TO	:	TA/AGR of the Agency for International Development U.S. Department of State
FROM	:	The Environmental Assessment Team of the Tsetse Research Project, Tanga, Tanzania
DATE	:	April 1, 1977
SUMMARY STATEMENT	:	The Environmental Assessment Team has concluded that the Tsetse Research Project, Tanga, Tanzania will have negligible detrimental effects on the environment of the Project Laboratory at Tanga and the field test site at the Mkwaja Ranch. As a result, given the successful conclusion of the Sterile Male Insect Release Method, future tsetse fly eradication projects may be undertaken with a 40 to 50% less dependence upon insecticide applications.

THE TSETSE RESEARCH PROJECT -- AN ENVIRONMENT ASSESSMENT

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I. INTRODUCTION

The U.S. Agency for International Development (AID), Department of State, in accordance with the National Environmental Act of 1969 published "Environmental Procedures," Amendment 216 in the Federal Register, Volume 41, No. 127, 1976. The Amendment insures that environmental factors and values are integrated into the decision-making process of AID program actions. This report describes AID's first step in implementing the new amendment, an environmental assessment of the TA/AGR Tsetse Research Project on the Sterile Insect Release Method (SIRM) that is currently being conducted in Tanga, Tanzania. The Project is jointly sponsored by U.S. AID and the United Republic of Tanzania.

The Rules and Regulations of Amendment 216 provide for exemption from environmental assessment of "controlled experimentations confined to small areas and carefully monitored." Although the Tsetse Research Project may well meet the requirements for exemption, AID has elected not to apply the provision. The Tsetse Research Project was initiated in 1966 and therefore the absence of an initial impact statement (see 216.3 of the Rules and Regulations) has meant that the assessment team did not have the benefit of the evaluations from other Federal Agencies which for future programs may be available.

The environmental assessment team was appointed in the fall of 1976. It conducted a literature search in the U.S., convened a preliminary planning session and soon thereafter, undertook an on-site visit in January of 1977. AID requested the assessment team to provide AID and the Host Country with a comprehensive statement of the reasonable foreseeable environmental effects of the SIRM as a component of an integrated tsetse fly eradication program at Mkwaia Ranch. The assessment team was also asked to consider technically viable alternatives, so that the expected benefits of development objectives could be weighed against any adverse short or long-term impacts upon the total environment or against any irreversible or irretrievable commitment of resources.

The Tanzania-AID Tsetse Research Project is an experiment to test the SIRM under controlled circumstances. Advances in tsetse fly biology and fly sterilization techniques indicate that the tsetse fly may be susceptible to control by the SIRM in appropriate combination with other methods of reducing the fly population. It is also possible that the SIRM may develop into an important maintenance control method. The success of failure of the experiment will provide the necessary guidelines for future large-scale operational programs.

The assessment team undertook to: (1) describe the existing ecosystem; (2) delineate activities that might have beneficial or deleterious effects

on the environment; (3) assess the type and levels of pesticide and herbicide application; (4) anticipate the effect of the treatment upon the ecosystem; (5) assess direct social and economic implications of the SIRM on animal and human populations; and (6) assess how an understanding of the basic science of tsetse fly eradication can contribute to ecosystems management. The information thus derived has been collated in this report for concerned persons in the U.S. and Tanzania.

We wish to thank the staff at the Tsetse Research Project in Tanga, the management of the Mkwaja Ranch, the Department of Zoology at the University of Dar es Salaam, and the Ministry of Agriculture in Tanzania for their cooperation.

A. PROJECT RATIONALE

Tsetse fly infestation in Africa is considered a major constraint to the full utilization of large areas for agricultural livestock production. Infestations of the tsetse fly have precluded human and or livestock occupation of approximately 10 million square km. in Africa. There are several types of trypanosomes, but the major ones cause Nagana in cattle, and sleeping sickness in humans.

With regard to Africa, the World Food Conference in Rome in 1974 declared that "trypanosomiasis and tsetse fly control must be the first phase of an integrated plan of economic development." The declaration was given urgency in the United Nations study on the Future of the World Economy (1976). The Report argued that "the major thrust of food supply in the developing regions will have to come from an increase in their own agricultural output but even after mobilizing available excess arable land resources, the land productivity (including crop yields and cattle productivity) would have to be increased at least three-fold in the developing regions if the 5 percent annual agricultural target is to be realized."

The Tanzanian Ministry of Agriculture ranks animal trypanosomiasis second only to East Coast Fever among the livestock diseases which hinder development. It estimates that 60% of Tanzania is infested by the fly.

In the past, methods for controlling the tsetse fly have included large scale clearing of natural vegetation on which the flies depend for shelter, killing of indigenous wildlife on which the flies depend for food and, more recently, use of insecticides and herbicides. According to (J. Ford, 1976), "in Africa as a whole, one estimates that, since large scale attempts to eliminate tsetse fly were begun in about 1925, total success may have reached about 1.5% of the infested areas, but

that almost certainly this has been more than balanced by reinfestation of formerly fly free land". With an increasing population requiring increased food supplies at the same time that environmentalists are forcefully making the case for the preservation of natural ecosystems, research activities in biological control measures have been greatly stimulated. The most promising lead to date is the sterile male release.

In the case of the tsetse fly, the SIRM introduces within the environment active tsetse flies who have been rendered sterile by irradiation. A preponderance of sterile males can virtually halt the reproductive process of a natural fly population in a predictable period of time. Since 1963, U.S. AID has supported research on the development of techniques necessary for suppressing Glossina m. morsitans the species of tsetse which is a principal vector of animal trypanosomiasis in East Africa. The research has been conducted at Tanga, Tanzania.

The objective of the Tanga Project is to determine the efficacy of using sterile males for tsetse fly population control in an area protected from reinfestation. The questions to be resolved are whether a sufficient number of flies can be reared in the laboratory, sterilized, transported, and released so that the flies disperse and effectively compete with the males of the natural population.

B. PROJECT FACILITIES AND THE TEST SITE

The fly rearing laboratory for the Tsetse Research Project is located 3 km. west of Tanga, Tanzania. The facilities consist of a rearing station, laboratories, and headquarters for the administrative staff. Construction began in June 1972, and the third insectary was completed early in 1977 In addition to the three insectaries, there are associated animal sheds, animal quarantine buildings, and an irradiation complex. The 8 hectares surrounding the buildings serve as the animal paddocks and the forage crop production area.

In addition to the routine rearing of flies and animal husbandry, the 126 member staff has developed methods for handling, sterilizing, and transporting the tsetse flies and is conducting ecological studies of the field site. The staff plans to assess the density and distribution of the natural fly population, the fertility of the fly population treated on the ranch, and the disease incidence among wild and domestic animals.

Mkwaja Ranch field site for the Tsetse Research Project, is located 100 km south of Tanga, Tanzania (38° 41.5'E, 5° 45'S). The Ranch has operated under the Swiss management of the Amboni Sisal

Estates, Ltd since 1953. Approximately 12,000 head of commercial cattle graze the ranch which consists of a coastal woodland-savannah vegetation mosaic varying from open grassland to dense thicket and high forest. The ranch is divided into northern and southern sections (see Figure I). The northern section covers about 260 sq. km. and is the site of the research program; the southern section is slightly smaller and serves as the untreated control area.

Tsetse files (G. morsitans, G. pallidipes, and G. austeni) inhabit the ranch and transmit animal trypanosomiasis to the livestock. Human trypanosomiasis does not occur on the ranch or in the surrounding area. Four times each year the livestock receive prophylactic treatment (isometamidium) to prevent trypanosomiasis and in addition they are dipped weekly in toxaphene to control tick-borne diseases.

Since the beginning of the ranch operation, several programs have been undertaken to control the tsetse fly. However, today the tsetse flies are present in even larger numbers than they were originally. Importantly, moreover, G. m. morsitans, which was not detected earlier, has become a dominant tsetse species. Past experiments with insecticides and partial barrier clearing have failed; the only new element to be introduced into the environment by the Project is the sterile male fly. These conditions, together with the large number of cattle at risk, make the Mkwaja Ranch an ideal site for the field trials.

C. PROJECT SCHEDULE

The Tanga Tsetse Research Project was conceived in three phases. The first phase, now successfully completed, was to establish a captive colony of G. m. morsitans. The second phase is to expand the colony so as to produce sufficient numbers of flies for sterilization and release. The third phase is to complete the ecological studies and field operations for the suppression or eradication of the tsetse fly in a test area of about 260 square km. The colony of G. m. morsitans at Tanga is the largest colony of a single species of tsetse fly in existence. The colony will reach the level of 45,000 females and 15,000 males sometimes between June and September of 1977, making available between 800 and 1200 males for daily release. These numbers will permit a daily release rate of 3 to 6 flies per square km.

The present conception of the release technique is based upon letting the bulk of the females emerge at the rearing laboratory (females precede males in emergence) and cooling the remaining pupae (mostly males) for transport to the Mkwaja Ranch where they will be irradiated and released prior to emergence as adults. The release of the sterile males will follow two or three aerial applications of endosulfan designed to reduce the tsetse fly population to a manageable level. The releases

will continue for 16 to 20 months. The effectiveness of the treatment will be monitored by routinely assessing the fertility and population density of the target species, G. m. morsitans, and the density of G. pallipides. The adjoining section of the ranch will serve as the control area and will not be treated. The Tanga Tsetse Project is expected to be completed by the end of FY 1979.

II. THE EXISTING ECOSYTEM

A. THE MKWAJA RANCH

Description of an ecosystem requires comprehensive consideration of the interaction between living and nonliving portions of a natural unit. In order for the whole interlocking mechanism to function as a natural community, its various components must be present in sufficient approximation of working harmony to permit normal growth and replacement of the constituent plants and animals. Examples of the nonliving components of an ecosystem are energy, water, essential minerals, and atmospheric gases. Examples of the living components are forage and food producing plants, food producing animals, organisms which aid in recycling, and the dominant species which create the general character of a landscape. It is necessary that all these materials and processes be compatible if an ecosystem is to approach its proper rate of productivity. Removal, stress, or ill health of the important participants can reduce production of materials or cause the natural resources present to diminish.

At the Mkwaja Ranch, the elevation, topography and soils vary and these differences represent distinctive ecosystems. The past and present land use has determined the natural communities as they are described in this report. The general setting for the regional environment has been ably presented in The Natural Resources of East Africa (Russell 1962). Another important reference is the Atlas of Tanganyika (1956). Specific source material will be cited in developing the discussion of separate environmental elements.

Since the establishment of the Mkwaja Ranch in 1953, the management has tried to control the tsetse fly by barrier clearing and use of insecticides. Livestock productivity depends, however, upon chemoprophylaxis and drug treatment as the most effective ways to combat trypanosomiasis. Because of the ranch's professional management and experienced employees, this ranch operation represents, as T. Ford and E. Blaser wrote in 1971, "a large scale field experiment" in commercial livestock production in the semiarid regions of East Africa.

Prior to the ranching operation, the land had been unoccupied because of the low rainfall and the generally poor condition of the soil.

It is representative of many other areas where farming cannot be productively undertaken, but where livestock operations could be maintained. The Mkwaja ranch manager described the major constraints to improve livestock productivity as, first, the tsetse fly, and second, pasture maintencance in the face of the rapid bush regeneration. Forage quality is also a problem and varies from season to season.

The Mkwaja ranch employs 200 workers who, together with their families constitute essentially the total present population of 600. All the settlements on the ranch are related to its operation. Approximately half of the workers and their families have resided on the ranch for over ten years. The other half, primarily herders, come and go frequently. The job of herding has low status and the turnover is so great that it is constant source of frustration to the management.

Almost all settlement services are provided by the ranch. The first ranch school was opened 18 months ago by a teacher provided by the government. Only first and second grades one offered, and children must go to the neighboring village 8 km distant to continue their education. Some 40 children on the ranch reside in small settlements near the corrals or bomas and do not receive any scholling. In compliance with the government campaign that was initiated two years ago, the ranch management embarked upon a massive reading program for adults. Every worker who could read was excused from work two afternoons a week to engage in teaching. This effort lasted for about a year; at its completion, the literacy rate had risen from 30 percent to 90 percent. Other services provided by the ranch are housing, water, and minimal health care.

The ranch organization is atypical. It is the only ranching operation in Tanzania which as remained under private ownership. Although the ranch has invited neighboring farmers with cattle to take advantage of insemination and disease control procedures, there has been little response. The role of the Mkwaja Ranch in training and providing regional leadership is disproportionately small in comparison with its substantial experience in livestock production.

Figure I shows the ranch and the surrounding areas. The ranch area occupies the width of the coastal plain and is divided into two sections, north and south. The Tsetse Project field site is an irregular square between the Indian Ocean on the east and the East African Railway on the west going north from Dar es Salaam to Tanga. Along the north side of the ranch lies a fairly dense mountainous high forest; to the south is the control area of wooded grassland which resembles much of the test site uplands. Between the ocean beach and the ranch is a strip of scattered small plots cultivated by subsistence farmers. The nearby villages are occupied by member of the Zigua tribe. About 5 km to the

northeast of the ranch begin the extensive estates of sisal, cashew and coconuts.

1. Non-Living Components of the Environment

Physiography: The coastal plain at the Mkwaja Ranch release site is a flat, narrow belt of consolidated sands extending inland about 20 km to the toe slope of the escarpment that raises to the Masai plains some 70 km distant. Elevation on the site varies from mean sea level near the mouth of the Msangazi River, containing brackish tide water, to high points of about 100 m on the central east-west ridge that transverses the ranch; approximately half of the ranch area lies below a 65 m contour. The Msangazi River flood plain which courses through the northern part of the ranch does not exceed 40 m in elevation. The lower oceanside portion is a slightly raised, level plain that does not exceed 50 m above the mean sea level. This nor-south strip occupies the eastern 25% of the ranch.

Climate: This tropical region is characterized as having high humidity, an annual rainfall of 800 to 1200 mm, and mean annual temperature ranging between 24° and 32°C. From the requirements of plant growth, the area has a subhumid tropical climate; however, the potential evaporation and moisture deficit is high during the dry seasons, altering the climate of semi-arid conditions at times. Rainfall patterns at the ranch are typically bimodal. The 21-year average annual precipitation is 1,008 mm; however, rainfall is erratic as in many places throughout East Africa. Beginning in 1969, six out of eight years recorded an abnormally low rainfall.

Averages for the 21-year record period as well as for the moist and dry segments are given in Appendix A. When analyzed, these figures show apeak for long rains in April and short rains in November. The corresponding low points in the dry season occur in August and again in February. Humidity remains high except during the mid-day period of direct overhead solar radiation, and the corresponding period of relative humidity sometimes reaches as low as 35 and 40 percent for several hours (see Appendix A).

Parent Material and Soils: The substratum underlying the coastal plain is a combination of coral rag, sandstone, and some limestone (Atlas 1956). The first 5 km inland from the coast contains underlaying of Quarternary alluvium; the next 10 km band contains Quarternary sediments. Deeper marine sandstones and limestones date back to the Jurassic period. The east central uplands of the ranch are suspected to have been caused from a raised Plaistocene reef. Upland soils consist mainly of gray and red orange loamy sands; flood plain alluvium found along the Msangazi

River consists of gray to dark gray "black cotton" soils. Soils of the eastern coastal plain are loosely consolidated and form shallow sandy drainageways coursing south and eastward toward Mkwaja village. The greyish cast is a humic layer to a depth of about 25 cm. This humic layer is also present throughout most of the uplands except on steeper slopes. Below this depth is a red-orange sandy loam. Bleached greyish brown sands, occur in areas of recent erosion and on steeper slopes. Finer, light-colored sandy clay loams of the Msangazi flood plain and along lower portions of the alluvial flats show heavy contraction cracks in rain pond relief. Along the south eastern upland, soils grade from rather well consolidated grey-brown surface sands in the north central portion to poorly consolidated red-orange sands in the southeastern corner. Where the central uplands break toward the Msangazi River to the north and west, grey sands again become higher in color; this reflects more rapid geological erosion from the steeper slopes. Isolated outcropping of coral rag can be found at or near the surface throughout the southern parts of the ranch.

Water: For several months following good rains, the Msangazi River maintains a continuous course across the ranch. Other larger drainages such as the Chogera tributary, which drains the northwestern extension and a few rivulets in the southeast corner also flow following the November-December and March-April rainy periods. Large earthen dams provide year round water for cattle and game. There are 65 dams; 40 are presently functional which is unusual considering the loose sandy soil texture. During the dry season only the largest dams retain water and frequently water is hauled from a distance of up to 32 km. There are 15 good reservoirs, some in excess of five hectares. Attempts at exploiting subsurface water have not been successful. Salt water is all that has been obtained from the several previous borehole attempts. At the present time a borehole is under construction on which an accurate log is being kept. The prospects for this 41 m well appear to be favorable and will provide hydrological information of this little surveyed region south of the Pangani River.

Atmosphere: Atmospheric conditions, apart from the climate, consist of air movement patterns and particulate suspensions, both natural and man-made. As to the latter, except for somewhat excessive daily cattle trailing to and from the corrals (bomas) and the necessary administrative vehicular travel, no man-made agents are produced which escape into the air. Natural agents consist of wildlife induced carbon particles and associated oxides from burning herbaceous and woody materials. The uncontrolled fires are usually caused by man but on a sufficiently routine basis to be considered a normal or "natural" phenomenon. These fires are much reduced and less frequent than earlier years when the ranch was undeveloped land. Formerly, wildlife begun through the coastal plain highgrass and consumed all but the most resistant woody species during both the short and long dry periods each year. Lightening undoubtedly was an agent in the large scale firespread, but under present

range grazing conditions is of less significance. So called wildfires contribute nearly all smoke particulate matter except that from wood fires needed for meals preparation by the ranch household.

Wind patterns follow a prevailing westerly path from the ocean and are stronger during the February - March short dry season than during the July through September long intermonsoonal period. Daily wind (1100-1600 hrs.) movement is highly irregular with strong drying mid-day winds diminishing to near calm between 2200 hours and daybreak. Mid-day extremes might approach 25 to 35 km per hr), while normal movement is between 10 to 20 km hour. Upper level storm patterns can originate from inland convection patterns but the monsoonal begin at sea. Storms produce intensely heavy rain of short duration which, when occurring on dry or super saturated soils, produce large volume run-off with accompanying sheet and gully erosion. These high run-off situations are aggravated by the excessive removal of ground cover caused by cattle, trailing, grazing and fire.

2. Living Components of the Environment

The topical subhumid coastal climate produced by the equatorial latitude and coastal geography has furnished a diverse ecosystem of plants and animals. Most of East Africa is geologically old, with plant and animal evolution and speciation having proceeded uninterrupted relative to the general situation in the temperate zones. In spite of more recent geological changes along this eastern coastal region, plant and animal speciation and distribution show a mixture of interior ecosystems with that of the marine and oceanic environments.

The impact of the ranching operation has not radically altered the fauna or flora so as to exclude many, if any, species. Perhaps the greatest change which has resulted from twenty years of domestic grazing animals has been the rapid encroachment of woody vegetation. In the past, the high volume of grass fuel for repeated burnings prevented bush establishment and maintained only fire tolerant species. The recent efforts to suppress range fires and the effect of livestock grazing have resulted within a short time period in the invasion of bush and the consequent mobilization of much of the nutrient capital of the basic soil productivity.

These vegetational changes have altered the composition of the dependent animal communities. This is not to say that any species of animals or plants have necessarily disappeared; on the contrary, some existing or new species may well have acted as invaders or actually increased their presence. Wart hogs and perhaps waterbuck are examples of species which have been favored by the livestock occupation.

Animal Field Inventory Procedures: During the six day survey period, the range ecologist logged all large animal species observed in order to approximate the biomass. Bass data included date, time of day, route traveled, kilometers traversed and the number of animals by species. Gender was noted when detected. The total of 23.5 hours of daytime observation represented a normal distribution of morning, midday and evening hours. More species were observed during morning and evening activity periods than during the midday periods. This was particularly true in cases of the ruminant ungulates. During the field inventory 373 km of primary and secondary bush track were tranversed. In addition, cross country travel and foot safaris were undertaken to observe plant and animal communities throughout the entire ranch. Animals recorded during the inventory constitute about 40% of the species known to reside for at least part of the year on the ranch.

Animals not seen but known to be present, such as the elephant and buffalo, would add considerably to the biomass. The field inventory and the complete list of larger mammals, birds, and reptiles known to occur on the ranch are given in Appendix B.

Plant Communities: Appropriately, the translation for the Swahili word Mkwaja is the locally conspicuous tamarin tree (*Tamarindus indica*). Unfortunately, this is where a simple approach to identification and classification of East African coastal vegetation ends. Although a number of classification schemes has been suggested for East African plant communities and ecosystems, none has yet been generally accepted or has stood the test of time. The in-local classification is the physiogomy or plant structure and the surface area coverage by the dominant woody species.

In view of the variation in local methodology and the nature of this in-local tsetse fly habi-at, it was decided to combine the best features of several systems in use and develop a classification method which would meet the specific objectives of this assessment. A review of the literature upon which the assessment method for typing and map preparation was drawn is found in Appendix C.

Limited time precluded a detailed inventory listing of all six types of species components. However, major trees, bush, and grass associations are presented and discussed in Appendix D. The field survey was essential for the analysis of the 1976 aerial photos and the subsequent preparation of the map. Our general interpretation followed the scheme of land units (coastal plain-bush grassland) proposal, Christan (1958). Gillman, who was perhaps most familiar with Tanzanian vegetation, broadly mapped the Mkwaja region as bushed grassland (1949). The assessment team analysis identifies the field site for the Tanga Tsetse Project as four major and three minor land units and associated vegetation cover types.

1. Evergreen grouped tree grasslands found generally throughout the western and southwestern uplands.

2. Mixed (deciduous-evergreen) wooden and/or bushed grassland interspersed between the above forest islands and making up a large part of the northwest extension.

3. The Doum palm-high grass savannah found in the eastern coastal lowlands.

4. Doum and Borassus palm-high grass found in the alluvial flood plains of the Msangazi River.

The minor types which occur in addition to these units may be identified as riverine gallery forests of the Msangazi River and tributaries, the high mixed (evergreen-deciduous) forests of the northern and northwestern mountains, and secondary bushland thickets.

B. THE TANGA REARING LABORATORY

The Tanga Project employs 126 individuals, of whom five are expatriates. The senior staff includes four entomologists, a veterinarian, and a rearing specialist. There are 2 research officers, 3 field officers and 14 assistant field officers with government certificate training. The remaining employees are laboratory and field assistants drivers and support staff.

The construction of the insectaries began in June of 1972; and the third and final insectary was completed in early 1977. All facilities are simply designed and, except for the importation of scientific instruments, have been built with local materials. The complex consists of the three insectaries, associated animal sheds, animal quarantine buildings and the irradiation unit. The 8 hectares surrounding the building serve as the animal paddocks and the forage crop production area.

The insectaries are designed to house 60,000 flies capable of producing 30,000 males per month. Approximately 490 goats and 115 rabbits are maintained as hosts for the flies. The Tanga laboratory uses only blood of living animals. A method for feeding colonies of tsetse flies on blood presented through artifical membranes has recently been developed in Europe, but was not available when the Tanga Project was initiated. In the future, however, the costs of mass-rearing flies will be much reduced by the use of membrane feeding.

A research program such as the Tanga Project does not have a primary responsibility for training. However, the on-the-job training is excellent and must be judged as a significant contribution albeit an indirect benefit. The laboratory is rearing flies successfully with a staff (average age 20), only a few of whose members have had more than seven years of formal education. As the project leader pointed out, if training is neglected at the research stage, when the project becomes operational trained manpower will be scarce. The conclusion reached from observing the management and work disciplines of the Tanga Laboratory is that training, intermediate and advanced, must be a component both of research programs and operational programs.

The Tsetse Research Project has developed good contacts and exchanges with other institutions in Tanzania; however, it would have been desirable if the initial funding of the Project had permitted a more flexible and innovative outreach program. For example, students from national educational institutions would have profit from short-term training fellowships as well as opportunities to conduct research projects under the joint supervision of the Tanga Laboratory scientists and the host country institutions.

The Project is to be commended for the preparation of a brochures in Kiswahili. The Project has developed a working relationship with the International Atomic Energy Agency and the Food and Agriculture Organization and The Tsetse Fly Research Laboratory at Bristol, England. Informal relationships have been maintained with the ICIPE and ILRAD in Nairobi.

III. THE ENVIRONMENTAL ASSESSMENT

A. PROCEDURES

The measures and procedures used by the team to weigh the adverse and beneficial impact of the Tsetse Project were based upon the identification and estimates of the effect of insecticides, and herbicides, bush clearing, and the release of sterile male tsetse flies upon the fauna, flora, soil, water, and atmosphere of the test site. These impacts were evaluated from the perspective of the proposed control of *G. m. morsitans* at the field site and the utilization of the rearing facility in Tanga . The separate impact were not weighed, and, therefore, no comparisons were made of their relative significance.

The team notes that the present environment assessment cannot resolve all the complex socio-economic issues surrounding the mounting of integrated tsetse fly control programs, including the SIRM, over large land areas in Africa. The analysis and prediction of the impact upon human population are considerably more difficult than the technical

analysis of the impact of the control techniques themselves. Information is simply not available as to how the present populations, often already abused and impoverished, will respond to new situations brought about by new technologies. Thus, in its socio-economic evaluation, the team has limited its assessments to those that could be made with a high degree of confidence and has indicated the limitations in the analysis.

The estimated environmental effects of specific projects activities are summarized below. Each aspect of the tsetse fly program at the Mkwaja Ranch and the Tanga Rearing Laboratory has received a separate evaluation.

B. EXPLANATION AND SUMMATION

1. Barrier Clearing: The Mkwaja Ranch management had cleared a one km wide barrier of trees and shrubs around much of the ranch in order to reduce the migration of tsetse flies from the surrounding areas. The Tanga project is presently engaged in completing the barrier. Clearing operations will be limited to the barrier zone. In previously cleared sections, the barrier has become open grassland, and it is anticipated that the entire barrier zone of 65 square km will be covered by grass when the operation is completed. If the grassland barrier is to be maintained and erosion to be prevented, the ranch management must continue to invest in the barrier clearing.

2. Application of Herbicide to Portions of the Cleared Barrier: Following the clearing operation, the herbicide Tordon 155 will be applied to control vegetation regrowth. The herbicide will be hand-applied by brush onto the stumps to avoid general contamination of the soil. The treatments will prevent regeneration and, in turn, the reestablishment of insect and avian population that had inhabited the localized environment.

The effect of the clearing operations on the vegetation is clearly high but at the same time it is very localized. Similar local but rather strong effects will modify certain conditions in the animal community (invertebrate, avian, and mammalisn) in the barrier zone.

3. Application of Residual Deposits of DDT Along the Edges of the Barrier: The 1 km barrier clearing will not be wide enough to prevent all tsetse flies from immigrating into the ranch. Therefore, the barrier will be reinforced by the application of DDT to vegetation outside the perimeter of the barrier. Applications of 5% DDT will be made to the lower 3 meters of tree trunks greater than 25 cm. diameter and on the undersides of lower branches in order to kill resting flies and prevent movement of flies into the ranch area. One application will be bi monthly throughout the duration of the field experiment. The minimum insecticidal barrier will be 300 meters, and each application will probably require about 90 to 100 kilograms of active ingredient equivalent to 2.2 grams per hectare per annum (0.02 lbs) per acre annually) over the ranch as a whole, and 90 grams per hectare (0.08 lbs. per acre annually) in barrier zone. Some short-term contamination of surface water limited to the Msangazi River will occur and limited DDT may accumulate in certain nontarget organisms and in the soil. Since the area to be treated with DDT is relatively small, the effect on nontarget invertebrates, bird and mammals will be minimal.

4. Three Aerial Applications of Endosulfan: Studies of the population density of G. morsitans at the Mkwaja Ranch indicate that two or three aerial applications of endosulfan may be required in order to reduce the population to a level that can be handled with sterile males. Approximately 215 square km will be treated. The insecticide will be applied in droplets (35-45 u in diameters) that float and impinge upon resting and flying tsetse flies, but are not large enough to leave a permanent toxic residue. Endosulfan will persist at low levels in the treated areas. Each treatment will utilize 30 grams./ha. of active ingredient, totalling about 600 kg of insecticide or 90 grams per hectare each (0.0825 lb per acre total for 3 applications). Five or six such applications at two to threeweek intervals are routinely used to eradicate G. m. morsitans. Other studies indicate that even with 5 or 6 applications, residues and the effect on non-target organisms are minimal. Any such effects would normally be limited to invertebrates and fish. When high concentrations of endosulfan are used, it is toxic to fish; however, at the time of the Mkwaja ranch applications, the rivers will be dry and contamination of surface water will be of limited duration. Air polution during the actual spraying operation will be transient.

It must be noted that the normal requirement for tsetse fly eradication over an area of the same size would be five to six applications of insecticides. The use of sterile males following two to three applications will reduce the insecticide application by 40 to 50 percent.

5. Release of Sterile Male Tsetse Flies: As the summary table shows, the release of the sterile males would not affect any of the environmental factors. It should be emphasized that the flies are not radioactive, but they do have the capacity of transmitting disease as vectors of trypanosomiasis. The release of the sterile males at the rate of 3 to 6 per day per square km, following the reduction of the natural population by aerial applications of insecticide, avoids the situation in which there would be more flies than were present in the pretreatment population. The anticipated elimination of the target species from the environment should not be accompanied by an increase in population of other Glossinas species since they are habitat-specific and not interdependent.

6. Rearing of Flies and Host Animal Production: The rearing activities at the Tanga Laboratory are confined to 410 square meters of enclosed space and do not cause any environmental impact. Likewise the maintenance of the host animals takes place only on the enclosed 8 hectares and has no or little impact on the environment with the exception of waste accumulation which is dealt with by the septic tank and recycling of manure.

7. Socio-Economic Consideration: An analysis of the operational and economic feasibility of the rearing laboratory at Tanga will be possible only upon the completion of the field trials in early 1979. Similarly, a useful cost/benefit assessment of tsetse fly control could not be made on the Mkwaja ranching operation, nor could the possible application of the economic feasibility of the SIRM be definitively assessed. Only gross indicators of costs, benefits and returns were available. The Mkwaja Ranch could not operate without a careful and expensive regime of prophylactics and curative drugs or tsetse fly eradication maintained by intensive and continuous insecticide applications. Only four of the past twelve years have been profitable reflecting the substantial capital development costs, including tsetse fly control measures and an average expenditure of $3.00 per head per year for maintenance of minimal disease control. Following the analysis of the SIRM as part of an integrated tsetse fly eradication program, it will be possible to compare the Mkwaja Ranch with other ranching operations in Tanzania and with other successful livestock operations such as Ankole in Uganda and Zululand in South Africa.

The team did not have access to the detailed financial records of the privately managed Mkwaja Ranch and therefore could not directly assign observable benefits to specific operations. Nevertheless, based on observations and discussions with the ranch manager, the following indicators emerged: (1) a profitable livestock operation is not possible when the tsetse fly exists in terms of present state of knowledge of therapeutic and curative treatments; (2) tsetse fly eradication requires a large initial capital investment and continuing high cost maintenance; and (3) ranching operations in the semi-arid regions of eastern Tanzania must be well planned and well managed with respect to the carrying capacity of the land and the available water resources.

IV. APPLICABILITY OF THE ASSESSMENT

A. THE STERILE MALE INSECT METHOD (SIRM)

The elements of the Tsetse Research Project which are relevant to existing or future tsetse fly eradication projects may be summarized as follows: Tsetse fly eradication schemes require extensive planning and careful coordination of each phase of the operation. Of major significance is the fact that fly populations become undetectable well before they are actually eradicated. Due to the low reproductive capacity and the low rate of increase of natural fly populations, many generations may elapse before incipient populations are detected by normal surveillance techniques. The use of sterile males to consolidate and insure eradication in the phase following the use of other techniques may be the most effective approach under certain circumstances.

The Project's research activities involve a wide variety of specific information accrual perhaps more so than other types of control research. This is due to the fact that livestock are used to regulate at the density of natural insect populations of the same species. Thus, original data are required not only on fly production requirements, sterilization effects and handling methods, but also on a wide spectrum of population characteristics of the wild flies, e.g. density, longevity, dispersal, seasonal variation, etc. These data are necessary to make optimum use of the released insects. In addition, integration of the sterile insects with conventional methods will provide new perspectives on population dynamics that can be useful in other programs. Thus, all aspects of the biology, ecology, and insecticide research will provide data and concepts that are directly relevant to other tsetse fly eradication projects.

Population studies being conducted will be particularly important as will studies on the effectiveness of insecticidal barriers used to supplement natural or artificially created barriers. These significant facets of control technology will have a major bearing on most other eradication projects. The advances made on rearing and sterilization research will directly expand the capabilities of African scientists to conduct tsetse fly research and related studies on disease transmission. Field studies with laboratory reared flies will greatly enhance the ecological and biological information currently available.

Conclusive proof that the sterile male technique is effective will make available another tsetse fly eradication technique for futher practical development. Mass rearing of other species of tsetse flies as developed for G. m. moristans at the rearing laboratory, will be applicable to other species, as well as related studies on artifical rearing techniques being supported by Project funding. An increased capability in rearing other species will increase the flexibility of the technique by making its use advantageous in areas with more than one important vector species. The integration of the sterile male releases with control programs that might otherwise be only partially effective may result in effective and efficient eradication of target species that would not have been attempted. The costs of using the sterile male technique in this research program may provide useful information for predicting the costs for integrated eradication schemes in other suitable areas. Thus, any contemplated new eradication scheme should consider incorporation of sterility techniques in the planning stages because of the potential economic savings and/or increases in the total area of land cleared with a fixed amount of capital. For example, in addition to existing tsetse fly control projects, consideration is being given to field operational programs at four locations in Tanzania. 1. The island of Zanzibar; 2. The West Lake area; 3. Mafia Island east of Dar es Salaam; 4. the Handini

area near Masailand. Assuming successful completion of the SIRM trails, it may be anticipated that the insectaries at Tanga might be expanded to provide sterile flies for new programs. Relevant to this point, in 1971, a panel of 32 internationally recognized experts met in Paris to deal with the possible applications of the sterility principle for tsetse fly control. The panel analyzed the possible advantages and disadvantages, and their summary remains the most reliable assessment yet available. The following remarks are based upon the report of the panel, (IAEA Report, 1972).

1. Advantages of the Sterile Male Insect Method: The principal advantage of the SIRM is that the control effort becomes more economical as the natural population declines. This economy results because increasing ratio of sterile to wild males are achieved. As the program proceeds, the total numbers of release flies can be reduced and control becomes increasingly more efficient. In contrast, conventional multiple application of insecticides becomes less efficient in terms of the number of insects killed as the population declines because the cost and percentage kill factor per application remains fixed.

In areas where the SIRM can be utilized alone, this technique avoids contamination of the environment and selectively attacks one Glossina species, resulting in a minimum distriburbance of the environment and other insects. Even if an integrated use of insecticide is indispensable, the contamination of the environment nevertheless is considerably less than that which results from a program based entirely on chemical control. Unlike the majority of other Diptera, Glossina species have an extremely low reproductive potential and low rate of increase per generation. Therefore fewer sterile males are required. The density of the vegetation in the environment, often a serious obstacle for the application of insecticides, does not hinder the dispersion of the sterile insects.

When population density is low the efficiency of eradicating the species is theoretically better with sterile insect release method than with insecticides. The sterility method could be utilized as the final phase of an integrated program. Release of sterile males in low numbers can prevent reestablishment of the species. This technique may be cheaper and more effective than maintaining constant surveillance. In areas, where two Glossina species coexist, the elimination of one species by the SIRM is not expected to result in a sudden increase in numbers of the second species since population sizes are not believed to be interdependent.

Where the control of tsetse is regarded by the authorities as necessary to game reserves or national parks, the use of the SIRM would minimize the detrimental side effects of control. Reduction of the wild tsetse population by other methods may be necessary before sterile males can be effectively used. The use of not more than two or three

applications of a nonpersistent insecticide is not likely to significantly contaminate the environment or damage the fauna except where rare endemic insects are present. Even in areas where the SIRM does not represent an economical gain over other tsetse suppression techniques, it may be the method of choice where disadvantages of chemical or other control methods must be avoided.

2. Disadvantages of the SIRM: The method is not practical nor is it designed to be used alone against high natural populations. Prior reduction with chemicals or other means is a prerequisite. When used alone this method, unlike insecticides, does not immediately reduce the insect population enough to rapidly interrupt disease transmission. Release of large numbers of sterile flies in an area where trypanosomiasis is endemic could temporarily increase the transmission rate. For this reason, the method should not be used alone in areas where human trypanosomiasis is endemic and where immediate interruption of transmission is required.

B. SEPARATE AND INTEGRATED APPROACHES TO TSETSE FLY ERADICATION

Before chemical insecticides were developed, the two most commonly practiced methods for controlling tsetse flies involved clearing woody vegetation on which the flies depend for shelter and eradicating game animals on which they depend for food. These methods are rarely practiced at present; but because of the need to clear a barrier around the Mkwaja Ranch, the method of vegetation clearing is included in the following description of tsetse fly eradication techniques.

1. Clearing of Vegetation. Sheer clearing, involving the destruction of all trees and shrubs, is an effective means of eradicating *Glossina*. It is costly, even when carried out by mechanical methods (Glover et al, 1959; Wooff, 1967) and is now rarely employed except to establish barriers, often in conjunction with insecticides, to prevent the reinvasion of areas freed of tsetse flies. The technique has been employed over wide areas of country against species of the *morsitans* group and linearly against riverine and lacustrine species of the *palpalis* group. In some circumstances soil erosion can result, but there is much evidence that in sanannah regions, removal of all trees and shrubs often causes grass growth to increase and to improve pasture (Ford, Nash and Welch, in Mulligan, 1970). Discriminative or partial clearing involves the removal of only those elements of vegetation essential for the survival of *Glossina*. It has been extensively practiced against riverine *G. palpalis* and *G. tachinoides* in West Africa (Nash 1969) and *G. morsitans*, *G. swynnertoni* and *G. pallidipes* in East Africa.

21. Game Destrication. Slaughter of game animales as a method of tsetse control has been widely practiced in the past in Uganda and Rhodesia. Even when refined by removing only the favored host species (Cockbill et al, 1969), the method is unacceptable today.

3. Insecticides. Treatment of tsetse-infested zones with insecticides is currently the most common method of eradication. Insecticides are applied as persistent deposits of such compounds as DDT, dieldrin, or endosulfan (either from the ground or from helicopters), or as sequential applications of formulation of either dieldrin or endosulfan of ultra low volume from fixed - winged aircraft.

4. Toxicology. The Acute Oral/Dermal (LD^{50} in Rats) and the Acute 24 hour (LC^{50} in Fish) of 4 Pesticide/Herbicides is given below in Mg./Kgm.

	Endosulfan	DDT	Dieldrin	2/4- D
Oral	43	113	46	375
Dermal	130	2000	90	-
Fish*	2.7	7	14	100

*P.P.M. for Blue Gills/Trout fingerlings.

Heavy deposits of persistent pesticides can be applied discriminatively from the ground as a single treatment to the resting sites of the fly. These persistent deposits remain effective for several months, and therefore a single application even kills the flies which emerge from puparia in the soil during the weeks following the application. This method is particularly applicable against species of Glossina with linear distributions and has been widely practiced against G. fuscipes in East Africa (Glover et al, 1960). The method is less practicable against those species, such as G. morsitans, which often occur throughout wide tracts of country. Such species can be attacked, however, when their distribution is restricted during periods of climatic stress (Davies 1971). The most commonly employed insecticides in ground-spray campaigns have been DDT and dieldrin.

Presistent deposits can also be applied by helicopter. Applications can be restricted to certain habitats but are less discriminative within those habitats than are applications from the ground. Extensive successful operations, primarily against G. morsitans, have been performed in Nigeria. Dieldrin emulsion has been the most widely used insecticide, but trials have also been conducted with endosulfan (Spielberger and Abduratim, 1972; Spielberger et al, personal communication).

Observation made on the side effects of insecticides used in various tsetse control schemes indicate that applications of persistent deposits leave heavy local residues (Park et al, 1972, cites initial deposit of 1-10 g active ingredient m^2) that also affect other organisms, especially when applied over large areas. Koeman and his colleagues have studied

these side effects for many years. Koeman and Takken (1976) showed that even a single application of residual dieldrin or endosulfan caused mortality in many nontarget species. Helicopter application affected a wider range of bird species than discriminative groundspray application. Certain species of the fringing forest birds are very vulnerable and disappeared from the treated area. Certain mammal populations also markedly decreased in size (examples are Tantalus monkeys after application of dieldrin, and fruit bats after aerial residual application of endosulfan). Appreciable mortality occurred among fish, amphibians, lizards and snakes.

In general, groundsprays are more discriminative and are therefore less likely to cause irreversible damage than are helicopter applications. Endosulfan was found to cause more damage to cold blooded vertebrates than dieldrin; warm blooded species reacted conversely. In areas treated once, many of the affected species repopulated the treated areas a year or so later by migrating from the nearest untreated populated habitat, provided the areas reclaimed from tsetse had not been altered drastically and the habitat remained suitable. Residues of dieldrin and DDT observed in fish, fish-eating birds, and other organisms collected in areas sprayed one or two years previously have generally been low (unpublished WHO/FAO Report 1976).

When the distribution of the fly is diffuse, restricted application is not feasible and a blanket cover is required. Since residual deposits need to be relatively heavy in order to obtain adequate persistence, it is not feasible to apply insecticide on this scale over the whole habitat available to the fly. The development of methods for the sequential application of nonresidual ultra low volume formulations of dieldrin and endosulfan has been reviewed by Lee (1969) and Burnett (in Mulligan, 1970). Concentrated solutions of insecticide in volatile oil are used, which are dispersed as medium aerosols consisting mostly of 20 - 50u drops. The insecticide must be highly toxic to the fly so that a single drop will contain a lethal dose. Park et al (1972) used 30 gm of active ingrendient (a.i.) per hectare in each of five applications of endosulfan to eradicate G. morsitans in Zambia, and in Botswana as little as 6gm a.i./ha have been used per application (Kendrick and Alsop, 1974). Because puparia in the soil cannot be reached by the insecticide, repeated applications (usually 5 or 6 at about 18 day intervals) are necessary to prevent newly emerged females from reproducing.

A team from the Centre for Overseas Pest Research, London, is currently investigating the effects of sequential aerial application of endosulfan on nontarget organisms in Botswana. In contrast to the effects of residual aerial applications, preliminary results with sequential application suggest that there are unlikely to be any immediate lethal effects on fish or terrestrial or fresh water invertebrates (Russell-Smith, personal communication) because Glossina are highly susceptible and require much less insecticide than other insect species. Most studies followed application rates of 6 gm a.i./ha but there were also little evidence of direct mortality after one application at 12 gm a.i./ha; endosulfan can be highly toxic to fish, but at least these extremely low application rates it clearly had no detrimental effect. No data are yet available for possible sub-lethal effects of endosulfan; samples of fish and water are currently being examined for insecticide residues.

4. Genetic Control. In addition to the SIRM, various other genetic control techniques have been proposed. The most practical at the moment seems to be the exploitation of the hybrid sterility resulting from some combination of crosses between subspecies of G. morsitans. No field trials have been carried out.

5. Biological Control. A number of attempts (especially by Nash, 1933) have been made to exploit parasites of tsetse as a means of control. None have been successful. Tsetse predators and pathogens must be categorized and then effects on tsetse populations must be quantified before they can be used as control agents. Research is proceeding on other chemical control techniques. At a number of laboratories in the United States and Europe, research projects are underway to characterize the effects of juvenile hormones (Denlinger, 1975) ecdysones (Whitehead, 1976) and diuretic hormones (Gee, 1975), but the formulation of a hormonal insecticide for use against Glossina is only a distant prospect. Such insecticides are already in use against other pest species, they have a number of attractive features, including virtually no harmful effects on mammals.

The recent development of highly efficient catching devices that utilize the natural attractiveness of host animals (Vale 1974) is a major advance. In addition, a sex pheromone in G. m. morsitans has recently been isolated and identified (Langley, Pimley, and Carlson 1975), suggesting the possibility of developing a male attractant for use in control activities. It has been suggested that the sounds produced by tsetse flies may act as a means of communication (Kolbe, 1973). Should this be so, it may be possible to devise an auditory attractant.

C. BENEFITS AND IMPLICATIONS FOR DEVELOPMENT STRATEGIES

The tsetse fly belt stretches across the middle of Africa. Generally, it lies between latitude 12 degrees north and 20 degrees south. Little of this vast area is utilized except for periodic livestock grazing, much of which is nomadic. It has been estimated that 240 to 325 million hectares are presently utilized for livestock grazing and that another 200 million hectares could be developed. Recent advances in soil sciences and soil moisture management could expand these estimates. Therefore, this tsetse fly belt looms importantly in the goal of increasing the food production of Africa — and, in fact, of the world. Yet, while the area is potentially productive, its development is complicated by many problems: poor soils, inadequate water, disease, and perhaps in some cases maladaptive social features of the human populations may at times be comparable to the tsetse fly in their negative effects. Moreover, campaigns to control animal trypanosomiasis cannot be isolated from the efforts to prevent other animal diseases. East coast fever, rinderpest, and contagious bovine pleuropneumonia are a few of the many diseases endemic in the tsetse fly belt of Africa.

The mapping of soils by classes and capacity for supporting agriculture or livestock production have been limited in Africa. Techniques are being refined which can help, although progress will depend upon building indigenous capabilities for soil classification and analysis in each nation. Soil classification is necessary since any development strategy for land utilization must reflect the use potential and carrying capacity of the land. The details of land use planning in each country naturally depend on pre-existing institutions and policies. Each form of ranch system must be made economically viable and consistent with national goals on size, employment, and production. Beyond the development of the farmland itself, improvements in roads, markets processing and storage, worker incentives and education and training opportunities are all integral parts of any successful program of economic and social change. The tsetse fly is thus a major constraint, but its eradication is only the first step toward making the tsetse fly belt of Africa productive. Since animal trypanosomiasis is only one of many constraints on optimal livestock productivity, the full benefits of tsetse fly eradication can only be attained within a system in which all other constraints have been eliminated or are at least brought within manageable limits.

Although development planners and tsetse fly experts have stressed that tsetse fly eradication must be integrated with rural development and land use, complete success has seldom been achieved. The Mkwaja Ranch provides an opportunity to experiment with new tsetse fly eradication techniques which appear to be less hazardous to the environment. The ranch also offers the opportunity to observe the integration of tsetse fly control techniques with livestock and resource management. However, the production outputs of the Mkwaja ranch currently are less than satisfactory. Factors other than the tsetse fly which bear on the productivity of the ranch are the relatively low levels of forage production and its seasonal variation in nutritional value: rapid regeneration of bush; other animal diseases; and a calf breeding rate that is limited to about 50 percent per year. The death loss due to trypanosomiasis is low but the effective chemotherapeutic regime requires a substantial investment. Even in this relatively well managed case, the data show that commercial ranching in the semi-arid coastal region of Tanzania is still at best marginally profitable. These observations reinforce the need to precede major tsetse fly eradication efforts with investigations on land carrying capacity, water availability, and training and incentive programs for the populations who will occupy the land claimed from the fly.

If tsetse fly eradication is undertaken on a large operational scale, appreciable environmental modifications will occur and must be weighed against the benefits, short term and long term, of increased food production and employment. It is inevitable that man and his domestic animal will replace wildlife on many areas and that the large game animals will be reduced in number. These anticipated modifications in the environment must be studied well in advance of any large scale tsetse fly eradication programs.

Throughout the twenthieth century, Africa has been exposed to numerous grazing and development schemes, many initiated during the colonial period. Much effort and capital have been spent to superimpose western technologies of animal husbandry and range management on pastoral subsistence economies. Those attempts have often failed because they were not combined with a parallel effort to improve the socio-economic environment of the local people. These past failures dramatize the importance of involving the local communities in the initial stages of development programs. Proposed changes must be carefully evaluated from the perspective of the local populations, and must be supported by thorough analyses of human needs and capabilities. In analyzing the effectiveness of the water development and grazing schemes in Masai areas, Z. Neveh (1966) has found that the failure of the programs could not be explained by the "insatiable desire of the Masai to build up livestock populations for bridal wealth and prestige" as developmental planners have often argued. Rather, the earlier disruption of the Masai nomadic ecosystems by the encroachment of agriculturists upon the better lands formerly available to them caused the Masai to depend for their survival on larger and larger herds. The trauma of the often repeated

experience of disaster and starvation... and the development of water points and disease controls have not improved things but made them worse.

In a similar study of African Pastoralists, Alan H. Jacobs (1965) has described how preconceived views and prejudices about a pastoral society can impair the development planner. For example, "The generalization that pastoralism implies an especially strong and characteristic resistance to social change deserves attention... . The evidence for such a statement is by no means consistent or conclusive. Not only have many African pastoral societies been dependent on external markets and responsible to social change over long periods of time, such as the Fulani and Somali, but others have changed rapidly within a period of a few years, such as Kipsikis and Nandi of Kenya."

Such studies on man and his environment in Africa should be taken into account by every development project, although clearly they were beyond the resources of this environmental assessment.

The Assessment Team did not attempt to identify the options available to national planners in Africa, nor to assess the tsetse fly eradication experiences in Tanzania. The Team wishes to emphasize, however, that international agencies involved in tsetse fly eradication schemes must act in close accord with the host countries. The role of foreign experts should be primarily to determine the probable affect of the various eradication options, and the range of uncertainties regarding the consequences. International and national aid agencies then must leave to the host country in light of its own political and development strategies, the interpretation of this advice and the decision as to what the country should actually do. In particular, the participation of African nations in a continent-wide effort to eradicate the tsetse fly, such as the FAO program, will in the end be weighed against each nation's priorities.

V. CONCLUSIONS

The team concludes that the Tsetse Research Project in Tanzania will have negligible detrimental impact on the environment of the Mkwaja Ranch. In those localized situations where some environmental change has been anticipated, the effects have been evaluated. The objective of the Research Project is to test a new technique for the control G. m. morsitans in an area where it will have no effect on the present use and occupation of the land. To this extent, the 435 sq. km of the Mkwaja Ranch is atypical of the 10 m. square km of tsetse fly infested Africa. The test site was selected to fulfill the conditions and requirements of the experiment.

An assessment was made of the socio-economic impact of the research project upon the ranch environment and the rearing laboratory environment in Tanga. Other than the important component of training and the demonstration of the role of science in helping man shape his environment to his needs, the social impact of this project has been minimal.

The creation by the ranch management of a 1 km wide barrier clearing around the test site to reduce fly immigration is being completed with project funding. The replacement of the natural habitat with grassland in the barrier zone will have a high level of impact on the plant and animal communities, but the disturbance on the ecosystem will be localized and the proper maintenance of grasslands may contribute to a stable ecosystem, providing additional forage.

The herbicide, tordon 155, will be applied to the tree stumps in the barrier zone. Since the applications will be restricted and will be applied manually with brushes, the minimal effects will occur only in the barrier zone.

In order to reinforce the barrier and protect the test area from any fly immigration, DDT will be applied bimonthly to a 300 m strip along the perimeter of the barrier. This selective application will deposit about 545 kilograms of DDT on the test site. This represents an application level of 280 grams/hectare (0.25 lbs/acre) for the treated area. The localized effects of the DDT treatments on the soils and atmosphere will be minimal but the effect on the ecosystem will be high. However, the effects are limited to less than 8 percent of the total test area and within this area only 3 to 10 percent will be actually sprayed.

Two or three aerial applications of endosulfan will be applied to red[illegible] the tsetse fly population prior to the release of sterile males. The [illegible]tal amount of insecticide will be about 1800 kg (92 grams per hectare of 0.0825 lb/acre). These applications will leave minimal residues which will not measurably affect nontarget organisms.

The daily release of 3 to 6 sterile male flies per square kilometer will not affect the environment. The flies are not radioactive and the number released will be lower than the initial population and therefore, the incidence of animal trypanosomiasis will not increase.

V. GUIDELINES FOR FUTURE ASSESSMENTS

The assessment team recommends that when an initial examination of a proposed AID action identifies the need for an environmental assessment, it should be combined with the development of the work plan. This procedure will substantially reduce the costs and enable AID to consult with experts during the preliminary planning stage.

The team recommends that the AID program authorities identify the individuals required for an assessment. A tsetse fly project should include the following specialists:

1. a chairperson, preferably a tsetse fly expert;
2. an entomologist, whose work compliments the chairperson; and
3. an ecologist or wildlife biologist.

Depending upon the design of the project, the environment in which it is to be undertaken, and requirements for integration of land use and development programs, the following specialists should be included as team members or as experts to be consulted by the chairman.

4. animal production specialist; and/or epidemiologist (sleeping sickness); and
5. behavioral scientist.

The ex-officio members of the team will include the mission project officer and the Washington AID program manager. The organizational arrangements and correspondence should be the reponsibility of the Washington office of the AID program manager.

The host country representatives participating in the preliminary planning of the proposed action should be invited to recommend the host country specialist in tsetse fly control and a planning officer from the relevant ministry as members of the assessment team.

Before visiting the site of the proposed action, the members of the assessment team should convene for several days in Washington. At that time, AID should provide all members with relevant past assessments, project evaluations, reports on ongoing projects in related fields, all preliminary data on the proposed action, and any general information on tsetse fly eradication programs.

The chairperson should assign specific responsibilities to each team member. Arrangements must be made in advance for the team to consult with the appropriate experts and officials in the host country during the period of the site visit.

The site visit should be of a duration to allow the necessary data to be collected--one to two weeks. At the conclusion of the site visit, each team member should submit his report to colleagues and as a team prepare the draft report. The team noted that "when AID unilaterally considers that there is a reasonable risk of significant adverse effects on the environment from an activity proposed to it for support, and when efforts to encourage the incorporation of appropriate safeguards are unsuccessful, AID reserves the prerrogative of declining to participate in the activity."

The team has noted that international agencies, FAO and WHO, have undertaken continent-wide assessment of long range programs for tsetse fly eradication in Africa, including a two-year study which will survey selected regions for an assessment of the socio-economic importance of trypanosomiasis and costs of alternative methods of control. The U.S. Government is a participant in the specialized agencies and therefore the team does not see any need for AID to undertake the broad program assessments described in section 216.6 of the Rules and Regulations. Attached to this report are the FAO/WHO studies to date.