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TRYPANOSOMIASIS IN AFRICA: ITS EFFECT ON DEVELOPMENT

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Trypanosomiasis is a disease endemic to sub-Saharan Africa. Its vector, the tsetse fly, thrives in the savanna woodlands and tropical rain forests of the continent. Trypanosomiasis in animals and sleeping sickness, as it is called in humans, illustrates the dynamics between disease control, environmental change, and economic development. Currently, 50 million Africans are at risk each year from sleeping sickness, and 40 million cattle for trypanosomiasis (Gerster 1986). Trypanosomiasis in cattle not only lessens the ability of African states to meet the protein needs of their populations through livestock production, but also restricts a potential source of draft animals for agricultural work.

Development of an African livestock industry able to meet the needs of a growing population has been precluded by widespread infestation of trypansome-carrying tsetse flies in savanna and forest areas of the continent. Programs intended to control tsetse flies have utilized bush-clearing, insecticide spraying, human settlement, and resettlement to open new areas for livestock and agricultural development. Opponents of tsetse control programs argue that opening new areas to cattle will promote overgrazing of marginal

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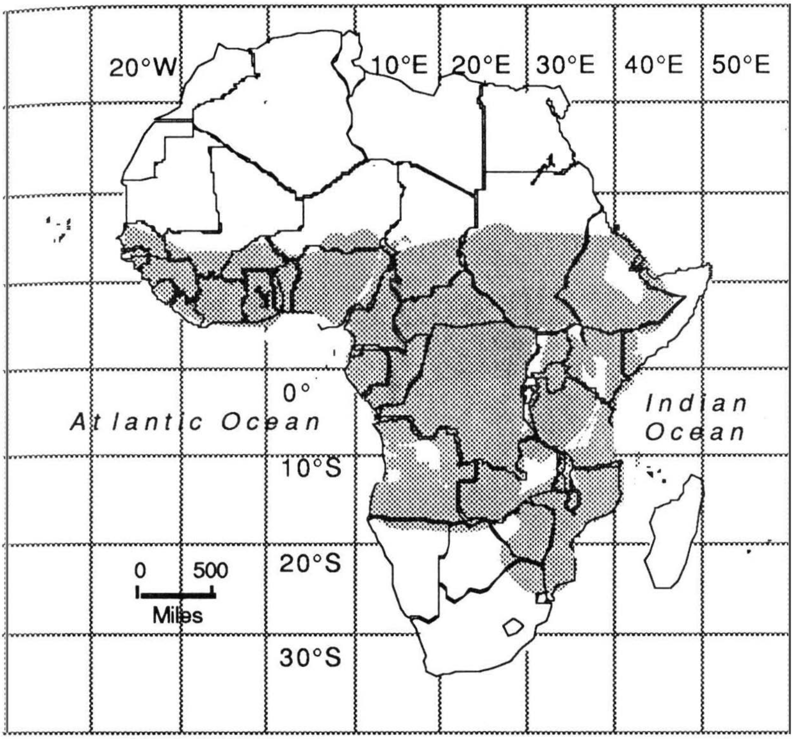
lands and threaten the habitat of Africa's diminishing wild game.

This essay examines how altering patterns of land use through tsetse control can either exacerbate an already bad land-use situation, or provide new opportunities for greater self-sufficiency through intelligent land management. The essay reviews current literature with a critical eye toward these objectives.

Tsetse and the Trypanosomes

The tsetse fly is found only in Africa—between latitudes 15° North and 29° South (Hendry 1979). Its boundaries are primarily climatic, vegetative, and altitudinal; and they delimit an area roughly the size of the United States, between the Sahara and Kalahari deserts (Figure 1). Within more than 11 million square kilometers of the continent, high temperatures and low annual rainfall mark the northern limits of the tsetse fly, while cold temperatures mark the southern limits. In between, areas above 1300–1800 meters (approximately 4200–6000 feet), depending on temperature, are generally free of tsetse. Tsetse cannot survive in open, treeless grassland or in grassland with only scattered trees; and the fly is rarely found in areas with less than 500 millimeters (approximately 20 inches) of annual rainfall. The optimum temperature for tsetse populations is around 25° C (77° F) in relatively moist and shady environments. Tsetse larvae will not develop into adult flies if the temperature is less than 10° C (50° F) or higher than 40° C (104° F) (Udo 1982; Jordan 1986, Lee and Maurice 1983; Rogers and Randolph 1985).

The tsetse fly is the main vector of the trypanosome pathogen (Hendry 1979). Aside from a few isolated cases of transmission of trypanosomiasis by bites from horse flies and stable flies, the only way to contract trypanosomiasis or sleeping sickness is from a bite by a tsetse fly infected with the trypanosome virus (Lee and Maurice 1983). Only in the saliva of the tsetse fly are trypanosomes able to complete



Source: J. Ford, "The Geographical Distribution of Glossina", 1970

Figure 1. Distribution of the Tsetse Fly in Africa.

their life cycles (Jordan 1986). It is difficult to imagine a more unlikely vector for successful disease transmission than the tsetse fly, with its relatively low population densities, short life-span, and dependence on only one food source.

Tsetse* belongs to the genus *Glossina*. Within this genus are three groups and twenty-two species, some of which are divided into sub-species (Putt et al. 1980). The three groups are characterized by the terrains which they inhabit: *G. fusca*

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*The word "tsetse" (pronounced 'tet´se' in English) is from the Sechuana language spoken by some groups in Botswana. It refers to a 'fly destructive to cattle' and may be onomatopoeic, suggesting a buzzing sound.

is found primarily in the tropical forests of West Africa and the Congo Basin; *G. palpalis* is found in the tropical rain forests and river basins of North–Central and Western Africa; and *G. morsitans* is found in the savanna woodlands of South–Central and Eastern Africa (Lee and Maurice 1983) (Figure 2). *G. morsitans* is the species of *Glossina* which has the greatest impact on both humans and animals. *G. morsitans* is the principal vector of the *Trypanosoma brucei rhodiense*, which causes the acute form of sleeping sickness in people and is also the major vector of nagana,† that is of animal trypanosomiasis (Jordan 1986).

The average life-span of the tsetse fly is usually ninety days, with female flies living somewhat longer than males (Lee and Maurice 1983; Jordan 1986; Langley and Weidhaas 1986). The tsetse is very temperature dependent, both in the rate of its daily metabolic activity and in the overall climatic and meteorological conditions in which it can survive (Rogers and Randolph 1985). Vertebrate blood is the tsetse's only food source (Lee and Maurice 1983; Jordan 1986). When tsetse larvae emerge as adult flies, they are free of trypanosomes. Only if they take a blood meal from an infected host will they become vectors of the disease.

Trypanosomes exist in many species of wild game without becoming pathogenic to their hosts (Jordan 1986). Trypanosomes are parasitic protozoa of the genus *Trypanosoma*. The primary hosts and relative importance of each species is outlined in Table I. It is the subgenus *Trypanozoon* that has the greatest impact on both humans and animals. The natural hosts of the trypanosomes are the wild game of Africa, such as the kudu, waterbuck, eland, and giraffe—all of which are insusceptible to the trypanosome infection (Jordan 1986).

T. brucei trypanosomes do not infect human beings but are the primary cause of trypanosomiasis in domestic ani-

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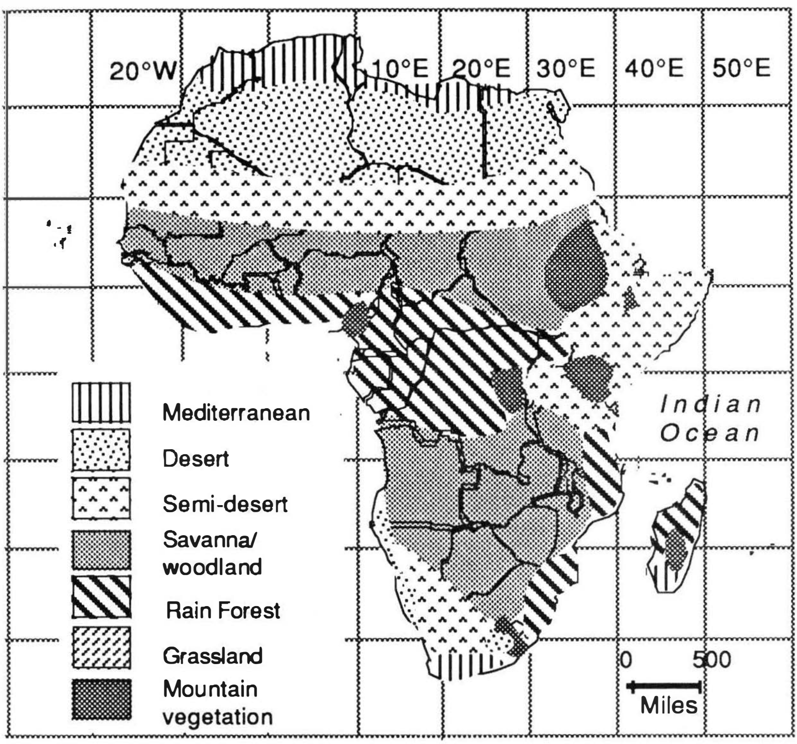
†Nagana is a Zulu word which signifies 'a state of depressed spirits.'

mals. Both *T. brucei rhodiense* and *T. brucei gambiense* infect humans. *T. brucei rhodiense* is associated with the acute form of sleeping sickness that occurs primarily in East Africa. *T. brucei gambiense* occurs primarily in West Africa and is a chronic, and usually more deadly, form of sleeping sickness (Lee and Maurice 1983).

Human Trypanosomes

The human form of trypanosomiasis is a disease of the central nervous system; it initially manifests itself in swelling of the lymph glands, high fever, and general lethargy (Jordan 1986; Gerster 1986). Left untreated, the victim's condition may deteriorate for weeks, in the case of in-



Source: I. LL. Griffiths, An Atlas of African Affairs, 1985

Figure 2. African Vegetation Zones.

Table 1. THE TSETSE-TRANSMITTED TRYPANOSOMES OF AFRICAN MAMMALS

Group/ Subgenus	Hosts	Distribution	Importance
T. vivax	Wild and domestic mammals (not pigs)	As for *Glossina*	Major disease of cattle and other ungulates.
T. uniforme	Wild and domestic mammals (not pigs)	East and Central Africa. Restricted.	Localized. Mild disease.
T. congolense	Wild and domestic mammals	As for *Glossina*	Major disease of cattle and other ungulates.
T. simiae	Wild and domestic pigs	As for *Glossina*	Acute disease of domestic pigs.
T. brucei brucei	Wild and domestic mammals	As for *Glossina*	Acute disease of dogs and horses. Chronic in cattle and pigs.
T. brucei rhodiense	Humans, wild and domestic animals	East and South–Central Africa	Acute form of sleeping sickness in humans.
T. brucei gambiense	Humans, wild and domestic mammals	West and North–Central Africa	Chronic form of sleeping sickness in humans.
T. suis	Wild and domestic pigs	Tanzania, Burundi, (elsewhere?)	Very localized. Pathogenic to young domestic pigs.

(Adapted from A. M. Jordan, *Trypanosomiasis Control and African Rural Development*, p. 4.)

fection caused by *T. brucei rhodiense,* or even years when the infection is caused by *T. brucei gambiense.* In either case, the victim becomes more and more emaciated, falls asleep often during the day, and eventually dies. The disease progresses from the bloodstream to the cerebrospinal fluid and then to the brain itself (Jordan 1986). If treated early, before the disease enters the central nervous system, trypanosomiasis can be cured. In some ways, the acute form of the disease caused

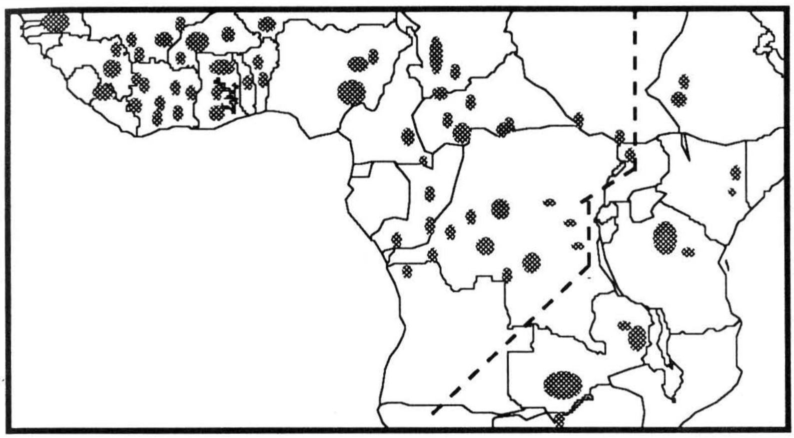


Figure 3. Approximate distribution of known foci of sleeping sickness in Africa. The dashed line divides *T. brucei gambiense* western and central foci from *T. brucei rhodiense* eastern foci. (From DeRaadt and Seed, 1977, as shown in Jordan, 1986).

by *T. brucei rhodiense* is the lesser of the two evils, since the victims are more likely to seek medical attention earlier on than are those who contract the seemingly milder form caused by *T. brucei gambiense* (Figure 3).

Between 1896 and 1906, half a million people died in the Congo Basin and another 200,000 died in Uganda during sleeping sickness epidemics (Jordan 1986). Nash (1969), Duggan 1970), and Ford (1971) have commented on the role of European colonization in disrupting the ecological balance of traditional African settlement patterns. Resettlement schemes under colonization resulted in the establishment of many rural hamlets in tsetse-infested areas (Jordan 1986).

Sleeping sickness was a greater problem earlier in the century than it is today. This is because early preventive measures were concentrated almost exclusively on the disease in humans (Jordan 1986). Nevertheless, the occurrence of sleeping sickness today is not insignificant. Up until at least 1979, 10,000 new cases were reported each year (Lee and Maurice 1983). In addition to the existence of endemic foci of sleeping sickness, other factors have contributed to continuing outbreaks of the disease. The drought in the Sahel in the early 1970's forced a concentration of population around a diminishing number of water boreholes—for both people and animals—that became sleeping sickness transmission sites in Benin (WHO/FAO 1979). Lack of access to rural areas has hampered efforts to control outbreaks in Cameroon and Gabon, while the difficulty of maintaining medical surveillance and follow-up treatments on nomadic populations, as well as drought and civil war, have all hampered control efforts in Ethiopia (WHO/FAO 1979).

W. E. Ormerod (1976) and F. V. Roboff (1977) imply that recent emphasis on trypanosomiasis control in animals instead of humans has actually helped to increase the probability of outbreaks of sleeping sickness. As larger herds of cattle compete with humans for shrinking water supplies, areas around boreholes and irrigation canals can become breeding grounds for tsetse, mosquitoes, and diseased snails (Jordan 1986). The abrupt departure of the Belgians at the end of the colonial era left medical administration and surveillance in disarray in Zaïre, thereby contributing to an increase in sleeping sickness infection rates (Roboff 1977).

Civil unrest, too, has disrupted sleeping sickness surveillance and control programs in Angola, Uganda, and Zimbabwe (WHO/FAO 1979). Failure to maintain programs in areas that previously had been cleared of tsetse resulted in new outbreaks in Tanzania in the early 1970's (WHO/FAO 1979).

The West African variety of the disease has endemic foci in Cameroon, Ivory Coast, the Central African Republic, Zaïre, Senegal, the Sudan, and the northern part of Angola. Its vectors are the riverine *Glossina*: *G. tachinoides*, *G. palpalis*, and *G. fuscipes*. Foci areas often are remote locations with dense vegetation, which makes on-going control programs difficult. The Sahelian drought contributed to an increase in tsetse populations in areas south of the desert that were previously free of the fly (Lee and Maurice 1983).

The East African form of sleeping sickness is carried primarily by the savanna/woodland *Glossina*: *G. morsitans*, *G. pallidipes*, and *G. swynnertoni* (Lee and Maurice 1983). Unlike *T. brucei gambiense*, which can be effectively transmitted to tsetse from humans, tsetse acquire *T. brucei rhodiense* mainly from infected dogs, horse, sheep, and infected wild animals. Endemic foci of the disease exist in Botswana, Ethiopia, Uganda, Mozambique, Tanzania, Rwanda, Zambia, and Kenya. Men have a higher incidence of infection with *T. brucei rhodiense*, probably because its natural reservoirs are the wild game with which hunters, woodsmen, and fishermen come in contact more frequently than women and children (Lee and Maurice 1983).

Lee and Maurice cite infection levels in Uganda as high as those of the epidemic there earlier in this century. In part this is due to an expansion of savanna/woodland vegetation which has helped to increase human/tsetse fly contacts. Also a factor is deep distrust of civilian authority on the part of a population subjected to prolonged civil unrest.

Animal Trypanosomiasis

Animals are at a considerably higher risk of contracting trypanosomiasis than humans, since only about 0.1 percent of the trypanosomes carried by tsetse are infective to humans, while almost all are infective to animals (Jordan 1986). The primary reservoirs of infection for domestic animals are wild game. Various species of *Trypanosoma* infect cattle, horses, dogs, sheep, pigs, and camels. As with sleeping sickness in humans, trypanosomiasis in animals can be either acute or chronic. The degree of susceptibility to trypanosomiasis in domestic animals depends on their overall level of nutrition, the extent to which they are used as draft animals, and the density of the surrounding tsetse fly population. The highest infection rates usually occur at the end of the dry season and during the early rains (Jordan 1986).

The disease in cattle can persist for months with the animal becoming increasingly emaciated and comatose. Alternatively, cattle can succumb to the infection almost immediately, with no clinical signs at all (Jordan 1986). Trypanocidal drugs exist that are quite effective in controlling trypanosomiasis in cattle, at least when used in prescribed doses under veterinary supervision. Unfortunately, most African states do not have either the necessary veterinary services or the administrative expertise for sustained drug therapy programs. Beyond that, drugs are often diluted to make them last longer, a practice which can lead to development of trypanosomiasis strains resistant to drugs (Ormerod 1976; Lee and Maurice 1983). In addition, the use of trypanocidal drugs can diminish development of cattle's natural immunity to low levels of trypanosomiasis infection (Ford 1971).

Trypanosomiasis in domestic animals has a long history in Africa. Some argue that its existence affected cattle-trading routes of ancient times, accounted for the failure of Islam to expand into sub-Saharan Africa, and—in contrast to Europe and Asia—long ago precluded the use of animal power for development purposes in Africa (Nash 1969; McKelvey 1973).

The impact of animal trypanosomiasis on land use in Africa today is the same as it has been historically. Ten million draft animals in contemporary tropical Africa contribute less than 10 percent of the labor used in agriculture, while over 80 percent is still provided by hand (Jahnke

1982). This confines African agriculture, for the most part, to small subsistence plots of land, making the economies of scale which might be provided by large plots out of the question. The persistence of tsetse-infested areas also precludes the keeping of domestic livestock in large areas of the continent that would otherwise be suitable for grazing and for the development of mixed agriculture (Jordan 1986).

Control Methods

The traditional method of preventing trypanosomiasis and sleeping sickness was to avoid tsetse-infested areas altogether. As population pressures grew and rural settlement pushed into fly-belt areas, other methods were devised. Since it was known that tsetse preferred savanna/woodland and riverine vegetation, the primary method of control was to cut back the vegetation. Similarly, after it was learned that wild game were natural hosts for trypanosomiasis, wholesale slaughter of wild animals was carried out (Lee and Maurice 1983). Gerster (1986) cites the use of pigs to distract tsetse flies from people in a West African village. In the Ugandan sleeping sickness epidemic of the early 1900's, whole populations were evacuated from the Lake Victoria area and resettled in non-tsetse areas (Ormarod 1976).

All of the traditional methods have serious drawbacks. Vegetation clearing, to be effective, must be carried out over a large area—at least three kilometers—to match the fly's range (Lee and Maurice 1983). It requires constant maintenance to prevent regrowth of vegetation and, because it is so labor-intensive, it can be extremely expensive. Killing wild game on a large scale is no longer ecologically desirable. African states have thus turned to chemical, biological, and mechanical means for tsetse control.

In the measures taken against trypanosomiasis, the emphasis is on control, rather than eradication. For several reasons, the target is the primary disease vector, the tsetse fly, rather than the pathogen trypanosome itself. Because foci of the disease are scattered in remote and often inaccessible areas, and also because of its endemicity, it is unrealistic to have total eradication as a goal in most areas (Jordan 1986). Additionally, the ability of the *Trypanosoma* to undergo antigenic variation makes it difficult to develop prophylactic and trypanocidal drugs which are effective against all species of the parasite (Lee and Maurice 1983; Jordan 1986). Eradication of trypanosomiasis is a realistic goal only in areas of isolated tsetse populations, such as those in northern Nigeria (Putt et al. 1980), or at the very edge of tsetse fly-belts, where natural barriers to re-infestation, such an open, treeless grassland exist (Lee and Maurice 1983; Jordan 1986).

Eradication campaigns, although very expensive in the short run, at least have the advantage of being short-term programs with a definite end in sight. Control programs, on the other hand, are long-term commitments which by their very nature require substantial financial and organizational resources to be successful. It is for this reason that control of trypanosomiasis is primarily a question of land use (Jordan 1986).

Insecticide Spraying

By far the most frequently-used method of tsetse control and eradication is insecticide spraying. Insecticides are sprayed by hand on the ground, by fixed-wing aircraft, or by helicopter. Insecticides vary in their residual capacity and can be either persistent or non-persistent in their long-term effect. The effectiveness of insecticides varies with dosage per unit of land area, type of vegetation, and prevailing meteorological conditions.

The oldest and most widespread method of insecticide spraying has been ground-spraying of residual insecticides with knapsack sprayers. This technique allows insecticide to be applied selectively against "tree trunks, lower branches and other tsetse resting sites (Allsopp 1984)." These campaigns are carried out during the dry season, using persistent insecticides with high residual capacities against the daytime resting sites of the fly (Lee and Maurice 1983). The most commonly used insecticides against the tsetse are DDT, dieldrin, and endosulfan (Allsopp 1984), all of which are lethal to the tsetse far beyond the minimal pupal period. To be effective, ground-spraying campaigns must be well organized and require a great deal of labor. These campaigns also require follow-up sprayings to kill any flies missed during the initial spray (Lee and Maurice 1983).

Helicopter spraying has the dual advantage of using less labor and being logistically less demanding than ground spraying. It is, however, three to ten times more costly than ground spraying, due to the amount of insecticide used on the one hand, and hourly rates for helicopter rental on the other (Lee and Maurice 1983).

Spraying from fixed-wing aircraft is comparable in cost to ground spraying; and by using up to four airplanes in sequential operation, as much as to 6,000 kilometers can be covered in a three-month period (Allsopp 1984). Zimbabwe has used a technique of ground spraying the periphery of an area which has been selected for aerial spraying before the aerial spraying itself is done (Allsopp 1984). This has proven very effective in halting tsetse re-invasion of areas previously sprayed from the air.

Success of insecticide spraying, either on the ground or from the air, is dependent on many factors. Insecticide type, dosage per unit of land area, terrain, meteorological conditions, and even the size of aerosol droplets all have an affect on the ability of an insecticide to kill tsetse. During the rainy season, no spraying can be effective, since the insecticide will not cling to vegetation. For all of these reasons, spraying campaigns must be tailored to the conditions of a specific country and land area. Much of this work is still in the trial-and-error stage.

Another chemical means of tsetse control involves use of insecticide-impregnated traps strategically placed in infested areas. Traps have long been used as a means of sampling the size of tsetse populations. In recent years, more attention has been paid to trapping because of its potential for cost effectiveness and ease of use on a local level (Lee and Maurice 1983). Traps do not require highly-trained personnel for their use and have a lesser impact on the ecology of the trap area in comparison to insecticides.

Environmental Impact of Control Methods

In most industrialized countries, DDT has been banned because it is a deadly toxin that remains in the food chain (Gerster 1986). Dieldrin and endosulfan can be equally toxic when used in concentrated doses. These insecticides can kill not only *Glossina*, but also other arthropods and invertebrates, as well as fish, birds, and mammals (Dance and Haynes 1980). In a study of effects from aerial spraying of endosulfan in the Okavango Swamps of Botswana, Russell-Smith and Ruckert (1981) found that when endosulfan was used as an ultra low volume (ULV) aerosol from fixed-wing aircraft in low application rates no damage was done to the invertebrate population. Insecticide-impregnated traps can also pose a hazard if they are placed indiscriminately in the environment (Langley and Weidhaas 1986).

Further research is needed to develop insecticides that are both lethal to the tsetse and safe for the environment. currently, the most promising technique for minimizing toxic side effects from insecticides is the ULV application method, which uses as little insecticide as possible in sequential, non-residual applications.

Controversies Surrounding Tsetse Control

As earlier noted, opponents of tsetse control programs argue that they will promote overgrazing of marginal lands and threaten wild life habitats. One of the consequences of the Sahelian drought of the 1970's was to force herders to move their cattle further south onto more marginal lands where they concentrated their herds around water boreholes. W. E. Ormerod of the London School of Hygiene and Tropical Medicine argues that resultant local overgrazing in the wake of such moves is contributing to a denudation of Sahelian vegetation that could affect the region's climate (Ormerod 1976). Ormerod cites studies which indicate that decreasing vegetative cover increases the albedo—or reflectance of the area—which results in less moisture returning to the surrounding atmosphere, which in turn results in less rainfall in the area. He thinks that control or elimination of the tsetse will worsen this feedback process.

Ormerod also argues that promotion of tsetse control campaigns on the ground that they help control sleeping sickness in humans is false. Because of the economic importance of the meat industry to West African states, Ormerod contends that sleeping sickness control has been of secondary importance to trypanosomiasis control. Even if it were of equal importance, he does not think it is necessary to have widespread bush clearance or aerial spraying to protect human populations; for the normal clearing of vegetation associated with traditional farming methods offers sufficient protection (Ormerod 1976).

Ormerod raises several important points. Both overgrazing and denudation of ecologically fragile lands, for example, are readily demonstrable. Ormerod is supported in his observations by Jahnke:

> Most of the pastoral areas of Eastern Africa show the signs of overgrazing and degradation. The pastoral organization of production cannot cope with ever increasing populations of man and stock and tends to destroy the very basis of production. This process is the quicker and the more dangerous the lower the natural potential of the area. Pastoralism can therefore not only be characterized by a figure of average production and benefits, but must, in its traditional form, be seen as a system of land use with an inherent mechanism for self-destruction (Jahnke 1974).

Jahnke also argues that ecological damage to former tsetse areas from cattle grazing can be minimized by changing the land tenure basis of pastoralism. In discussing the economic benefits of tsetse control in Uganda, for example, Jahnke suggests changing the land tenure system to insure either that land is held privately by an individual or group, or that both land and cattle are owned collectively:

> In either case the management must have the power to adjust stocking rates to the long-term capacity of the land, and in either case this must be in the material interest of the individual or collective owners of cattle .
>
> The process of converting pastoralism into a stable and productive form of land use through land tenure reform is a painful one. To facilitate this process should in my opinion be the major role of tsetse control. Tsetse-infested areas are as a rule empty areas to which no traditional claims are held. The establishment of a suitable land tenure system and the determination of the suitable man-land ratios are technically and politically desirable. The provision of additional land is an attraction to the pastoralist from a neighboring area and can therefore be more easily combined with stipulations concerning the acceptance of the tenure system and the adherence to certain basic husbandry standards. At the same time population pressure in the neighboring areas is relieved to facilitate land adjudication there. The resulting systems of cattle production may not be much more productive than traditional pastoralism, but the basis has been established for the future (Jahnke 1974).

It can be argued that—with or without the presence of tsetse—human population pressures are competing with traditional agriculture and cattle herding for available land in many parts of Africa. It can also be argued that—with or without the overgrazing of cattle—desiccation and drought may well be part of the normal climatic pattern of the West African Sahel. Similarly—with or without tsetse control campaigns—there is competition for land use between traditional farmers, large-scale ranchers, and the large game reserves on which wild life harbors trypanosomes as natural hosts. All of these considerations complicate the process of conscientious land use management.

Tsetse Eradication in Northern Nigeria

Throughout the 1960's and 1970's, the Nigerian government carried out extensive eradication campaigns in northern areas of the country which approached the limits of the tsetse fly's continental range. These areas remained fly-free as of 1980; and tsetse eradication had stimulated local economies and livestock production, as well as prompted an alteration of agricultural practices. In the past, a potential existed for crop farmers and traditional Fulani herdsmen to be pitted against each other over the use of available fly-free land. Tsetse eradication, however, opened up new areas to the farmer for cultivation and to the herdsmen for cattle grazing. Two examples of this successful campaign are the Fika Emirate and the Gongola North area.

The Fika Emirate, in the Borno state of northeastern Nigeria, comprises the districts of Fika, Nangere, and Potiskum, a small district around the town of Potiskum (Figure 4). The emirate was an area where valuable pasture resources were underutilized because of widespread tsetse infestation (Putt et al. 1980). Lowland Sudan vegetation and savanna/woodland vegetation in the emirate's uplands contrast with swampy areas, along the banks of the Komadugu–Gana and Gongola rivers, which are lined with tall shade trees—an ideal environment for riverine tsetse (Putt et al. 1980).

Historically, Fika Emirate had suffered severely during the years of the great sleeping sickness epidemics (Putt et al. 1980). The last big outbreak occurred during 1955–1956 in the Nangere District along the Komadugu–Gana river. The overwhelming majority of sleeping sickness cases were among men between the ages of fifteen and forty-nine. This was attributed to fishing trips taken during the dry season, which was a heavy period for tsetse (Putt et al. 1980).

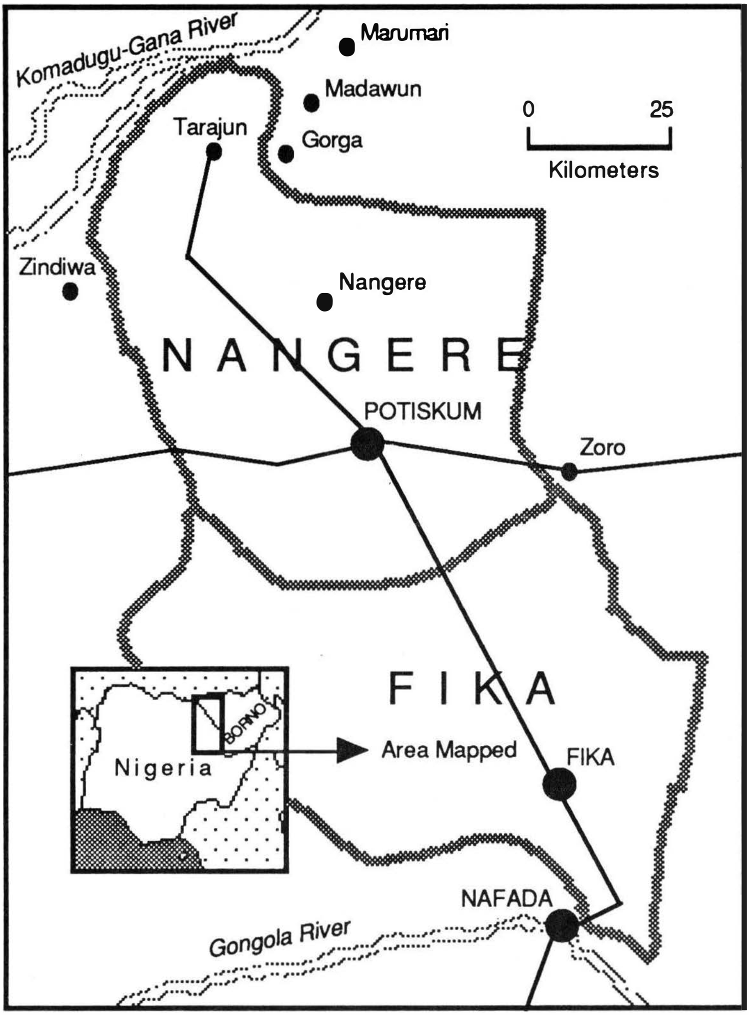


Figure 4. Fika Emirate in Borno State, Nigeria (From Putt, *et al.*, 1980)

Although *G. palpalis* was found in the region, the heaviest infiltration of tsetse involved *G. morsitans* and *G. tachinoides*, from areas along the Gongola river. Insecticide spraying campaigns commenced in the northern part of Fika during 1957–1960, and in the southern part during the years 1963–1964 and 1967–1968. A two-mile-long barrier clearing was made to prevent re-infestation in the south (Putt et al. 1980):

> Eradication has made available valuable dry season grazing and water resources to the livestock industry, which previously could only be utilized at a severe risk of contracting trypanosomiasis. Tsetse eradication has increased the year-round carrying capacity of the region, and more animals are now kept in the area.

After eradication, there was a problem with overgrazing in the northern part of the district, primarily as a result of increased pressure for dry-season grazing land during the Sahelian drought. There was no evidence of overgrazing in the southern portion of the emirate (Putt et al. 1980). Tsetse clearance opened up rich agricultural land to vegetable growing along the banks of the Gongola river. Probably the greatest single benefit of tsetse eradication for the area was the resultant ability to use cattle to do farm work and thereby greatly increase "the amount of land that can be cleared and farmed by a single farmer (Putt et al. 1980)." As of 1980, Fika Emirate—which prior to tsetse eradication was unable to support a settled cattle population—had the highest number of cattle per capita of any district in Nigeria.

The Gongola North area of Gongola State is located north of the Benue river, near the Cameroon border, and encompasses approximately 8,000 square kilometers (Putt et al. 1980) (Figure 5). Before 1970 it was a haven for tsetse flies. Although there were few occurrences of sleeping sickness, the *G. morsitans* population in the area prevented the use of its prime agricultural land and caused "the virtual disappearance of livestock from the area," with heavy cattle mortality in stretches along the Song and Tiel rivers (Putt et al. 1980). A 1970–1972 campaign of vegetation clearance and insecticide spraying—carried out in cooperation with the government of Cameroon, which undertook similar measures on its side of the border—cleared tsetse and trypanosomiasis from the area (Putt et al. 1980).

Following eradication, Fulani herdsmen not only began to graze their cattle throughout the year, but also to supply dairy products, meat, and manure to local residents.[85]

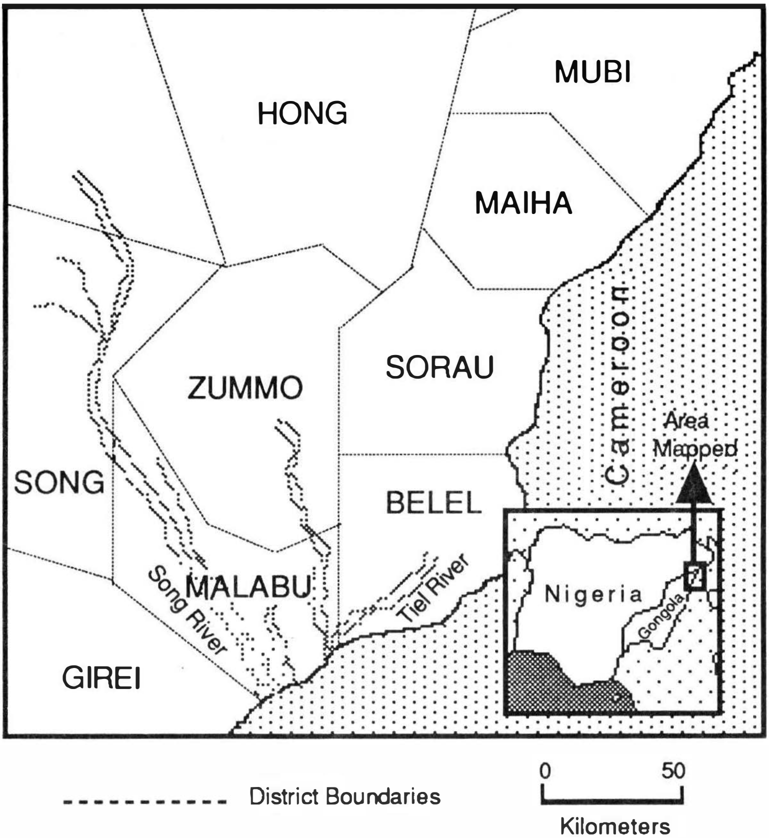


Figure 5. Gongola North Area (From Putt *et al.*, 1980).

Predictably, settlement in the area increased and, as a consequence, both agricultural development and livestock production rose dramatically (Putt et al. 1980). In the Belel District of Gongola alone—with some of the best agricultural land in the State—the population rose from 720 in 1971 to more than 5,000 in 1980. Earlier population under-reporting (as a means of avoiding taxation) was eliminated as a cause. This increase was due solely to the eradication of tsetse (Putt et al. 1980). Similarly, it was reported that before 1972 there were no cattle or horses in Belel because they had all died after the 1954 outbreak. Since eradication cattle have again been kept (Putt et al. 1980).

Conclusions

This essay is not a complete representation of Africa's trypanosomiasis problem. Even so, a general conclusion can be drawn—specifically, that trypanosomiasis control in Africa must be part of a balanced system of land use.

Though many factors contribute to land degradation, poor land management practices of the past offer insufficient grounds to close the door on new opportunities for development. The key consideration should be whether potentially good land for development goes unused because of tsetse infestation. Marginal lands with poor soils should be left alone. Riverine areas which have good agricultural potential as well as good potential for grazing and watering should be primary candidates for development.

Opening lands previously closed—because of tsetse infestation—to development can be part of an overall program of land management which simultaneously promotes conservation of easily degradable areas as well as preservation of vegetation and wild life. The key to such land use involves both planning and utilization of resources which, to the extent possible, are in harmony with traditional agricultural practices. As pointed out by a World Bank study of trypanosomiasis control, land use, environmental impact, and livestock management studies are needed *before* carrying out tsetse control programs (Lee and Maurice 1983).

Because tsetse fly habitats do not conform to international boundaries, programs to combat tsetse should be international in scope, as was the previously noted joint campaign between Nigeria and Cameroon in Gongola State. International cooperation, in the form of subregional intergovernmental organizations, might help African states to pool limited resources and trained personnel (Lee and Maurice 1983). Indeed, successful cooperation and planning to control the tsetse fly could provide a model for tackling any number of Africa's most pressing developmental problems.

REFERENCES

Allsopp, R. 1984. Contol of tsetse flies (Diptera: Glossinidae) using insecticides: a review and future prospects. Bulletin of Entolological Research 74:1-23.

Brisset, C. 1986. Irrigation: the absolute imperative. *Ceres* 19:20-24.

Dance, K.W., and **Hynes, H.B.N.** 1980-. Some effects of agricultural land use on stream insect communities. *Environmental Pollution* 22:19-28.

DeRaadt, P., and **Seed, J.R.** 1977. Trypanosomes causing disease in man in Africa. In Kreir, J.P. ed. *Parasitic protozoa. Volume 1. Taxonomy, kinetoplatics, and flagellates of fish.* pp. 175-237.

Duggan, A.J. 1970. An historical perspective. In Mulligan, H.W., ed. *The African trypanosomiases.* pp. xli-lxxxviii.

Ford, J. 1971. *The role of the trypanosomiases in African ecology.* Oxford: Clarendon Press.

Gerster, Georg. 1986. Tsetse—the deadly fly. *National Geographic* 170:814-833.

Griffiths, I. LL. 1985. *An Atlas of African Affairs.* London and New York: Methuen.

Hendry, P. 1979. After the tsetse. *Ceres* 12:13-18.

Jahnke, H.E. 1976. *Tsetse flies and livestock development in East Africa: a study in environmental economics.* Munich: Weltforum Verlag.

————. 1982. *Livestock Production Systems and Livestock Development in Tropical Africa.* Kiel: Kieler Wissenschaftsverlag.

Jordan, A.M. 1986. *Trypanosomiasis control and African rural development.* London and New York: Longman.

Kreier, J. P. *Parasitic protozoa. Vol. 1. Taxonomy, kineplastids, and flagellates of fish.* London: Academic Press.

Langley, P.A. and **Weidhaas, D.** 1986. Trapping as a means of controlling tset se, *Glossina* spp. (Diptera: Glossinidae): the relative merits of killing and of sterilization. *Bulletin of Entolological Research* 76:89-95.

Lee, C.W., and **Maurice, J.M.,** eds. 1983. The African Trypanosomiases: Methods and Concepts of Control in Relation to Development. *World Bank Technical Paper* 4.

McKelvey, J.J. 1973. *Man Against Tsetse: Struggle for Africa* Ithaca: Cornell University Press.

Mittler, T. 1985. *Annual Review of Entomology.* Palo Alto, CA: Annual Reviews, Inc.

Mulligan, H.W. 1970. *The African trypanosomiases*. London: George Allen and Unwin.

Nash, T.A.M. 1969. *Africa's bane: The tsetse fly*. London: Collins.

Njogu, A.R.; Dolan, R.B., Wilson, A.J.; and **Sayer, P.D**. 1985. Trypanotolerance in East African Orma Boran cattle. *Veterinary Record* 117:632-636.

Ormerod, W.E. 1976. The ecological effect of control of African trypanosomes. *Science* 191:815-821.

Owen, D.F. 1973. *Man in tropical Africa: The environmental predicament*. Oxford: Oxford University Press. 139-158.

Putt, S.N.H.; Ellis, P.R.; Shaw, A.P.M.; Matthewman, R.W.; Bourn, D.M.; Underwood, M.; James, A.D.,; and **Hallam, M. J.** 1980. *The social and economic implications of trypanosomiasis control: A study of its impact on livestock production and rural development in northern Nigeria*. Reading, Berks.: Veterninary Epidemiology and Economics Research Unit, University of Reading.

Roboff, F.V. 1977. The moving target: health status of nomadic peoples. *Economic Geography* 53:421-428.

Rogers, D.J., and **Randolph, S.E.** 1985. Population ecology of tsetse. In Mittler, T.E., ed. *Annual Review of Entomology*. 197-216.

Russell-Smith, A., and **Ruckert, A.** 1981. The effects of aerial spraying of endosulfan for tsetse fly control on aquatic invertebrates in the Okavango swamps, Botswana. *Environmental Pollution* (Series A) 24:57-73.

Udo, R.K. 1982. *The human geography of tropical Africa*. Ibadan, Nigeria: Heinemann Educational Books.

World Health Organization and **Food** and **Agricultural Organization.** 1979. Report of a Joint WHO Expert Committee and FAO Expert Consultation on the African Trypanosomiases. *World Health Organization Technical Report Series 635* and *FAO Animal Production and Health Paper 14*.