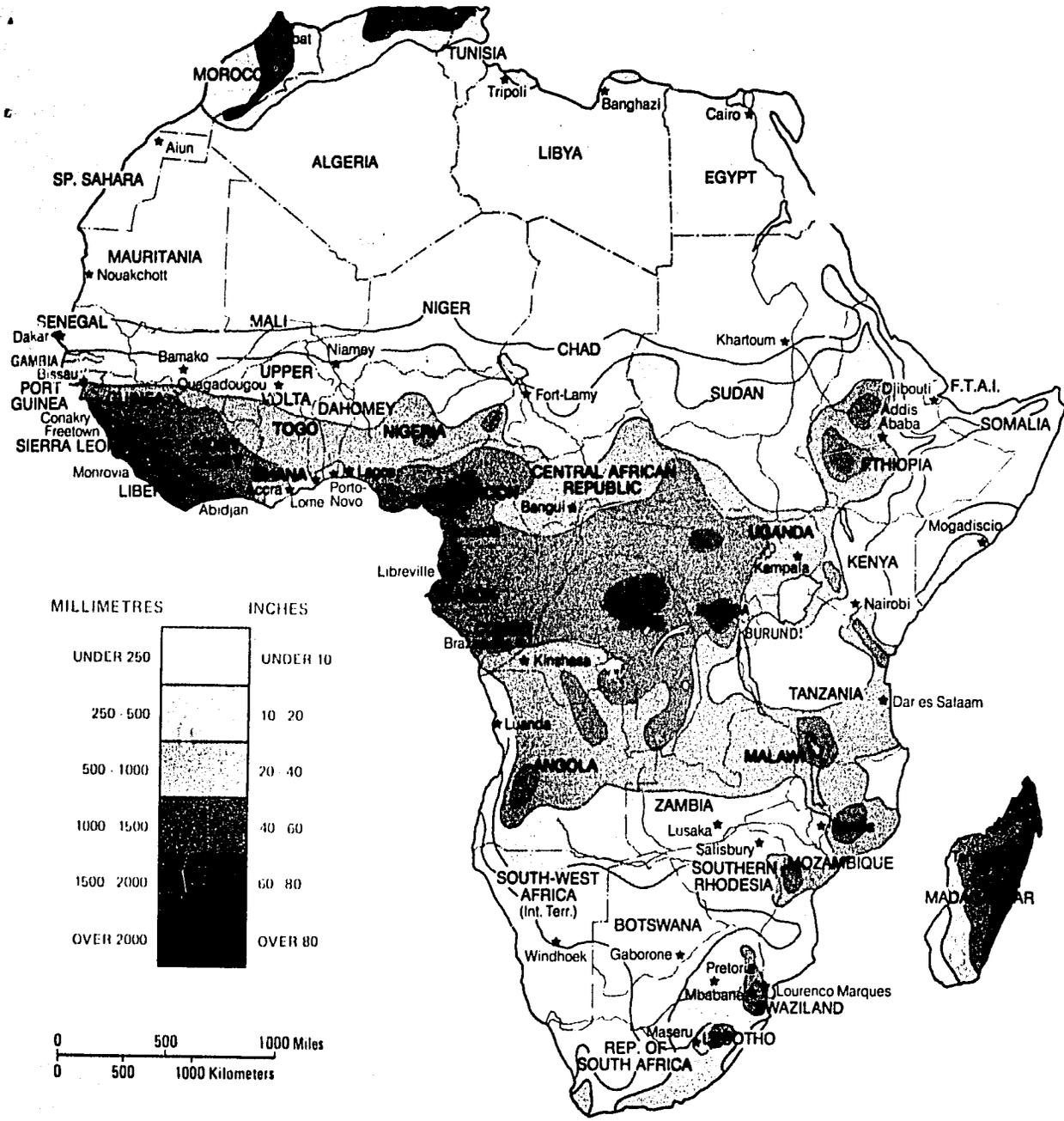
From Arnold Moeller, "Tsetse Land - An Overview"

Map 1
 DISTRIBUTION OF TSE-TSE FLY



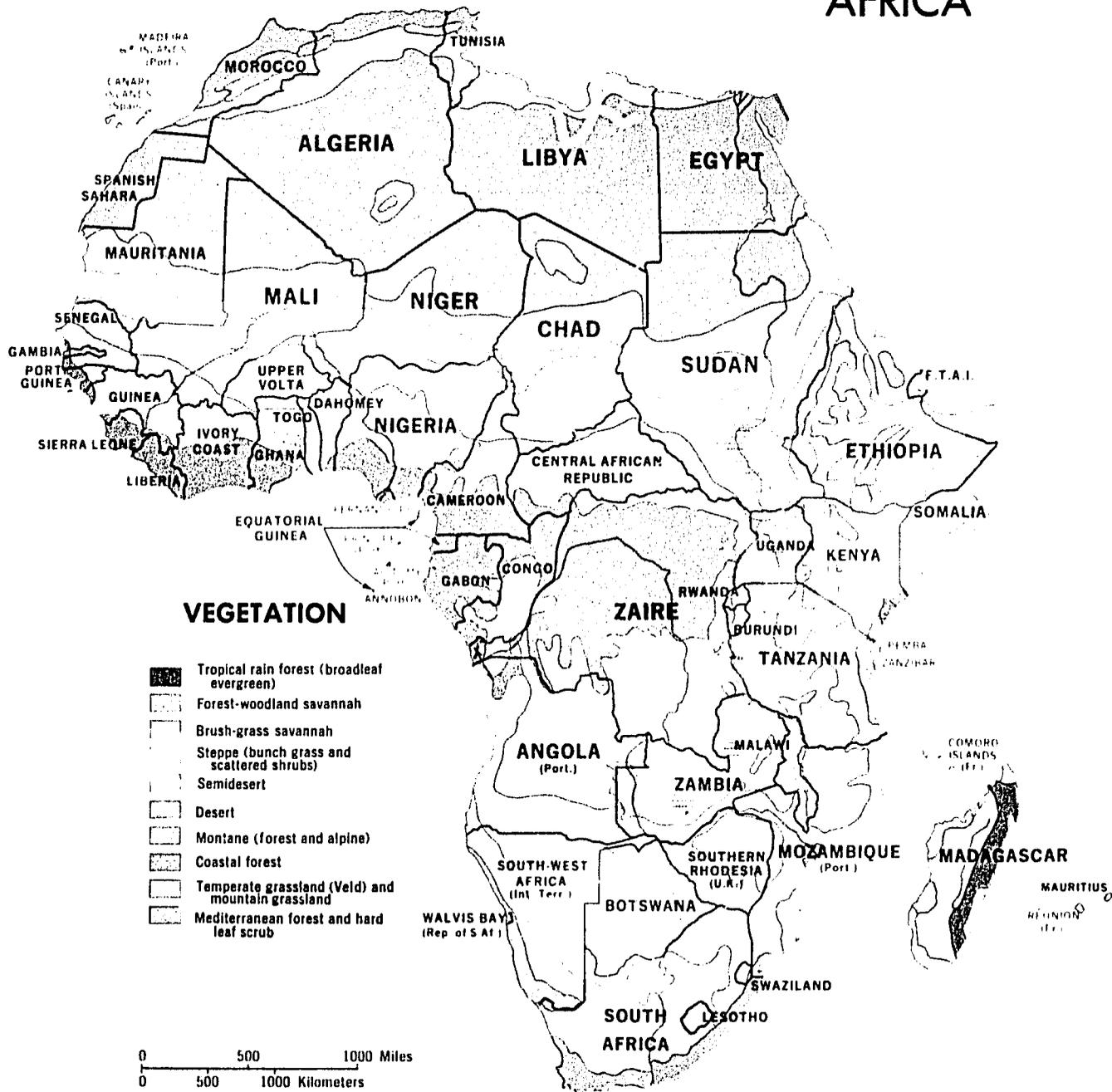
From Arnold Moeller, "Tsetse Land - An Overview"

Map 4
 AVERAGE ANNUAL RAINFALL



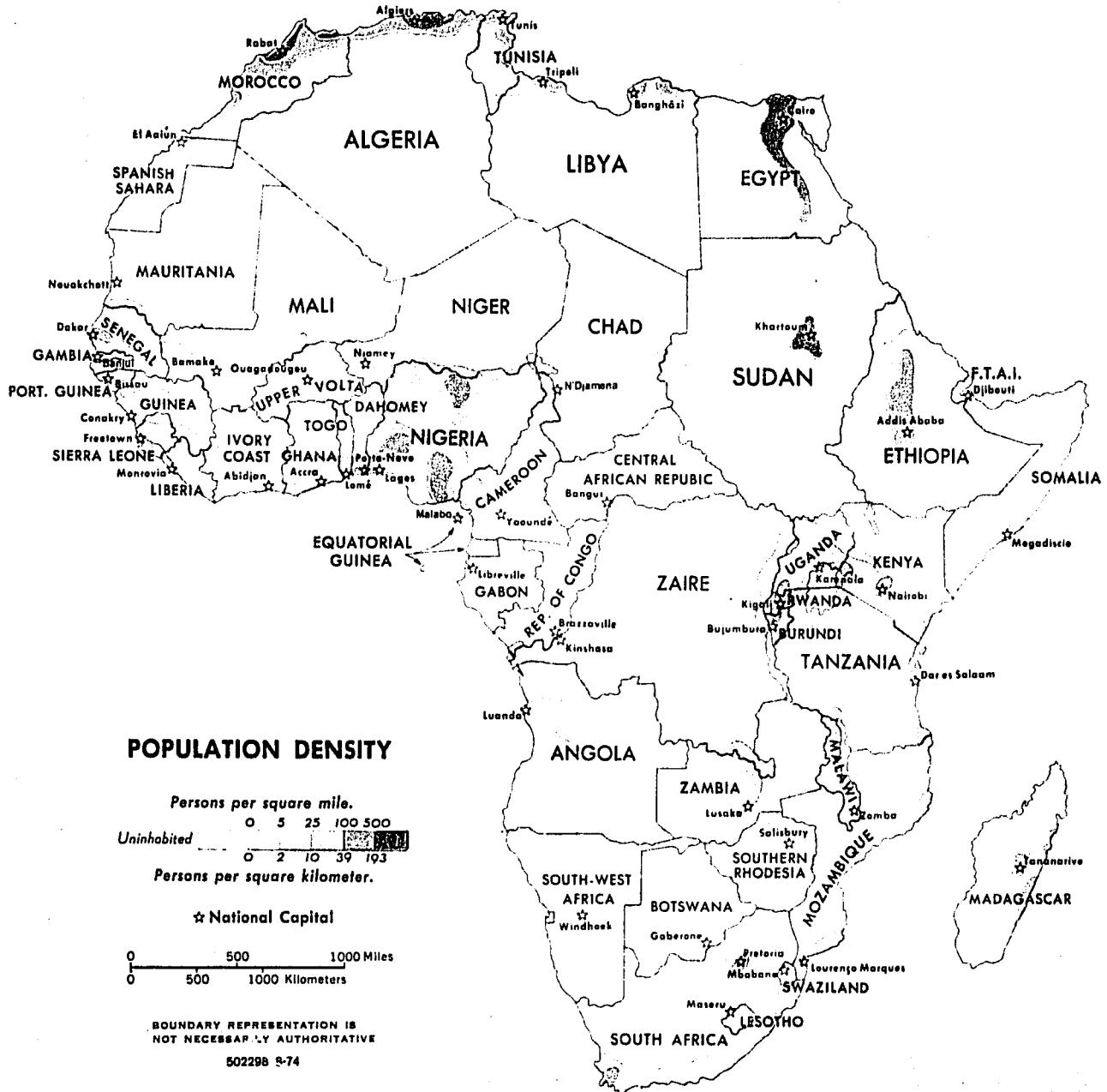
From Arnold Moeller, "Tsetse Land - An Overview"

AFRICA



From Arnold Moeller, "Tsetse Land - An Overview"

AFRICA



From Arnold Moeller. "Tsetse Land - An Overview"

APPENDIX C

In The Role of Trypanosomes in African Ecology, John Ford documents the disruption and reestablishment of the man-tsetse fly balance in detail for a number of areas. One of the most striking examples is that of Sukumaland, Tanzania.

- 1) Severe reduction of the human population began soon after 1890, and continued until about 1920. The evidence is abundant but not quantitative.
- 2) In 1891 and the next few years the domestic cattle population was almost completely exterminated by rinderpest. Buffaloes in the bush around Sukumaland were wiped out and probably other species including the Snidae and some antelopes were nearly exterminated.
- 3) As a consequence of (2) there was a recession of tsetse from the borders of the settled country, but recovery of the animal hosts was rapid and by 1913 the flies were spreading again and now invaded the country, denuded of much of its human population, (1) above, which had previously been tsetse-free.
- 4) An outbreak of Rhodesian sleeping sickness in the Maswa district probably began in 1918 and reached a peak in 1925. It was controlled by evacuation of people and this, in turn, accelerated the spread of G.swynmertonii.
- 5) The greatest spread of Glossina was in Shinyanga in the south of Sukumaland from an area of bush with abundant wild animals, the "Nindo jungle", that had been extant at least since 1858. This area was part of a Grenzwildnis between the southern Sukuma and the northern Syamwezi.
- 6) Between 1923 and 1930 organized bush clearing halted the spread of tsetse in this area and the remaining bush was preserved for experimental purposes by the Tanganyika government Tsetse Research Department.
- 7) The cattle population of Sukumaland probably continued to multiply very rapidly until about 1925 when the rate of increase diminished. In 1931 and 1932 famine plus a rinderpest epizootic brought about a decline, but thereafter the cattle population continued to rise, though increase again was halted by famine in 1942 and, very severely, in 1949.

8) The human population ceased to decline in the 1920's and may have been showing a true increase by the mid-1930's (0.8 per cent per annum between 1934 and 1944.

9) Until the mid-1930's, spread of tsetse fly around Sukumaland continued but was halted in some parts by bush clearing.

10) After about 1935 the trends were reversed. The increase rate of the human population may have reached 1.5 per cent per annum between 1944 and 1947.

11) By 1947 the tsetse belts were receding all around Sukumaland, and the tsetse-free area of cultivation steppe had increased, as compared with 1924, by 3,000 square miles, of which only 800 could be attributed to direct entomological attack on the tsetse.

12) The growing human population began, during the late 1930's, to reclaim bushland both on the east and west of Sukumaland. In the south, expansion was prevented by the preservation of about 1,000 square miles of bush, much of which had earlier composed the ancient frontier zone of Sukumaland.

13) The greater part of the excess population moved westwards into Geita district, where the population probably increased from about 60,000 in 1934 to 270,000 in 1957. The expansion eastwards began later and in the south only when the preserves of the Tsetse Research Department were decontrolled.

14) In 1949, epidemic human trypanosomiasis appeared among immigrant people in the van of the westward movement into Geita. This was easily reduced by preventing scattered settlement and by reduction of tsetse density by partial bush clearing. The medical coverage was also greatly superior to that which it had been possible to provide in the 1920's.

15) Apart from sleeping sickness, there was considerable evidence that, in contrast to the situation in the 1920's, cattle trypanosomiasis was less of a problem. In Geita, even without drug therapy, immigrant settlers grazed their cattle quite close to bush in which G.morsitans could be taken. On both sides of Sukumaland cattle trypanosomiasis was not a serious obstacle to the occupation of bush and expulsion of the larger wild fauna by peasant farmers.

16) The principle control over cattle population density is exerted by availability of pasture. Pasture is created by the destruction of bush by farming. This process, however, does not proceed rapidly enough to prevent overstocking. This leads in turn to heavy periodical mortality from famines and thirst in bad years.

17) A further control over stock numbers is exerted by theileriosis, a tick-borne disease that spreads outside enzootic areas when heavy losses of cattle by starvation lead to temporary understocking. This causes more abundant grass growth than is usual and hence enlarges the environment available for the growth of tick populations. These, in turn, produce epizootic conditions. Development of immunity in the calves of surviving cattle assists in the build-up of the cattle population to a level at which pasture grasses are kept too short to support enough ticks to maintain an epizootic." (28, p. 232-233)