THE ECOLOGY OF LARGE HERBIVORES IN SIMANJIRO PLAINS, NORTHERN TANZANIA

BY

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DECLARATION

I, JAMES N.M. KAHURANANGA, hereafter the candidate declare that the work presented hereunder has not been submitted for a degree in any other University.

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SUMMARY

In his pioneer ecological study of the then Tarangire Game Reserve in northern Tanzania, Lamprey (1964) found out that while wild ungulates spent the dry season concentrated in the Tarangire at a high density of up to about 40 animals/km^2, during the wet season they dispersed over the Masai steppe at a low density of less than 1 animal/km^2. He further observed that other dry season habitats were being lost through human occupation. Since then, human settlement has continued to engulf more and more of the wildlife habitat particularly the wet season areas such as Ardai, Sanya, Kwa Kuchinja and Monduli Juu short grassland plains.

The Simanjiro Plains only 28 kilometres east of Tarangire has been mentioned before as part of the wet season habitat for migratory plains ungulates from the Tarangire (Naveh, 1963). Before this study was started, Simanjiro was the only viable wet season habitat for plains game within the Tarangire ecosystem but expanding settlement from Arusha was creeping towards it rapidly. There was therefore an urgent need for a study to assess the importance of the area as wet season habitat for zebra and wildebeest within the Tarangire ecosystem and suggest ways of safeguarding it.

This study fulfilled this need.

Research work commenced at the beginning of January 1970. The study area was 570 km^2 and was chosen so as to enclose the whole short grassland area located 64 kms southeast of Arusha.

In order to analyse the environmental factors constituting the habitat the vegetation was studied in detail as it is the main habitat component. The major vegetation types were classified according to terminology adopted for East African rangelands (Pratt et al, 1966). The types were then mapped and analysed in detail. The grassland was analysed with the list-count quadrat and line-interception methods which are described in various manuals (Oosting, 1956; Greig-Smith 1957; Cain and Castro, 1959). The woodland was analysed mainly with plot-less sampling method using an angle-gauge as described by Grosenbaugh (1952). The other vegetation types were analysed with other methods described in the thesis.

The major vegetation type is the Digitaria macroblephara - Panicum coloratum short grassland. Other important grasses are Pennisetum mezianum, *Themeda triandra* and *Bothriochloa radicans*. *Barleria ramulosa* is a very widespread shrub. The percentage cover is between 45-48%. Other quantitative details of dominance are given. The next vegetation type is the *Acacia-Commiphora* woodland with three subtypes. The bushland is dominated by *Acacia stuhlmannii* while the seasonally water-logged bushed grassland is dominated by *Pennisetum mezianum* in association with this *Acacia*. Quantitative measurements are given.

Soil samples taken show that the short grassland and *Acacia tortilis* dominated woodland are associated with red sandy loam. Grey sandy clay is associated with *Acacia nilotica* ssp. *subalata* and *Commiphora schimperi* dominated sub-types. Both the bushland and seasonally water logged bushed grassland are associated with black clay. The topography/soil/plant catenas are shown and explained. Rainfall records taken indicate a typical Masailand pattern as described by Griffiths and Gwynne (1961) with short rains falling from October to December and long rains from March to May. Also both permanent and seasonal surface water sources were mapped.

Important wild herbivores using the Simanjiro were zebra, wildebeest, eland, Grant's and Thomson's gazelles, ostrich, giraffe and impala. Domestic species were cattle, sheep and goats. Their populations were determined by monthly aerial counts using Method 2 of Jolly (1969). The average maximum population sizes or numbers were zebra 6000, wildebeest 5000, eland 200, Grant's gazelle 700, Thomson's gazelle 150, ostrich 200, giraffe 150, impala 200, cattle 18,000 and goats and sheep 5000. Full transect data including densities, biomass, group structure, mortality and reproduction are given. Calving in wildebeest is synchronised and occurs between January and February. Although calving in other species is not synchronised most species calve in the plains during the rains. Full data is shown.

Feeding observations were conducted and the results tabulated for the most important species. Occupation of different vegetation types by herbivores was worked out to determine habitat preferences using occupance and the Chi-square (χ^2) method similar to that used in Amboseli (Western, 1973). Results show that the short grassland is the most utilized vegetation type because of the availability of grasses upon which the important herbivores feed as they are grazers. The other vegetation types supplement this besides providing food for the browsers. The mechanisms of ecological separation are shown. The effect of surface water on the distribution of herbivores is also assessed.

Migration between Simanjiro and Tarangire was monitored by aerial reconnaissance supplemented by ground observations. There was an orderly progression of zebra and wildebeest from Tarangire to Simanjiro beginning at the onset of the rains continuing and ending during the long rains. There was an inverse relationship of herbivore populations between the two areas during the wet and dry seasons and the population sizes were comparable. Further observations showed limited migrations of plains herbivores from Tarangire to other areas. Postulated migrations within the Tarangire ecosystem were mapped.

In the discussion, the implications of the habitat analysis findings are shown, together with the importance of short grasslands in East Africa in supporting high animal biomass and providing high nutritional requirements needed in reproduction. The various parameters of the herbivore population are compared to other similar areas and their implications analysed. Evidence of factors affecting the stability of the herbivore populations are analysed.

The study in all conclusively shows that the Simanjiro Plains provide over 90% of the wet season requirements of zebra and wildebeest within the Tarangire ecosystem while at the same time providing grazing and water for a large cattle population and a small population of resident game animals. In order to safeguard the future of the area and hence that of the Tarangire National Park remedial measures are suggested. These include creation of a partial reserve in which human settlement is excluded besides livestock herding, increased anti-poaching work and carefully planned livestock management. The general aspects of the future of wildlife conservation are discussed.

Chapter I

INTRODUCTION

1. Background to the biology of conservation.

The conservation of natural resources has gained a lot of impetus in East Africa within the last decade. The emphasis and publicity have centred much on wildlife conservation particularly with regard to tourism (Lamprey, 1972). There is a multitude of definitions of conservation and according to the old American definition adopted by the Wildlife Society of the United States of America, it means "usage or the aggregate practices and customs of man that permit the perpetuation and sustained yield of renewable resources", (Mosby et al, 1965). However, the concept of conservation has since changed. The present trend is towards protection of the ecosystem and hence the prominence of ecology in modern science. Man has devastated so much of the ecosystem through thoughtless exploitation that he is now urgently seeking for urgent remedial measures and hence the rapid growth of the environment protection lobby. The setting up of the United National Environmental Program in Nairobi shows just how strong this lobby has grown. Experience has shown that human exploitation of any natural resource is a one way removal of biological material interfering with the circulation of material in the ecosystem leading towards depletion. Taking the wildlife of East Africa as a natural resource, conservation could justifiably be defined as the control of the activities of modern man so as not to interfere with the pepertuation of wildlife in its natural habitat within the important ecosystems.

Historically, records of wildlife conservation date back to early civilization. It is found in the Mosaic Law where Moses forbade the taking of nesting birds but allowed the taking of young or eggs (Deuteronomy, 22:6). Marco Polo in his travels narrates about the well kept game preserves of the Great Kublai Khan (1259-1294 A.D.) of the Mongol Empire where even food patches were meticulously kept. In England, Henry VIII was the first monarch to promulgate laws protecting waterfowl and their eggs although hunting reservations for the privileged were formally recognized by Canute the Dane as far back as 1062. More details are given by Leopold (1933). By and large early game conservation was aimed at the restriction of hunting.

Game conservation on a large scale started in the United States during the later part of the nineteenth century up to the early 1900. After the massive slaughter of the bison and the passenger pigeon resulting in the near extinction of the former and complete extinction of the latter, far thinking men decided to conserve what was left (Ziswiler, 1967). Laws were enacted to regulate hunting and the first national parks and wildlife refuges established. Yellowstone National Park established in 1894 was among the first (Leopold, 1933). It was also realized that if the wildlife resource was to be utilized on a sustained yield basis, information about factors affecting its existence and productivity had to be known. This led to the beginning of wildlife ecology. The word ecology is derived from the Greek word "oikos" meaning home and was first proposed by a German biologist, Ernst Hackel in 1869 (Odum, 1959) and was first used in the States in relation to the study of plant communities (Oosting, 1956). It is defined as "the study of the relationship of organisms or groups of organisms to their environment", (Odum, 1959). The study and manipulation of wildlife and their habitat led to game management. Theodore Roosevelt, the ardent naturalist and once President of the United States, was the first politician to realise the importance of science as a tool for game management (Leopold, 1933). The pioneer of game management in America was Aldo Leopold (1933). Since then, game management has grown into a sophisticated and specialised science using the most modern scientific equipment (Mosby et al, 1965; Dasmann, 1966). It is even taught in some Universities such as Colorado State University as a separate discipline. There also has evolved a proliferation of bodies involved in the different aspects of game management (Gilbert, 1971).

2. The Development of game conservation in East Africa

(a) Game conservation among Africa tribes

Conservation in East Africa and indeed in Africa as a whole started long before the coming of the Europeans. This was in the form of tribal taboos which regulated the hunting of game. Rules of hunting were so carefully designed that indiscriminate killing was prohibited and in most tribes only certain clans or groups of people were allowed to hunt and even these were often restricted to hunting certain species, of a particular age and sex (Taverner, 1930; Rushby, 1965). Conservation par excellence was found among the Masai who not only did not hunt game but shunned eating wild meat. In some West African tribes, some species were considered sacred (Morris and Morris, 1966).

Among the different tribes of East Africa no tribe has evolved an existence which is so dependent on wildlife as has the Hadza followed by the Sandawi and Ndorobo to some extent. The Hadza or Tindiga live in the area around Lake Eyasi mainly in Mbulu district, Tanzania. The Sandawi live mainly in Kondoa, Manyoni and Singida districts while the Ndorobo are wide-spread in both Tanzania and Kenya Masailand. All these tribes have no fixed homes but migrate according to the availability of game. They live in rock caverns, and sometimes in make-shift bomas. Occasionally they use baobab trunk holes. Their source of diet is wildlife, honey and wild plants. Among the three tribes mentioned, the Hadza have excelled in living a balanced life with their natural environment. They normally hunt antelopes and only sufficient meat is sought. There is no wanton excess. Once an animal is killed it is fully consumed before the next hunt begins. Hunting for trophies is unknown among the Hadza. In the past rhinos were abundant on the southern shores of Lake Eyasi together with elephants. When white settlers settled at Oldeani, they made the Tindiga country between Mongola and Iramba their favourite hunting grounds and decimated the pachyderms. Only then did the Tindigas learn to eat elephant meat. Once an elephant is shot in the area, word goes round and all members of the tribe within the vicinity converge on the carcass and camp there until it is fully consumed. The highly nomadic nature of the Tindigas dissipates their predation pressure over the entire area without undue exploitation from one locality. They use only poisonous arrows in hunting and they are very efficient with the bow. Wire snares, traps and pits are uknown among the Hadza. When members of the tribe die they are left to the hyenas. This is the ultimate intergration with the ecosystem! All this shows how the Tindigas have evolved a system of perpetuating the wildlife resource upon which livelihood depends. They have lived in equilibrium with their environment. The only other tribes which have managed such an existence are the Pygmies of the Congo, the Kalahari Bushmen and the tiny El-moro tribe on the shores of Lake Rudolf. The last mentioned are however facing extinction by integration into the Samburu tribe and exclusion from their hunting grounds by formation of a national park (McDougall, 1974).

Unfortunately intrusion by Bantu tribesmen from surrounding areas is now upsetting the balance of nature. Guns, traps, even chemical poisons have found their way into the land of the Tindigas. Even worse are ideals which are incompatible with a Tindiga way of life. An item appearing in the Daily News of January 24, 1975 stated that, "We have set a deadline for February 20 this year. All Wabarabaig and Watindiga should be living in Ujamaa and planned villages." This is an effort by the Government to make the Tindiga adopt a sedentary agricultural way of life. The chances are,such a drastic change of existence will not work. Previous attempts at settling the Tindigas were disastrous. The sudden change of diet from meat, honey and plants to continued posho diet caused sickness and it is reported that some members died. Members of the tribe used to a vigorous outdoor life could not adapt to confined settlement. They became lethargic. Widespread desertion made the settlements to be closed. Later attempts ended up more or less in the same way. A way of life which has evolved over a long time cannot be changed overnight. Either the Tindigas will be forced to settle down in which case they will miserably fail and become extinct or they will as they have done before desert the settlements and go back to the bush.

Unlike the Tindigas who have adhered to their customs and maintained the human/wildlife balance, the Sandawis have not been so successful. There is no doubt that there once existed a tribe of men who depended on hunting within Kondoa district as is depicted by the famous rock paintings in the area. It is possible that these were the forefathers of the Sandawi. The Sandawis had an earlier contact with the outside world than the Tindiga. Arab traders in the 18th Century had earlier established themselves at Kondoa and their Bantu agents made sojourns into the hinterland to look for ivory (Msafiri, pers. comm.) This influenced the Sandawis to engage in elephant hunting in return for trinkets, ornaments, cloth and other items. Then the Sandawis started loosing their customs by inter-mixing with the Bantus tribesmen and in particular the Nyiramba, Nyaturu and Irangi. The rigid hunting procedures followed earlier were gradually being abandoned. No more were they only hunting for meat . The ensuing indiscriminate hunting depleted the wildlife resource and the tribesmen started settling and becoming agriculturists.

The Ndorobo or Il-dorobo were not originally hunters. One view states that they are supposed to be the not-well-to-do Masais without livestock who opted to live in the bush (Maguire, 1948). The other and more plausible view is that the Ndorobo once belonged to certain Masai subtribes who were very war-like. The rest of the groups joined up and severely ravaged them. The vanquished sub-tribes were either absorbed into the other groups or took to the bush and these were the origins of the Ndorobos (Ole Sankan, 1972). They adopted the bush life and lived off game, honey and plants just like the preceding two tribes. They likewise became skillful hunters. However whenever they are near Masai bomas, they get generous rations of milk and meat from the later. Maguire (1948) narrates that during the great rinderpest scourge, the Masais lost most of their cattle and some were saved from starvation by the Ndorobos who hunted game for them. So the Masais have to reciprocate in kind. In view of their background, the Ndorobos have no rigid hunting customs. They are even reported to have tried a hand at elephant hunting. Maguire (1948) reports that he was told of a drive by the

Ndorobo in which 16 elephants were killed in one day. Unlike the Sandawi, the Ndorobo are not settling down and are continuing with their way of life. Only that Bantu trirbesmen from the urban areas are now influencing Ndorobos to hunt elephants for them. Even the antelopes and zebras which were once so abundant before in Masailand for the Ndorobo to hunt are now under great pressure from the urban poacher.

Among the African tribesmen, the Bantu tribes were the first to flaunt hunting customs. Hunting taboos were violated and eventually massive slaughter techniques were adopted. It is reported by Rushby (1965) that one tribe in Central Africa used fire to ring game and many animals perished in such conflagrations. He also reports that Bantus tribesmen were the main ivory hunters. Some even learnt how to prepare gunpowder and muzzle loaders. Other unordothox hunting methods developed by the Bantus included digging pits and snares. They pioneered the use of dogs in chasing game. All this led to extermination of game in most Bantu areas forcing the latter to depend more on agriculture. Originally shifting cultivation enabled the land to recover. Unfortunately, permanent settlement led to continued cropping without much nutrient in-puts and this is now exhausting the ecosystem in most areas. The land cannot support the everexpanding tribal populations. This is having disastrous results the most obvious of which is famine. The Bantus have also adopted the money economy with gusto with the inevitable consequences. The main victims of this have been trophy animals and in particular rhinos and elephants. Since Masailand and other once remote game areas are now accessible by four wheel vehicles and the use of rifles is rampat, wildlife is now being decimated at a shocking rate. This will continue as long as the trophies fetch lucrative returns on the world market. So, efforts by international conservationists to halt this trade will succeed only if the international trophy market is curbed. The only redeeming factor is that the governments are doing their best to contain poaching and international conservation bodies are lending a valuable hand.

Unlike the preceding two groups of African tribal groupings who have either lived by hunting and perpetuating the wildlife resource or have indiscriminately massacred the animals, pastoralists have co-existed with wildlife. The best example are the Masai. Not only have the Masais no interest in hunting except the occasional spearing of a cattle marauding lion they shun eating game meat. Also the ferocity of the Masai warriors in the past kept Masailand free of hunting forays by Bantu tribesmen. This has resulted in the widespread survival of game in the area. This is a blessing to East Africa as the best parks and reserves are in Masailand. Unfortunately the "modern" money economy is permeating into Masailand and the once "noble" Masai are now taking to trophy hunting. It is reported in Amboseli that they engage in rhino poaching (Western and Sindiyo, 1972). Cases of Masais spearing rhinos in Ngorongoro are also common (Saibull, pers. comm.) In southern Masailand of Tanzania, a lot of Masais have been lent fire-arms by middle-men from the urban areas supposedly for protection of livestock! The fact is that the guns are used for shooting elephants. So, it is evident now that unless the international trophy market particularly for ivory must be devalued if the wildlife is to survive. This is one area where international conservation bodies could greatly contribute. Already efforts mainly through the World Wildlife Fund have helped in restricting the sale of spotted cat skins on the big markets. The East African governments and particularly Tanzania and Kenya are already doing all they can to combat poaching. For one thing, sentences meted out to culprits are much heavier than they were in the past. Also campaign for conservation consciousness among the public has been mounted.

(b) Progressive phases in game conservation

After the coming of Europeans, game conservation went through distinct phases. The first phase was the exploratory phase. It consisted of exploration and recording of different species, and their general abundance and distribution. Also most of the museum collections were done during this phase. This phase was done by the early explorers and missionaries (Perham and Simons, 1957, Loftus, 1959). Some of the game species like Livingstone's Suni Nesotragus livingstonianus and Thomson's gazelle Gazella thomsonii were named after these explorers. Among the outstanding museum collectors were Schillings (1906), Theodore Roosevelt (1910) and Kershaw (1923).

The first phase was followed by the uncontrolled exploitation of the resource. This was the day of the commercial ivory hunter, the most famous of which were Karamoja Bell and Jim Sutherland (Rushby, 1965). It is said of the latter that he collected 14 tons of ivory each year. In addition to ivory hunters, pioneer farmers were shooting antelopes by the cart loads. This prompted the Germans in the then Tanganyika to gazette the Selous Game Reserve before 1912 and the Saba River Reserve before 1914. The later is presently known as the Rungwa Game Reserve (Rushby, 1965). This marked the beginning of the protection phase. In 1912 all licences for commercial ivory hunting were stopped (Anderson, 1946). Later on during the British administration, the first national parks were set up and additional game reserves and controlled areas gazetted. Among the famous ones are Serengeti National Park, Tsavo National Park and Kabarega National Park. Some of the early game rangers in-charge of game conservation made invaluable scientific notes. The most outstanding were Swynnerton, who compiled a check list of mammals of Tanganyika and Zanzibar, and Ionides who was an outstanding herpetologist specializing in snakes (Rushby, 1965; Lane, 1963). This protection phase was much extended after the three East African countries became independent. Additional parks and reserves were set up and rigorous measures to protect game initiated (Lamprey, 1972).

The protection phase later merged with the inventory phase which has extended up to the present time. The pioneers of this phase were the Grzimeks who carried out the first aerial census of the Serengeti National Park (Grzimek and

Grzimek, 1960). Later on several censuses were carried out in different National Parks and reserves in East Africa. The areas covered included Serengeti - Loita - Mara Plains, Ngorongoro, Tsavo West, Lake Manyara, Mkomazi and Loliondo Game Controlled Area. (Darling, 1960; Stewart and Talbot, 1961; Turner and Watson, 1964; Watson and Turner, 1965; Watson, Parker and Bell, 1969; Watson, Graham and Parker, 1969).

The inventory and protection phase later merged with the ecological research and management phase in which we are now. The pioneers of this phase were Lamprey (1963) who did ecological research in the Tarangire and Talbot and Talbot (1963) who did their work in the Serengeti/Mara area. Other later studies were mostly concentrated on individual species and were thus autoecological in nature. Important species studied included wildebeest, zebra, elephant and lately lion, buffalo and hyena (Talbot and Talbot, 1963; Watson, 1967; Douglas-Hamilton, 1967; Laws and Parker, 1968; Sinclair, 1970; Estes, 1969; Croze, 1972; Schaller, 1972; Kruuk, 1972). Ecological research in Tanzania was centred in the Serengeti and culminated in the formation of the Serengeti Research Institute largely through the efforts of Dr. Owen then the Director of Tanzania National Parks (Serengeti Research Institute Annual Report - 1969). Similar centres were established both in Kenya and Uganda, the former being the Tsavo Ecological Research Unit situated in Tsavo National Park and the latter being the Uganda Institute of Ecology situated in the Kabarega National Park formerly known as the Queen Elizabeth National Park (Lamprey, 1972; Eltringham, 1972). Besides autoecological studies, work on habitat utilization by herbivores has been done (Vesey - Fitzgerald, 1960; Gwynne and Bell, 1968; Stewart, 1970; Sinclair, 1972; Field, Harrington and Pratchett, 1973).

In addition to the above mentioned research work, wildlife ecology in East Africa has gained importance academically. The College of African Wildlife Management at Mweka, Tanzania was set up in 1963 to teach wildlife management to students from the English speaking African countries (Lamprey, 1963). Even of more academic standing is the introduction of wildlife ecology as a subject given by the Zoology Department at the University of Nairobi. Also since 1964 the Department has been supervising post-graduate research in the biology of conservation under the auspices of which this research has been supervised.

The present trend in ecological research is to move away from autecological studies to synecological studies, that is community studies. Western (1973) has recently finished a study of interactions between wildlife, livestock and the pastoralists in the Amboseli ecosystem. Even in the Serengeti, emphasis is now centred on the ecological monitoring programme (Serengeti Research Institute - Annual Report, 1971-2). Research in different parts of East Africa has shown that most of the national parks and reserves are not ecological entities and the wildlife habitat is deteriorating rapidly due to increasing pressure for land resources created by the fast expanding human population (Brown, 1965; Dumont, 1966; Laws and Parker, 1968; Watson and Bell, 1969). The population of Tanzania has increased from 8,788,466 in 1957 to 11,957,200 in 1967 (Tanzania Survey Division, 1969). There is therefore a strong need to carry out synecological studies to identify areas which are vital for the survival of wildlife within the protected areas and formulate sound land use measures therein thus ensuring the conservation of the wildlife resource upon which our lucrative tourist industry in East Africa depends. The present study is orientated towards this goal.

3. Background to the present study

When Lamprey (1964) carried out his research in Tarangire National Park, then still a game reserve, he observed that plains game, mainly zebra and wildebeest, migrated from Tarangire into the surrounding areas within the Masai steppe. These areas were Simanjiro, Ardai, Monduli Juu and around the shores of Lake Manyara. All these areas fall in the grassland zone of Masailand east of the rift wall (Langdale - Brown and Trapnell, 1972). Since then human activities have reduced much of these areas as wet season habitat for plains game. The Ardai plains were opened to large scale maize and beans farming in the early sixties. This was followed by apportionment of part of the area for military training. Later on the Komolonik Ranching Association was established in the Ardai area north of the Arusha-Dodoma road under the auspices of the Masailand Range Development Commission. Some of the ranching area has since been fenced. All these activities have rendered most of the area inaccessible to game. While hundreds of zebra and wildebeest could be seen in the area during the rains before, now only a handful remains, (Game Division Annual Reports 1943 - 1969). Also only a few Thomsons and

Grant's gazelle and ostrich can be seen in the area. In addition to being reduced in numbers, the animals seen in the plains are very wary which is an indication of heavy hunting pressure. The Sanya Plains have suffered a similar fate. The plains area hitherto only used by Masai for grazing was in the early sixties open to large scale cultivation of beans not to mention the large scale poaching. These developments have virtually annihilated the large numbers of zebra and wildebeest which used to migrate there during the rains. Only a handful of Thomson's gazelles and an occasional ostrich remain. The recent construction of the Kilimanjaro International Airport in the plains has been the last stroke. Monduli Juu is also now under cultivation. The areas around Makuyuni and Kwa Kuchinja through which zebra and wildebeest migrations to the areas around Lake Manyara used to pass have all been obstructed by human settlement (see figure 23). The original wet season habitat has now been reduced by about 60 per cent.

This deterioration of the above wet season dispersal areas has left the Simanjiro Plains as the only viable wet-season habitat in Southern Masailand east of the rift wall. Even before the elimination of the other areas, the

Simanjiro was known for its wildlife population. Naveh (1963) noted that the "Simanjiro Plains were grazed by considerable numbers of plains game ungulates, most of them using it as a wet season dispersal area ....any modification of these wet season dispersal areas and their water supply will have an immediate effect on the wildlife in Masailand." The heavy utilization by livestock and the encroaching cultivation from the Arusha area have prompted this study as a prerequisite for a rational land use plan which will take the plains game into consideration.

4. Objectives

The central objective of the present study was to assess the importance and stability of the Simanjiro Plains as the main wet season habitat for zebra and wildebeest within the Tarangire National Park ecosystem. In order to achieve this objective, it was intended to look into several aspects constituting the general ecology of the area. These fall into two main categories namely the habitat and the large herbivores. Relevant conservation measures would be the other outcome of this study.

The objective of studying habitat was to determine the major habitat components and how they affected the distribution of large herbivores in Simanjiro. The objective of studying the animal populations was to determine how many there were, how their numbers flactuated monthly where they came from and how they used the Simanjiro plains.

Habitat according to Hanson (1962) "is the sum total of environmental conditions of a specific place occupied by an organism, a population or a community." Odum (1959) defines the habitat of an organism, as "the place where it lives or place where one would go to find it." The habitat requirements of various animal species vary according to the diversity of their requirements. In the East African terrestrial aspect, habitat is the complex spectrum of the environmental components both biotic and abiotic which taking into account both the anatomical and behavioral adaptations of a given species provides it with food, shelter and physical well-being thus ensuring propagation of a viable population of that species. Generally, the most important habitat component of large terrestrial herbivores is vegetation (Mosby et al, 1965). The vegetation is important because it produces food and cover for the animals. Another important component of the habitat of large herbivores is the soil. The soil forms the substrate on which plants grow and its composition is a major limiting factor as to the type of vegetation growing in a place. Precipitation and surface water are other important parts of the animals environment. Besides providing drinking water for those water dependent species it is, like soil, a limiting factor to plant growth. There are other environmental factors which influence the habitat and they are, tempererature, evapotranspiration, radiation, atmospheric gases, biogenic salts, currents and pressures. (Odum, 1959).

In the tropics and particularly in East Africa, vegetation and rainfall are the two most important components of the habitat. The others are not limiting as they are available in sufficient supplies and are distributed nearly uniformly without extreme variations (Griffiths, 1972). The major vegetations are forest, woodland, bushland and grassland (Pratt et al, 1966). Large herbivores are distributed according to these types although most have an overlapping distribution. The grassland is the major habitat of plains grazing ungulates (Astley - Maberly, 1960; Dorst and

Dandelot, 1970).

The total area of available vegetation in East Africa is rapidly being eaten away by the rapidly expanding human population through cultivation, and cutting down of trees. The highland forest vegetation has suffered the most because it is on fertile soil much sought out by cultivators. Also highland forest is extensively exploited for timber. The Ngorongoro highland forest has recently been under high pressure from cultivators. Having devastated most of the available highland forest habitat in East Africa the human population is now spilling into the marginal semi-arid lands. The Acacia tortilis woodland is especially being ravaged by the charcoal burners. Although no study has been done to assess the effect on animals, browsing species must be especially affected. Going hand in hand with the assault on the woodland habitat has been the encroachment on grassland habitat. Besides the areas of northern Tanzania mentioned earlier, the Narok area in Kenya is now being appropriated for wheat farming. It is therefore evident that the game habitat throughout East Africa is facing obliteration with the exception of the ecologically incomplete parks and reserves. It is a well known fact that even the seemingly vast Serengeti National Park is not an ecological entity. It is therefore vital that if proper game conservation is to be effected in East Africa, all vital habitats within the parks and reserves ecosystems should be identified and protected either as additions to the parks or by balanced land use. This is why vegetation was given prominence in this study.

In order to analyse the Simanjiro, it was intended to classify the main vegetation types which make up the community. These would in turn be assessed as to their importance to the different herbivores. Right from the start it looked very probable that the short grassland would be the most important vegetation type for zebra and wildebeest. It was therefore decided that it should be analysed in detail to determine species composition percentage cover, density and frequency. All these measurements are related to the carrying capacity and productivity. All these measurements would contribute to establish the importance of the Simanjiro grassland in supporting a high biomass of grazing herbivores namely zebra, wildebeest and cattle.

It was also intended to collect and analyse soil samples as there were expected to be distinct soil/vegetation catenas. It has been conclussively shown in Serengeti and Ngorongoro that soil affects the distribution of vegetation types and their subsequent utilization by wild animals (Anderson and Talbot, 1965; Anderson and Herlocker, 1973). Even before these studies it was earlier shown by Michelmore (1939) that grassland types found in East Africa were highly determined by soil.

Rainfall is another very important factor in the abiotic components of animal habitat in East Africa. Besides the obvious factor of providing drinking water rainfall stimulates plant productivity which in turn influences the distribution and physiological processes in animals. Owen (1966) points out this effect particularly on reproduction. It has been shown that during the drought of 1960-61 the synchronised calving rhythm of wildebeest was upset and half of the calf crop was lost (Brown, 1965). The same drought caused dramatic changes in the migration of herbivores from Tarangire (Lamprey, 1963). It has also been shown that rainfall influences the survival or mortality of wildebeest and buffalo in Serengeti through its influence on grass productivity which in turn influence the amount of body fat which these ungulates accumulate ready for going through the dry season (Sinclair, 1972). Klingel (1969) has also shown that percentage recruitment in zebra is dependent on rainfall. In view of the importance of rainfall to the distribution and reproduction of ungulates, it was decided that monthly rainfall would be recorded in order to correlate it with migration and calving.

Effective rainfall is greatly influenced by evapo-transpiration. The duration of surface water for animals to drink and the availability of soil moisture upon which plants depend are all subject to this factor. However evapo-transpiration in the semi-arid habitat of East Africa is more or less uniform. It is regulated by the rainfall pattern through cloudiness and humidity. It has been shown for Kenya that the annual index of water availability, expressed as the amount of mean total precipitation which is available for transpiration by plants as a percentage of potential evaporation corresponds with the ecological classification (Woodhead, 1970). It was decided therefore to omit evapo-transpiration from this study.

In addition to habitat analysis, another major objective of this study was to determine the numerical size of herbivore populations in Simanjiro and particularly zebra, wildebeest and cattle. By carrying out monthly aerial counts, the population build-ups and declines would be monitored and this would furnish information on density, biomass and reflect inward and outward migrations. Also information obtained from these counts would furnish data on the occupance and hence preference of vegetation types by the different herbivores. These preferences would be correlated with food habits observed from the field. The link between Simanjiro and Tarangire would be established by aerial reconnaissance between the two areas and numerical comparison of zebra and wildebeest population between the two areas. It was postulated that the two would vary inversely according to season. Observations would be carried out in other areas within the Tarangire ecosystem to determine the general pattern of other migrations.

Calving observations would be made to determine the proportion of herbivores calving in Simanjiro which would establish the importance of the plains for the propagation of zebra and wildebeest in the Tarangire ecosystem. Mortality would be tabulated in order to compare it with calving in order to determine general population trends.

The study would be incomplete without assessing the extent of cultivation and other human activities. The total acreage ploughed would be measured together with the percentage of trees cut mainly for charcoal burning. Implications of intensive livestock ranching would also be assessed.

Finally all factors mentioned would be integrated in order to assess the stability of the vegetation and large herbivore populations in Simanjiro and its implications on the future of the Tarangire ecosystem. Relevant conservation measures would be suggested in order to safeguard the future of the area. Comparison with other areas would be made in order to determine the importance of the area in the context of the general pattern of wildlife conservation in East Africa.

Chapter II

A GENERAL DESCRIPTION OF THE STUDY AREA

1. Geographic location

The Simanjiro Plains lies within the great game country of northern Tanzania whose splendour inspired Hemingway (1935) to write the "Green Hills of Africa." All the important game parks and reserves of Tanzania are concentrated in this region. They include Serengeti, Ngorongoro, Arusha, Tarangire and Kilimanjaro. They form the famous northern circuit. Besides the parks, the area has an extensive network of controlled areas namely Lake Natron, Longido, Mto-wa-mbu, Burunge, Simanjiro, Lolkisale, Ruvu and Kitwai. Sanya game controlled area is virtually non-existent due to human habitation. The Simanjiro plains area is in the centre of Simanjiro game controlled area. The controlled area is bounded by Lolkisale game controlled area to the west and Ruvu and Sanya Plains to the east, the Arusha - Dodoma road to the north and the open Masai area to the south. The plains area is 28 kilometres east of the eastern boundary of Tarangire National Park (See figure 1 a).

The Simanjiro area is part of Kisongo division of Masai district. The district has

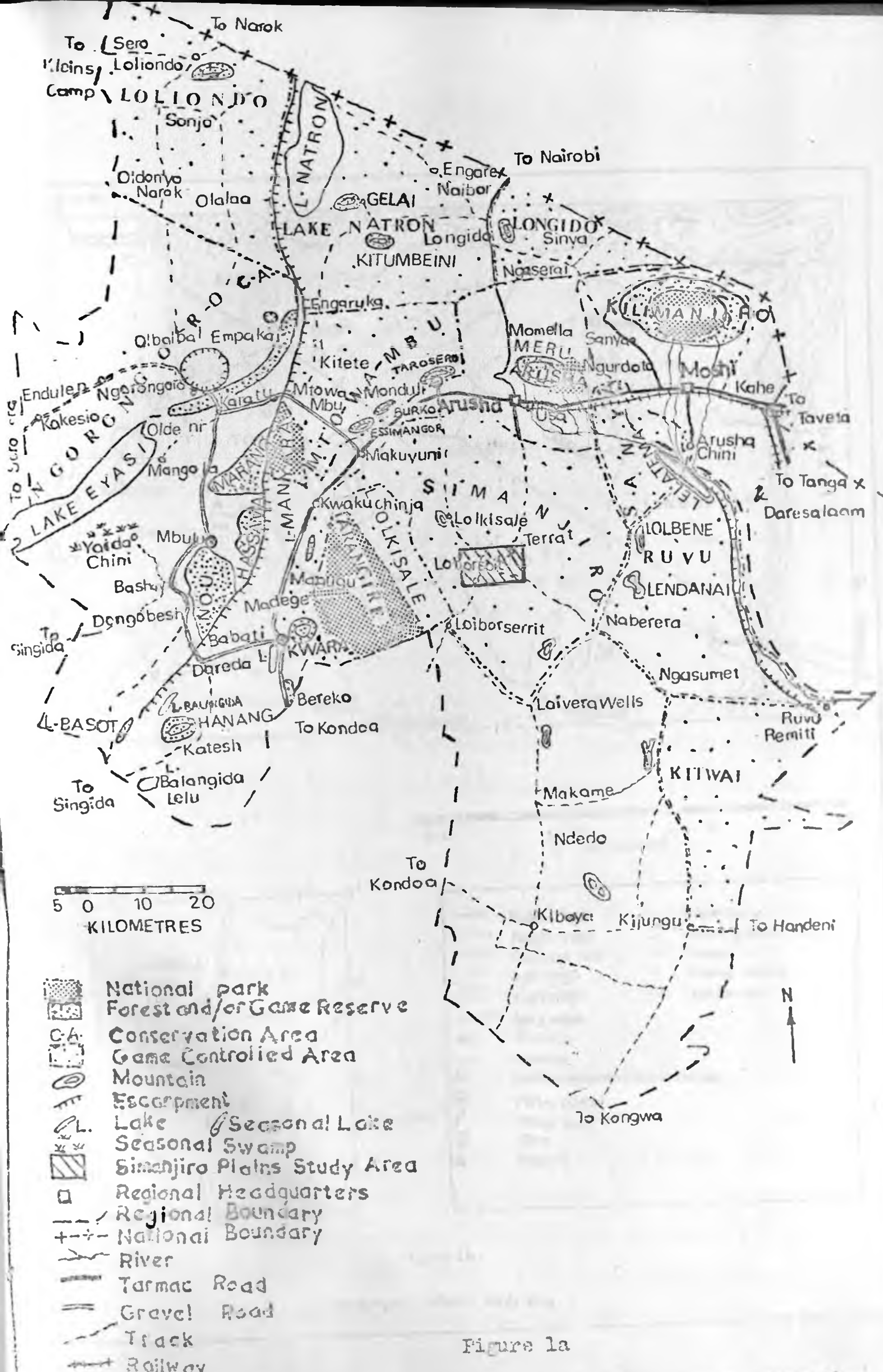


Figure 1a

Important conservation areas of northern Tanzania. Note the central position of the Simanjiro Plains.

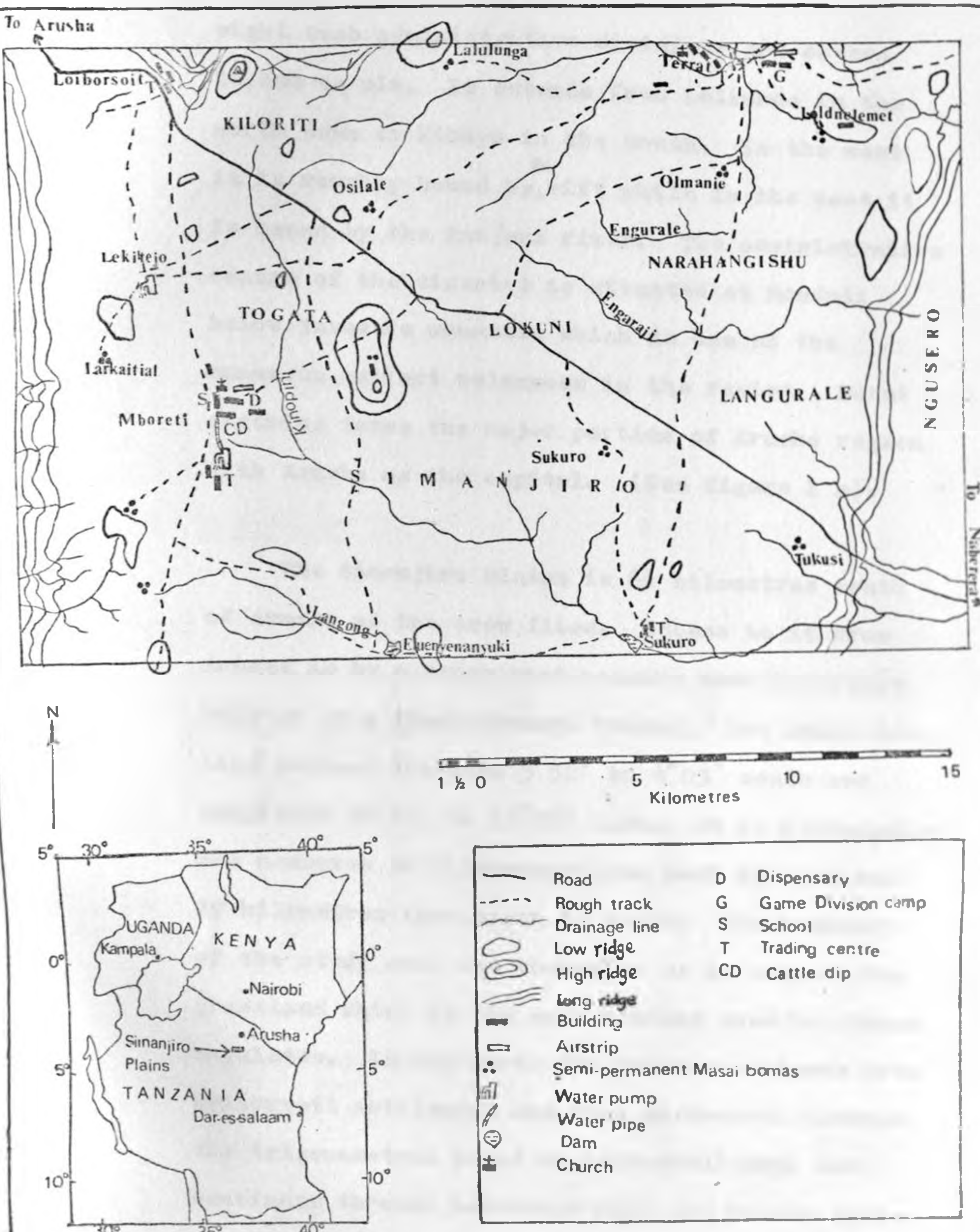


Figure 1b

Simanjiro Plains study area

eight such administrative divisions and covers 24,000 sq mls. It extends from Loliondo in the north down to Kibaya in the south. In the west it is roughly bound by the rift while in the east it is bound by the Pangani river. The administrative centre of the district is situated at Monduli below Tarosero mountain which is one of the numerous extinct volcanoes in the region. Masai district forms the major portion of Arusha region with Arusha as the capital. (See figure 1 a).

The Simanjiro Plains is 64 kilometres south of Arusha as the crow flies. Access to it from Arusha is by a rough road passing near Lolkisale Hill or by a track through Terrat. The study area lies between latitude 3°52' to 4°03' south and longitude 36°23' to 36°39' east. It is rectangular and measures 30 kilometres from east to west and 19 kilometres from north to south. The boundary of the study area was chosen so as to enclose the grassland which is the main habitat used by plains ungulates. In the north the boundary extends from Loiborsoit settlement and runs east-wards through the trigonometric point on Loiborsoit ridge and continues through Lalulunga ridge and passes just to the north of Terat Game Division camp extending a further 6 kilometres. Then the boundary turns directly south through the Ngusero depression down to a point 1.5 kilometres south of the road from Lolkisale to Naberera and in line with Sukuro and Elwenyenanyuki dams. There it follows a straight line westwards through the said dams for 30 kilometres and then proceeds directly northwards. It passes along the ridge bisected with scarps to a point 5 kilometres west of Loiborsoit. Then the boundary runs directly east to the starting point (See Figure 1 b).

2. Topography

The Simanjiro Plains area is on a raised plateau whose altitude varies from 1356 to 1605 metres. The land slopes up gently from the south-east to north-west. The general slope is about 2% (Anderson, 1972). The land surface is undulating with several low lying ridges in the western half, the highest of which has a trigonometric point whose altitude is 1605 metres. Both the eastern, western and northern boundaries are terminated by ridges orientated in a north to south direction. The ridges particularly in the west and north-west are dissected by tectonic scarps. There are also low lying depressions in the middle of the plains besides one to the extreme west. The major drainage lines are Terrat, Langong and Kinopini. They drain north-eastwards into the Kikuletwa river which flows into the Pangani.

Although the undulating nature of Simanjiro is a common feature of the major part of Masailand, the northern region of Masailand is dominated by volcanic features. Past volcanic activities within this area resulted in the formation of the major mountains of Tanzania and indeed East Africa. The largest is Kilimanjaro followed by Meru. Both can be seen from Simanjiro on a clear day. Others include Gelai, Kitumbeini and Oldonyo Lengai, which is still active. Another dominant feature of this region is the Gregory Rift Valley. In this region, it extends from Lake Natron in the north and goes southwards through the western end of Masailand. There are shallow alkaline lakes within the rift in this region. These are Lakes Natron, Manyara, and Eyasi. In addition to the mountains and the rift valley, another outstanding volcanic feature of this region is the famous Ngorongoro Crater. It was probably caused by a collapse during the period of active volcanic activity.

The major drainage of Masailand including Simanjiro is eastwards into Pagani or Ruvu river. The remainder drains internally into the main rift valley lakes already mentioned.

3. <u>Geology and soils</u>

Simanjiro is just south of the northern limit of the Archean basement complex region which extends from southern Tanzania. This complex ends to the north of Lolkisale hill which is 12 miles north of Loiborsoit the northern limit of the plains. Northwards is the great volcanic region. Simanjiro is underlain by granitic rocks which are ancient rocks of Sedimentary origin, all of Precambrian age. The basement rocks include metamorphic rocks such as quartzites, schists and gneisses. In some localities at Terrat and Loiborsoit, the rocks are exposed in long slabs. Also some of the gneisses contain garnet. In addition there are crystalline limestone and dolomite the latter bearing mica as is the case at Terrat.

Just north of Lolkisale, outside the study area the Basement complex changes into rocks of volcanic origin. These extend northwardsto Lake Natron. The tuffs also extend from Kilimanjaro in the east to the Serengeti Plains in the west. The underlying rocks are typically alkaline volcanics including olivine basalt, phonolite, trachyte, nephelinite, and pyroclastics.

The soils of Simanjiro are greatly influenced by the parent rock materials from the basement complex. The major soil within this basement complex zone is generally shown on the Tanzania soil map as the reddish brown soil of the semi-arid regions. The reddish colour is derived from gneiss the parent material which is rich in ferro-magnesium (Anderson, 1973). It has also been described as dark red sandy clay loam and as a latosolic soil (Scott, 1972). A sample of soil from the same zone in southern Masailand has been described as plains soil (Mohr and Van Baren, 1954). One sample profile from Loiborsoit in Simanjiro has been described by Anderson (1973). The profile was from 0-80cm. Starting at the top horizon the colour changes progressively from dark brown, dark reddish brown in the next horizon to red in the lowest sampled one. The composition varies from sand clay loam with moderate crumb structure at the top to sandy clay with weak prismatic structure at the bottom. The soil seems to be weakly acidic with a ph of 5.2 without much change with increasing depth sampled. The soil is well supplied with bases though low in available phosphorus. It is freely drained. Sheehy and Green, (1969) have described another sample from Simanjiro. In addition to the characteristics described above, they point out that the soil tends to form a hard surface crust. There is often a petrocalcic horizon of varying thickness at a depth of about 115cm just above the parent material. In addition to the phosphorus deficiency already mentioned, the soil has nitrogen deficiency. The cation exchange capacity ranges between 10 and 20 m.e per 100 gm. decreasing with depth. This large cation exchange capacity is due to a high concentration of organic matter in the top soil.

This red brown soil of the semi-arid regions is very widespread in Tanzania. Besides the described examples, it has been mentioned from other parts of the Masai steppe (Mohr and Van Baren, 1954; Lamprey, 1963) and central Tanzania (Muir et al, 1957; Anderson, 1963). Although this soil type is very widespread in Tanzania, it is only restricted to a small portion in Kenya to the southwest of Mt. Kenya (Scott, 1972).

Another soil type described by Sheehy and Green (1969) from Simanjiro is deep black cracking clay found in depressions with poor internal drainage. It has a cation exchange capacity of 35 to 55 me per 100 gm with the exchange complex saturated by calcium and magnesium making it alkaline. Available nitrogen and phosphorus is poor. Organic matter content is 1.5% and decreases with depth. This soil is commonly referred to as

"Black Cotton Soil" (Scott, 1972). It is also variously known as tropical black earth. There are both calcareous and non-calcareous types. In the former the calcium which is brought in dissolved water from higher ground accumulates in the profile and is precipitated as calcium carbonate when the water evaporates. In the later, the exchange complex is saturated with calcium but no excess precipitates in the form of calcium cabornate (Anderson, 1963). The black clay in Simanjiro belongs to the later group. It is similar to the one described from Nachingwea (Muir, Anderson and Stephen, 1957). Similar soils are described from various parts of the then Tanganyika (Calton, 1959). These soils are derived from colluvial material (Scott, 1972). Such soils are alkaline with a pH range of 7 and above as illustrated by the samples taken by Sheehy and Green (1969).

The black clay soil forms deep cracks on drying. Such cracking is usually caused by the proportions of clay and sands and the type of the clay mineral present. The usual minerals are montmorillonite, illite and kaolinite (Muir, Anderson, Stephen, 1957; Calton, 1959; Anderson, 1963). Another soil type mentioned by Sheehy and Green (1969) is dark grey clay found in shallow depressions. This soil is also known as light grey to white mottled loamy sand with a laterite horizon (Scott, 1972). Variations of it from Kongwa have been described as pale grey , buff or pallid soils (Muir, Anderson and Stephen, 1957).

4. Climate

In his pioneer work on the classification of the climate of East Africa, Griffiths (1958) included the Masai Steppe into Zone 8 together with Kilimanjaro and Dar-es-Salaam. His classification was primarily based on rainfall and this zone included areas with an average annual rainfall between 1000mm to 1100mm with the main rain period extending from March to May. In the Masai Steppe which covers Simanjiro the average annual rainfall is about 600mm (Lamprey, 1963; Ndambo, 1973). Later on Griffiths and Gwynne (1962) carried out more detailed work on the climate of Kenya Masailand. They pointed out that rainfall in this area is caused by the confluence of air at the Equatorial Trough. This Trough or Inter-tropical Convergence Zone (I.T.C.Z.) is caused by a low pressure belt along the equator caused by the position of the sun above the equator. This causes wind from the high pressure area to converve on the equatorial belt. These are the southeast and northeast winds. Along the coast these winds are known as the monsoons and bring moisture from the Indian Ocean. The 2 rain periods near the equator are caused by the crossing of the equator by the sun in March and August. The effect of the sun on the rain lags behind the actual position of the sun by one month. The actual local variations in the rain pattern are a result of altitude, topography and effect of inland water masses mainly around Lake Victoria, Tanganyika and Nyasa. Both convetive and relief rainfalls occur. In Kenya Masailand and for that matter the rest of the Masai steppe, the rains are of the latter type (Griffiths and Gwynne, 1962).

Although rainfall is a good measure of climate in East Africa, a more accepted method involves the Moisture Index as originally proposed by Thornthwaite (1948). Basically this method treats precipitation as income and potential evapotranspiration as expenditure while moisture stored in the soil is a reserve. Pant and Rwandusya (1971), used this method in the climatic classification of East Africa. According to this classification the Masai steppe including Simanjiro is in a semi-arid zone whose Moisture Index varies from -40 to -20. In their classification of East African rangeland, Pratt et al (1966) earlier included moisture indices for semi-arid climate to be between -40 to 30.

Since the zone proposed by Pant and Rwandusya (1971) is very wide, the figures used by Pratt et al (1966) are more representative of Masailand. This zone neatly correlates with the Acacia-Themeda association.

The temperatures throughout the Masai steppe are more or less uniform. Records taken at Sanya Chini show a diurnal temperature range of between 23°C and 26°C between January and February (Ndimbo, 1973). This is part of the hottest part of the year as this period normally extends from October to February. June and July are cool months and the lowest recorded temperature in Tarangire was 4°C recorded on one night in July, 1958 (Lamprey, 1963).

Surface winds are usually influenced by topography and therefore vary from place to place. Winds in Masailand are generally weak and are usually less than 15 knots (Ndambo, 1973). Maximum wind circulation occurs between mid-day and 3p.m. due to heating. During September whirl-winds or "dare-devils" are a common feature at around this same time.

5. Vegetation

In the global classification of floristic regions, East Africa falls in the Paleotropical division, African subdivision. It is further classified under the Tropical Grassland and Savannah biome (Odum, 1959). Within East Africa, the major vegetation communities are montane forest, intermediate or lowland forest, Miombo woodland, Combretum savannah, Acacia savannah, bushland, thicket, semi-desert vegetation, grassland and swamp (Trapnell and Langdale -Brown, 1972). In his pioneering vegetation survey of the then Tanganyika, Gillman (1949) included Simanjiro in the grassland and savannah area. Van Resnsburg (1951) classified the area under grassland and thicket formations. Edwards (1951) classified similar vegetation in Kenya as scattered tree grassland and open grassland. In order to use uniform terminology and avoid the use of ambiguous terms such as Savannah, the classification proposed by the East African Range Classification Committee has been adopted as the standard (Pratt et al, 1966). In this classification both ecological and physiognomic approaches are given. According to this system, Simanjiro falls within the Semi-arid zone whose major vegetation is grassland with woodland, bushed grassland and bushland occuring as minor types. The dominant woody genera within both the woodland and bushland areas of East Africa are Acacia and Commiphora and hence the derivation of the name Acacia-Commiphora woodland or bushland. The dominant grass is Themeda triandra and hence this vegetation is named the Acacia Themeda association. It extends from northern Kenya and north eastern Uganda to central Tanzania (Edwards, 1951; Langdale-Brown and Trapnell, 1972). Various parts of this community have been described in detail from Kenya (Edwards and Bogdan, 1951) northeastern Uganda (Breden and Wilson, 1963) and northern Tanzania (Lamprey, 1963; Greenway and Vesey-FitzGerald, 1969; Watson, 1969; Herlocker and Dirschl, 1972). Acacia tortilis is the most characteristic tree while in Tarangire the dominant Commiphoras are C. schimperi and C. pilosa (Lamprey, 1963).

The grassland types found within the Acacia-Themeda savannah are usually dominated by short to medium height grasses. The major grasslands are Serengeti and Athi-Kapiti but there are numerous scattered variations of grassland throughout the area (Heady, 1960). The main grass species found in these grasslands besides Themeda triandra are Digitaria macroblephara, Pennisetum mezianum and Cynodon dactylon. Other important genera include Sporobolus, Setaria, Panicum, Eragrostis and Bothriochloa (Michelmore, 1936).

In his classification of grassland types in East Africa, Heady (1960), recognised the

Simanjiro plains as an important second variant of what he called the Themeda-Hyparrhenia zone the latter covering a wide area in northern Tanzania east of Lake Victoria and also found in Ankole Uganda and the Athi-Kapiti plains in Kenya. So far he was the first person to describe generally the species composition of Simanjiro plains. He mentioned the dominant grasses as being Panicum massaionce, and a low form of Digitaria milanjiana in association with Cenchrus, Sporobolus, Chloris, Harpachne and Microchloa. A common constituent of the bush was Commiphora schimperi in association with Acacia, Dalbergia, Sclerocarya, Grewia, Balanites, Dichrostachys, Boscia and Albizia.

6. Animals present

a. Common mammals

The Simanjiro plains has already been mentioned as being part of the great game country of northern Tanzania. Brown (1965) refers to the whole complex of the East African grassland as "an animal paradise." Therefore it is obvious that animal species found in Simanjiro are generally those found throughout the Acacia-Themeda savannah. Accounts of these animals can be found in the numerous general publications on the subject and only a few will be mentioned here (Roosevelt and Heller, 1915; Bere 1962;

Maberly, 1962; Williams, 1967; Dorst and Dandelot, 1970). A standard account of the taxonomy and distribution of the mammals of the present Tanzania is given by Swynnerton and Hayman (1951).

There are 8 common large wild herbivores and 4 common domestic herbivores in the study area. All of them except one fall under Class Mammalia and the one exception belongs to Aves. Among the mammals, the Order Artiodactyla predominates being represented by 12 species the other 2 belonging to Perrisodactyla. The nomenclature used in naming them is mostly after Swynnerton and Hayman (1951). The family Bovidae is represented among the game species by the Eastern White-bearded Wildebeest *Conochaetes taurinus albojubatus Thomas*, East African eland *Taurotragus oryx pattersonianus* Lydekker, Grant's gazelle, *Gazella granti*, Thomson's gazelle, *Gazella thomsonii* Gunther and impala, *Aepyceros melampus suara* (Matschie). Among the domestic species it is represented by Masai Zebu cattle *Bos taurus* Linnaeus, goat *Capra hircus* Linnaeus and sheep *Ovis aries* Linnaeus. The first two game species are migratory and the others are resident.

In addition to these common bovids, there are some which are rather uncommon in the area. There are a few Lesser Kudu *Strepsiceros imberbis australis*

(Heller) resident in the area and they are seen only occasionally in dense bushland. Also Coke's hartebeest Alcelephus buselaphus cokii Gunthor sometimes wander into the study area and they were seen within the woodland. On rare occasions Fringe-eared oryx Oryx beisa callotis Thomas visit the plains during the rains. Cape buffalo Syncerus caffer (Sparrman) are infrequently seen in the densely wooded ravines. Giraffe Giraffa camelopardalis tippelskirchi Matschie is the only common non-bovid artiodactyl ungulate found in Simanjiro.

The order Perrisodactyla has two common species in the study area. One is Burchell's zebra Equus burchellii bohmi Matschie and the other is the domestic ass Equus asinus asinus Linnaeus. Black rhino Diceros bicornis bicornis Linnaeus is rarely seen in the plains.

Elephants Loxodonta africana knockenhaueri Matschie which belong to the Order Proboscidea sometimes go into the plains at the height of the dry season to drink from the dams and permanent springs in the area.

In addition to the large mammals already mentioned Masai ostrich Struthio camelus massaicus Newmann is a common herbivore of the Simanjiro Plains.

Though belonging to the Class Aves, the birds, its feeding habits, size and abundance place it is in the same ecological position as the mammals.

The study area also has the usual array of Carnivora found in the grassland habitats of East Africa. The Masai lion Panthera leo massaica (Newmann) is quite common in Simanjiro. Although notcommonly encountered, frequent roaring at night and incidences of cattle raiding especially during the dry season indicate their presence. Similarly the common occurence of leopard Panthera pardus fusca F.A.A. Meyer is detected through kills hidden in trees and also leopard purring is commonly heard at night. Cheetah, Acinonyx jubatus raineyi Heller, are occasionally seen in the area. Spotted hyena, Crocuta crocuta (Erxlebe) is the common species in Simanjiro while the striped hyena, Hyena hyena dubbah F.A.A. Meyer is less common and so is the aard-wolf Proteles cristatus termes Heller.

The wild Canidae are well represented by the Golden jackal Canis aureus bea (Heller), the side-striped jackal Canis adutus notatus (Heller), the Black-backed jackal Canis mesomelas mcmillani (Heller). The African wild dog Lycaon pictus lupinus Thomas appears intermittently when the migrant ungulates are present. Also present is the Bat-eared fox Otocyon megalotis virgatus Miller. There are numerous domestic dogs Canis familiaris Linnaeus some of which have turned feral.

Besides the large animals already mentioned, there are numerous smaller mammals in Simanjiro. The most commonly seen is the Ugogo dikdik Rhynchotragus kirkii thomasi Newmann. It is easily seen in the dense woodland and bushland at Terrat. The steinbok Raphicerus campestris neumanni (Matschie) is a common inhabitant of the woodland, bushland and grassland especially where there is medium height grass such as Themeda triandra and Hyparrhenia fillipendula. Warthogs Phacochoerus aethiopicus aeliani (Cretzschmar) are easily seen during the rains at wallows. There are two species of primates in the study area. Velvet monkeys Cercopithecus aethiops johnstoni Pocock are confined to the dense drainage line woodland and can always be seen at Terrat within the vicinity of the ground-water forest. Newman's Olive baboon Papio anubis neumanni Matschie inhabits the more open woodland and can be commonly seen near settlement at Terrat and Loiborsoit area when maize is maturing. Other smaller species found in Simanjiro are listed in Appendix 2.

b. Taxonomy and general distribution of the common large herbivores

In the present study it was intended to include only species constituting the large herbivores. These are zebra, wildebeest, eland, Grant's and Thomson's gazelle, impala, ostrich, giraffe, cattle, goats and sheep. Their general taxonomy and distribution is therefore explained mainly with regard to East Africa. The source of material is Swynnerton and Hayman (1951) unless otherwise indicated. The zebra species found in Simanjiro is the same one found throughout East Africa and is referred to as East African Burchell's zebra. There are several races of zebra found in the Ethiopean (African) Zoogeographical region. Burchell's zebra is a race whose distribution extends from southern Sudan, Ethiopia and Somalia through Tanzania down to the upper Zambezi area. It has also been referred to as Grant's zebra, the actual Burchell's race being regarded as extinct (Dorst and Dandelot, 1970).

The wildebeest found in Simanjiro is regarded as a separate race known as the Eastern White-bearded wildebeest. It is distributed in Kenya and Tanzania Masailand east of the rift wall. It is found in the Athi Plains, Sanya Plains, Lake Manyara and Tarangire.

The most numerous race is the Western White-bearded wildebeest <u>Connochaetes taurinus hecki</u> (Neumann) which is found on the Serengeti-Mara Plains. The Eastern White-bearded wildebeest is supposedly bigger than the Western White-bearded wildebeest (Lamprey, Pers. Comm). The White-bearded wildebeest's distribution extends from the Tana river down to Wembere Plains in central Tanzania. It is also referred to as the Brindled gnu (Dorst and Dandelot, 1970). The other wildebeest found in East Africa is the Nyasa Blue Wildebeest, <u>Connochaetes taurinus johnstoni</u> (P.L. Sclater) found in Southern Tanzania the largest concentration of which is in the Selous Game Reserve (Rodgers, 19[illegible]). The East African eland found in Simanjiro is the most common race found in East Africa. Its distribution extends from Tana river down to central Tanzania and also in Uganda. The other supposed race is Livingstone's eland, <u>Taurotragues oryx livingstonii</u> (P.L. Sclater). This is confined to Southern Tanzania (Dorst and Dandelot, 1970).

Similarly, Grant's gazelle found in Simanjiro is the commonest in Tanzania and Kenya. It is found from the Tana river down to central Tanzania. The other supposed race, the Wide-horned Grant's gazelle or Robert's gazelle is confined to Western Masailand and near Lake Victoria.

Thomson's gazelle occuring in Simanjiro is distributed in both Kenya and Tanzania. It is found south of Mount Kenya extending southwards to the east of the Rift Valley. It is found on the foot of Kilimanjaro and throughout eastern Masailand, Mbulu and down to Wembere Plains. The other so called Black-snouted Thomson's gazelle, Gazella thomsonii nasalis is distributed west of the rift valley northwards from Lake Eyasi to Speke Gulf, and in Kenya it extends from the Loita plains, north-eastwards into the Rift Valley and then northwards to the west of Mount Kenya. It is also called Gazella thomsonii biedermanni (Swynnerton and Hayman, 1951; Brooks, 1961).

The impala found in Simanjiro is known as the Tanganyika impala is the same as the East African impala. Its distribution extends from northern Kenya, Uganda and Tanzania. The so called Southern or Nyasaland impala Aepyceros melampus johnstoni Thomas is confined to southern Tanzania.

The Tanganyika or Southern giraffe found in Simanjiro is the commonest in East Africa. Other races found in East Africa are the Reticulated Giraffe Giraffa camelopardalis reticulata and the Baringo Giraffe, Giraffa camelopardalis rothschildi (Dorst and Dandelot, 1970).

The Masai ostrich found in Simanjiro is the same race found throughout Kenya/Tanzania Masailand. The other race, Struthio camelus molybdophanes Reichw is found in Kenya north of Tana river (Mackworth-Praed and Grant, 1955).

The livestock owned by Masai are zebu cattle, dwarf goat, sheep and donkey. The Masai zebu cattle are the same type throughout East Africa although there are variations in size. They originally came to East Africa from East Mesopotamia where they had long been introduced from Asia. The zebus owned by Masais are smaller than those owned by the Borana and Nandis. The latter two are called Boran and Nandi breeds. The other local cattle found in East Africa are the neck-humped Sangas or humpless long horn cattle (Epstein, 1955).

7. Human occupation

The main tribe inhabiting the Simanjiro plains are the pastroral Masai. This is a well known tribe in East Africa which ranges from northern Kenya down to central Tanzania. The war-like nature of this tribe in the early days virtually kept Masailand out of bounds for the other African tribes. Even the early travellers had a hell of a time trying to cross Masailand. Thomson the famous explorer was the first to travel across Masailand and had his share of encounters with Ol-Masai (Loftus, 1959). In spite of occupying such a huge tract of land, the Masais are rather few in number. In the 1957 census the population of Masai district was 64,683 people distributed at a density of 2.6 people/square mile (1.04 people/km^2). The average for the whole of Arusha region is 12.48 people/square mile (4.81 people/km^2).

The section of Masai found in Simanjiro are the Il-Kisongo. This group occupies most of southern Masailand from Kilimanjaro and Arusha southwards. Around Arusha live the Il-Arusha. Further north are the Il-Purko whose distribution extends into Kenya where it merges with other sections. For a full explanation of the different sections and their origin see Ole Sankan (1971).

Another smaller tribe which wanders in Simanjiro in pursuit of game animals are the Ndorobo who have already been mentioned earlier. Their excursions into the plains are during the rains when there is plenty of game to hunt. Normally their semi-permanent haunts are south of Simanjiro where the more dense vegetation and rocky outcrops afford them better stalking cover and shelter. The distribution and habits of the Ndorobo or Il-dorobo in southern

Masailand has been amply described by Maguire (1948).

In addition to the Masais and Ndorobo, Simanjiro has recently been invaded by the Waarusha from Arusha for purposes of cultivation and livestock grazing. Their main settlement is at Terrat. There are a few Somalis and Habesh who are traders. Other lesser tribes who are found in Simanjiro include a few Chaggas, Pares, Mbulus and Sukumas. Their main interest is trading with Masai or gemstone prospecting. This is not to mention the more or less de-tribalised urban Africans who often drive into Simanjiro mainly for poaching purposes. Also during the hunting season, the white professional hunters with their rich usually American or occasionally European clients camp in the area for hunting.

Chapter III

VEGETATION ANALYSIS

1. Methods

a. Vegetation type mapping

One of the objectives of the vegetation study was to classify the different vegetation types. Determining what a vegetation type is presents quite a formidable task especially in the tropics where the vegetation is extremely varied. In this aspect the classification of Pratt *et al.* (1966) was used. Aerial observations were made over the area and the extent of grassland, woodland, seasonally water-logged bushed grassland and bushland sketched on a rough map. Grassland included all the area covered primarily by grasses with a few widely scattered trees and shrubs. Woodland included the area covered by trees. The seasonally water-logged bushed grassland included grassland in depressions or sumps interspersed with bushes. Bushland included the area covered with a dense growth of bushes and shrubs. Determination of boundaries between different woodland subtypes was rather difficult because there was for example no clear cut boundary between the Commiphora woodland and the Acacia-Commiphora woodland. However the different woodlands are usually associated with specific topographic features and soil types. So these were used in order to determine boundaries. Even then these could not be taken as rigid boundaries. These more or less arbitrary boundaries were adjusted by reference to identifiable ground land marks such as hills, drainage line, roads, tracks, and ridges also shown on the 1:50,000 Series Y 742 maps of the Tanzania Survey Division. The area of each type was obtained by superimposing a transparent paper grid each 1 kilometre square and the number of grids falling in each type added up to make the whole area. Protrusions over half the grid were counted while those less than half the grid were discarded. After mapping the different types, each one was analyzed in detail for quantitative characteristics which were used in determining the different vegetation types.

b. Quantitative vegetation analysis

(i) Grassland analysis

There are several methods used in studying vegetation each of which is valid for a given vegetation type. These are explained in detail in various manuals (Oosting, 1956; Greig-Smith, 1957; Cain and Castro, 1959; Kershaw, 1966). All of the methods aim at analysing dominance.

Plate 1

Game Division Field Camp at Tenet

Plate 2

Grassland analysis

Plate 3

A close up of the grassland note clump of Barleria ramulosa in the left hand corner

In this study, the first method used in analysing the grassland was the List-count quadrat one. This is satisfactory in determining species composition, frequency and density. This method has been extensively used in the range lands of the United States and the 1 metre square quadrat has been adopted as standard for grasses (Stoddart and Smith, 1955). Very little or no work has been done using this method in East Africa. It has only recently been used in field exercises by botany students (Kokwaro, 1971). It could be because it is a rather laborious and time consuming method. Kerfoot (1965) working in northern Uganda extensively used the "point" method and line quadrats to analyse frequency, density and cover. In this study, it was rather difficult to determine individuals of clumped or tufted species such as _Panicum coloratum_ and _Pennisetum mezianum_ or rhizomatous species such as _Digitaria macroblephara_. The quadrats were too small for obtaining valid results for big shrubs such as _Barleria ramulosa_ and _Ipomoea hildebrandtii_. The relationship between quadrat size and plant size has been amply discussed and it is now an accepted fact that the larger the species to be sampled the larger the quadrat size needs to be (Cain and Castro, 1959). Therefore in this study the large species were analysed using quadrats measuring 10 by 10 metres.

In order to obtain a uniform dominance measure, the line interception method (Cain and Castro, 1959) was used. This eliminated the problem of size and shape of the different species. It gave cover percentage. This method was also developed in the United States and found to be accurate in measurement of grass types (Cook et al, 1962). Cover is used extensively in the United States in determining range condition and trend (Stoddard and Smith, 1955).

The List-count Quadrat Method (Cain and Castro, 1959) was used in obtaining frequency, density and percentage composition of the different species. Six sites were chosen within the grassland at Loldnolemet, Olmanie, Mboreti, and Tukusi, Narahangishu and Langurale. The sites were chosen so as to cover the whole area. The method used involved using a metre square frame consisting of four pieces of wood screwed together when being used but could be dismantled when not in use for easy carrying (see figure 2). At each site, a transect was arbitratily placed by means of a sisal string marked with red ink at one metre intervals. The wooden quadrat was placed on the ground at each 10 metre interval and the number of plants of each species therein recorded. In order to determine the number of quadrats which would be

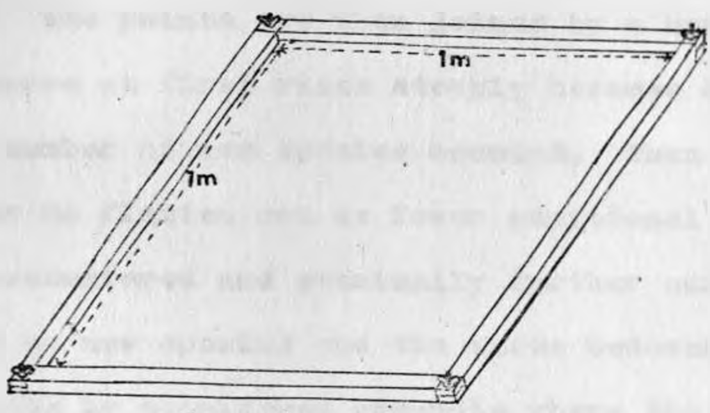
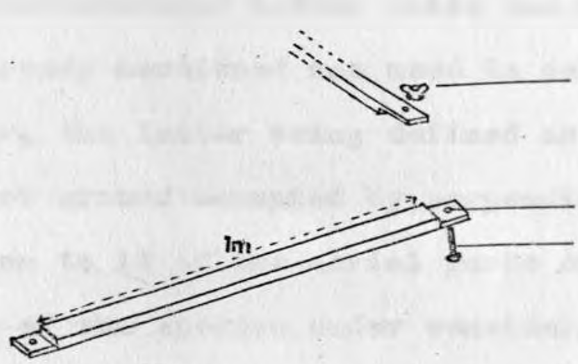


Figure 2
(a)

A complete M^2 quadrat used in the list count method for grasses, herbs and low growing shrubs.



(b)

Two of the pieces of the quadrat showing how they are put together.

sufficient for a representative sample for this area the species number curve test was applied (Oosting, 1956). In this test, the number of species accumulated in the sampling is plotted on the Y axis and the number of quadrats on the X axis. The points are then joined by a curve. The curve at first rises steeply because of the high number of new species counted. Then it starts to flatten out as fewer additional species are encountered and eventually further quadrats yield no new species and the curve becomes level. Sampling is considered adequate where the curve levels (see figure 5).

The Line-intercept Method (Cain and Castro, 1959) as already mentioned was used in determining ground cover, the latter being defined as "the proportion of ground occupied by perpendicular projection on to it of the aerial parts of individuals of the species under consideration" (Greig-Smith, 1957). In this method a baseline is laid out by means of a string, chain or measuring tape. Then at certain intervals chosen randomly or systematically, straight lines 10 metres long are laid out perpendicular to the base line. Starting from the base line and proceeding along each line the width of the aerial parts of each species falling across the line is recorded.

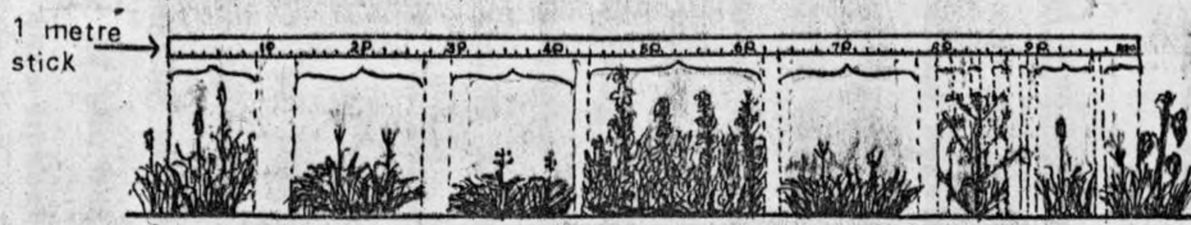


Figure 3

Line interception method

showing how the plant cover segments are measured

All widths of the same species are added up and expressed as a percentage of the whole 10 metre line. This then gives the percentage cover of that particular species (see figure 3).

(ii). Woodland and bushland analysis

The woodland vegetation was analysed with the plot-less variable-radius sampling method developed by Bitterlick in Austria (Cooper, 1963). This method was found to be rapid and accurate in determining basal area. Similar to the methods used for analysing the grassland this method has not been widely used in ecological studies in East Africa although it has been extensively used in the United States for forestry studies (Cain and Castro, 1959). In order to measure crown cover a modification of this method as proposed by Cooper (1963) in the United States was used. He has given a full discussion of the principles involved and the validity of the method. In order to test the validity of this method in this study aerial photographs were taken within each vegetation type. Also actual crown projections were measured and the results compared. There were no significant variations thus proving the validity of the method. Agnew (1968) used it satisfactorily in Tsavo National Park and commended it for being simple and quick and ideally suited for accurate large scale vegetation survey. This method cannot be used in bushland with density of more than 35 percent (Cooper, 1963) and aerial photographs were the only means used in determining cover. Other methods which have been used in East Africa in woodland analysis include use of stereoscope to determine cover density from aerial photographs (Bunning, 1972), the point-centred quarter method (Herlocker and Dirschl, 1972; Vesey-Fitz Gerald, 1973) and forestry enumeration (Abraham, 1958; Parry, 1966). Methods used in the grassland were only used in assessing the understory composed of low shrubs, herbs and grasses. The measurement of trees had to be done by another method. In order to get rapid results as already mentioned, plot-less sampling originally introduced by Bitterlick (1948) was used to determine basal area cover. In this method a sighting gauge is constructed with a piece of wood 33 inches (83.82 cm) long with a peep hole at one end and a metal piece at the other end 1 inch (2.54 cm) wide (see figure 4a).

An arbitrary baseline was selected in the woodland along a particular compass bearing starting from a land mark such as an ant-hill or characteristic tree. Then the surrounding trees were viewed through

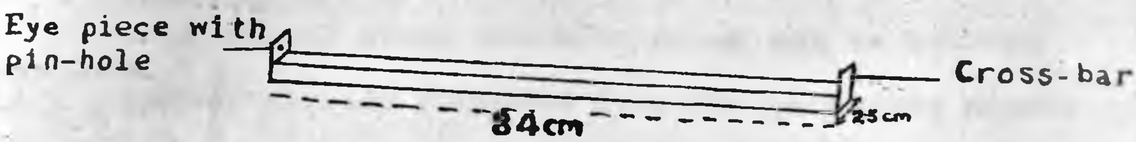


Figure 4
(a)

An angle-gauge used for estimating basal area in the woodland.

(b)

An angle-gauge used for estimating tree and shrub cover density in the woodland.

the peep hole of the angle-gauge. Trees whose diameter at breast height (d.b.h.) appeared larger than the 1 inch cross-arm were recorded. Sightings were repeated until a complete rotation was made. The next point was chosen far enough along the line so as not to include trees already recorded from the proceding point. This procedure was repeated until sufficient samples were obtained.

The angle-gauge is made such that when it is held to the eye it intercepts a horizontal angle of 1°44'. This angle was chosen such that it subtends tree trunks at their breast height diameter (d.b.h.) at distances equal to 33 times their diameter. If a tree has a d.b.h. of 1 metre it will subtend the angle when viewed from a distance of 33 metres (see figure 4c). In this exercise the tree trunk is assumed to be circular in shape. So using the same reasoning, a trunk that intercepts a larger angle than 1°44' will appear larger than the Bitterlick stick's crossarm and is closer to the eye than 33 times its diameter. One which intercepts a smaller angle is farther away and will appear smaller than the cross arm. The relationships are derived from the fact that the ratio of the arm to the cross-arm is 33:1.

If a circle is drawn using the cross arm as its diameter and another one is drawn using the whole arm as the radius, and if it is further assumed that the small circle has a diameter of 1 unit, the large circle will have a radius of 33 units. Therefore the relationship between areas of the two circles can be calculated as follows:-

Let d be the diameter of the small circle

The radius of the large circle will then be 33d

The area of the small circle A_1 will be $\pi(d.5)^2$

In this case A_1 will be 0.7857 square units

The area of the large circle A_2 will be $\pi(33d)^2$

In this case A_2 will be 3422.5092 square units

Therefore the percentage of the area of the large circle occupied by the area of the small circle will be $A_1/A_2 \cdot 100$

In this case it will be $0.7857/3422.5092 \times 100 = 0.029\%$

In order to determine what this means in terms of acreage, let us assume the large circle to equal one acre. Using a table of conversion (Pennycuick, 1974) we find the area of one acre to be $43560ft^2$ which is assumed to be the area of the large circle. Therefore during field measurements each trunk which seems large than the width of the cross-arm occupies $10ft^2$/acre of the plot being sampled. But during actual measurements each trunk appearing larger than the cross-arm is counted as 1. Therefore to convert that to be expressed in ft^2/acre it is

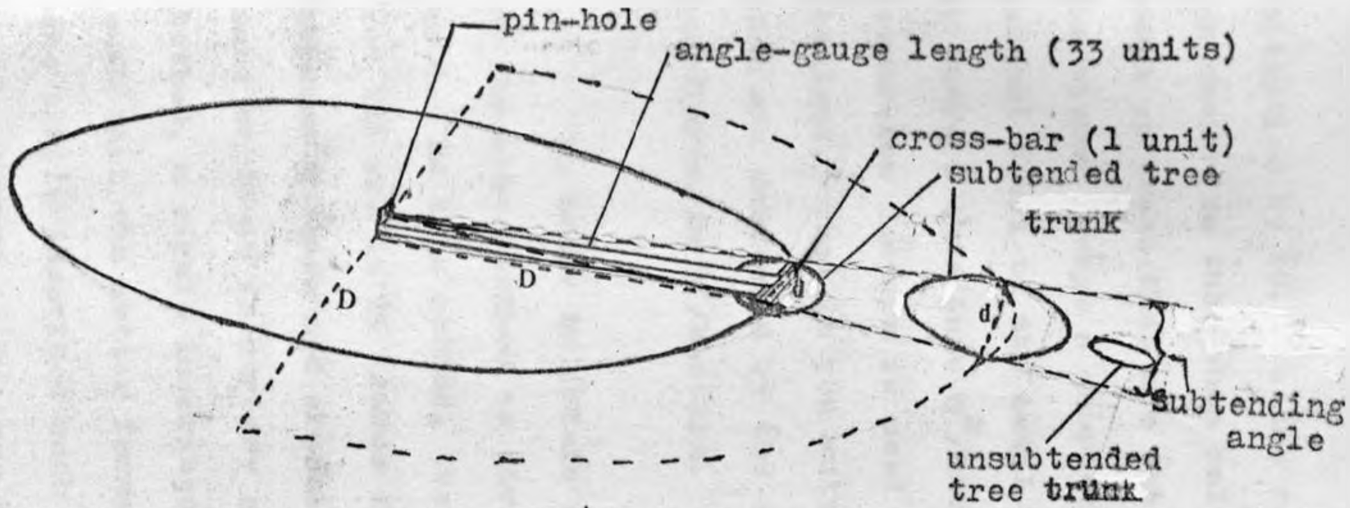


Figure 4c
Mechanics of the angle-gauge

Area of the large circle i.e area under survey = $\pi D^2 = \pi 33^2$
Area of the small circle i.e area of tree trunk = $\pi (\frac{d}{2})^2 = \pi.5^2$
Therefore the portion of the small circle to the large one

$$= \frac{\pi.5^2}{\pi 33^2} = \frac{1}{4356}$$

If the area under survey(large circle) = 1 acre(43560 ft^2)
The portion of the small circle or tree trunk = $\frac{43560}{4356}$ or 1/10

Therefore the number of tree trunks subtended by the angle-gauge multiplied by 10 gives the basal area in square feet per acre or by 2.29 to get the basal area in square metres per hectare.

multiplied by 10. So the relationship of 33:1 was chosen so that when multiplied by 10, the count of trees that are subtended by the angle as the viewer sweeps a complete circle gives a product equal to the total basal area in ft^2/acre. To convert this into M^2/hectare again the table of conversion factors is used and figure of 2.29 is obtained. That is you multiply the number of trees that are subtended by the angle by 2.29 to get the basal area in M^2/hectare.

In order to obtain crown cover, a modification of the above method as given by Cooper (1963) was used. In this method, the cross-arm is 6 inches and the arm is 30 inches thus creating a ratio between the arm and cross-arm of 5:1. Using the same argument as already given for the Bitterlich Method, a circle inscribed around the cross-arm such that the letter forms the diameter, is 1% of the circle inscribed such that the arm forms the radius. This is because if the same units are used, the area of the large circle will be $\pi 5^2$ which equals 78.57 square units and that of the small circle will be $\pi 5^2$ which equals 0.7857 square units. Therefore each crown appearing larger than the cross-arm occupies 1% of the area being sampled.

Another method used in estimating crown cover was by actual measurement. The crown was projected on to the ground and the diameter taken. For large trees this was done by taking two points on the ground which were directly below the two ends of the crown on each side of the trunk and the distance measured. The crown cover was then obtained by calculating the portion of the total area sampled obstructed by tree crowns. Measurements were taken in an area 10 metres in radius. The percentage cover of each species was the total area it occupied in the total sampled area. This method was used for comparison with the preceding method.

Further analysis of crown cover in the woodland and bushland was made from aerial photographs. The photographs were taken by a Motorized Nikon mounted through a hole cut through the belly of a Piper Cruiser flying at an altitude of 1000 ft. (304.8 metres). The film used was 35 mm Agfa Panchromatic. Exposures were timed at 2.5 second intervals while the speed of the plane was about 160 kilometres per hour. This created a 60% overlap in the photographs. Later the portion of the ground covered was calculated from the developed photographs (see plate 6).

The size distribution of the trees within each woodland association was recorded by measuring

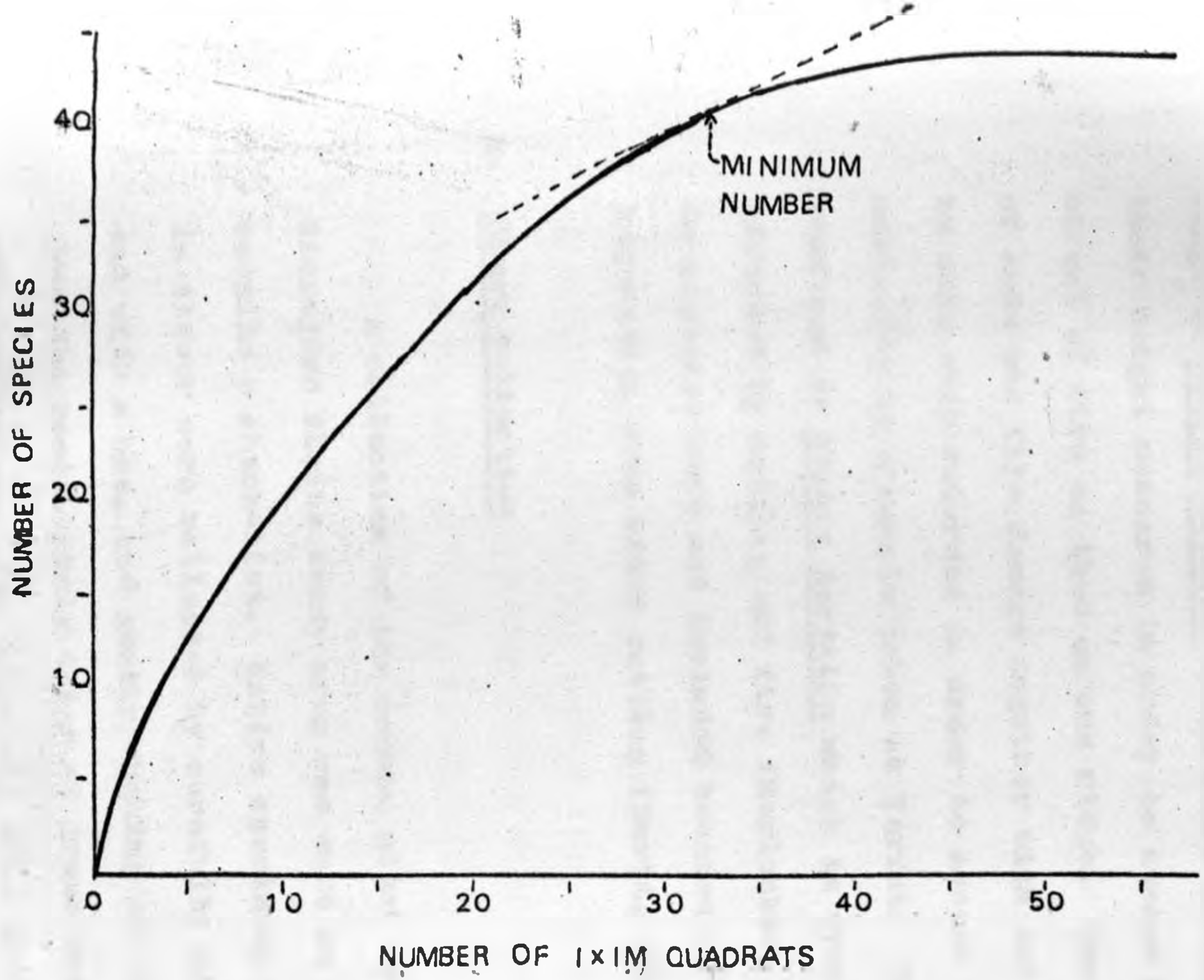


Figure 5

Species number curve to determine the number of 1x1 M quadrats needed for sampling the Simanjiro short grassland the diameter at breast height of all trees within a radius of 10 metres at each stop during the plot-less sampling. Smaller trees were measured in the middle of the main stem. Regenerating saplings of *Acacia tortilis* within the grassland had their height measured in order to assess the effect of fire on them on one ridge. The severity of cuts and fire damage together with infestation by ants were recorded in order to assess tree mortality in a sample taken at Terrat. This was confined to *Acacia tortilis* which is very much affected by cutting and fire (Herlocker, 1972). Commiphoras were not included because of their high regeration even after cutting (Burtt, 1953).

c. Plant collection

A collection of the common plant species of Simanjiro Plains study area was made in order to compile a check-list. Entire specimens preferably in flower were collected by carefully digging them out with a hoe, and gently shaking off the earth from the roots. Only twigs of trees and shrubs were collected. The specimens were then placed between folded newspapers measuring 28 by 43 centimetres and strapped in a plant press measuring 30 by 45 centimetres.
Before placement, the plants were carefully laid

out so that the various structures were clearly displayed and would not be damaged by strapping. Notes were written on a piece of paper which was placed inside the newspaper cover with the plant. Information recorded was date, common name, generic name and specific name if known, family name, locality, general description and the name of the collector. After a day's collection, specimens were then transferred to folders made of felt paper enclosed in Manila folders whose dimensions were the same as those of the newspapers. They were stacked and strapped in the metal press again. They were left in a dry place under shade for dessication. Care was taken not to expose them to direct sunlight as this would make them too brittle to be handled without breaking. After drying them for a day or two the specimens were transferred to fresh felt paper folders and pressed again using more pressure by piling heavy stones on boards placed on top of the stacks.

Before mounting them each specimen was treated with a preservative suggested by the East African Herbarium (Kabuye, Pers. Comm.) for protection against damage by insects and smaller organisms. The preservative was made by first melting 227 grammes of phenol crystals then added to a mixture of 18 litres 90% alcohol and 454 grammes mercuric chloride.

The whole mixture was shaken until it dissolved. It was applied to plant specimens with a brush and the specimens left in the open shade to dry.

After drying the specimens were each mounted by transparent cello tape on a sheet of stiff white paper. All the notes recorded in the field were copied on a specially prepared lable and glued to the right hand corner of the paper (See plate 2b). Two or three specimens of each species were put in each folder.

Index cards were kept for each species collected so as to simplify classification. Information put on the cards included species, genera and family according to botanical nomenclature adopted by the Flora of Tropical East Africa whenever possible. Grasses were named according to the nomenclature used by Napper (1965). The tribes in Gramineae were included.

Plants were identified by keying them with the Flora of Tropical East Africa and other common check-lists and guides (Brenan and Greenway, 1949; Edwards and Bogdan, 1951; Harker and Napper, 1960; Dale and Greenway, 1961; Lind and Tallantire, 1962; Heritz-Smith, 1962). Both identified and unidentified specimens were later sent to the East African Herbarium for confirmation of the former and identification of the later.

2. Results

a. Major vegetation types

Observations on physiognomy of the vegetation in Simanjiro showed 4 easily distinguished types. These were grassland, woodland, bushland and seasonally waterlogged bushed grassland (see figure 6). The naming of these types is after the proposed classification of Pratt et al. (1966), for East African rangelands. The differences between these types were distinct enough and it was possible to recognise them immediately after the reconnaissance survey.

(i) Short Digitaria - Panicum grassland

This is the largest vegetation type in the Simanjiro Plains. It covers 291 km^2 or 51.08% of the study area. The grassland occupies the central portion which has gently rolling topography. The altitude varies from 1417 metres to 1524 metres. On the whole, the grassland is in one continuous formation. However, there are grassland islands found in the other vegetation types at Loldnelemet, Mboreti, and Tukusi (see figure 6). The periphery

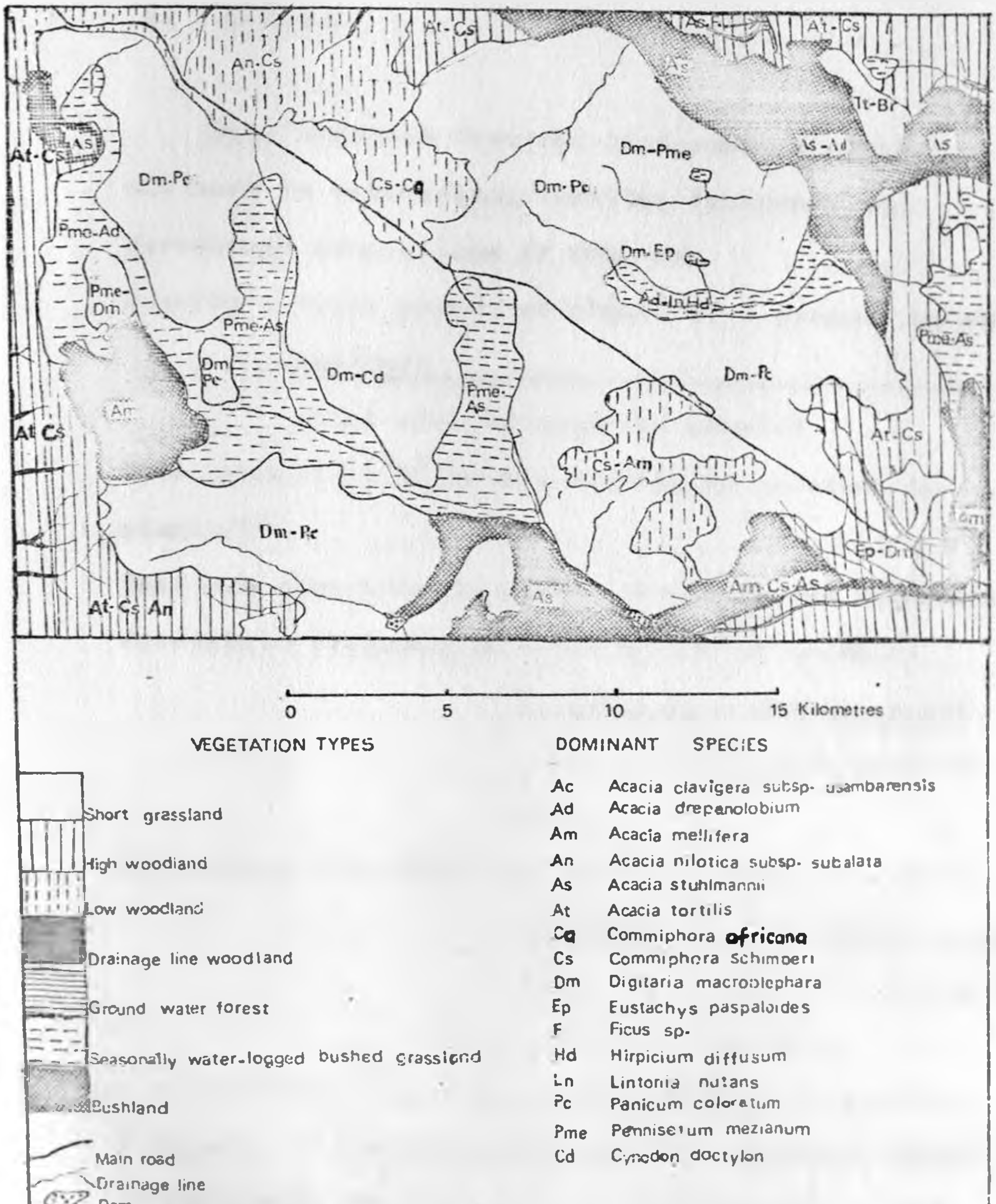


Figure 6

A vegetation map of the Simanjiro Plains of the grassland is mainly occupied by woodland and bushland.

Data obtained from the list-count quadrats was used in calculating density, frequency and percentage composition as follows:

$$\text{Density} = \frac{\text{total number of plants of a species in all quadrats}}{\text{total area of quadrats sampled}}$$

Each quadrat is M^2 so the density is obtained in plants/M^2

This was expressed as number of plants per square metre

$$\text{Percentate Frequency} = \frac{\text{total number of quadrats occupied by a species} \times 100}{\text{total number of all quadrats sampled}}$$

$$\text{Percentage composition} = \frac{\text{the total number of plants of a species in all quadrats} \times 100}{\text{the total number of all species in all quadrats}}$$

These parameters were used in determining the relative dominance of the different species, dominance being described as "the relative degree to which a kind of plant predominates in competition for limited supplies of the necessities of life", (Cain and Castro, 1959). The domiant species characterise a particular vegetation type. The results of the dominance parameters are given on table 1-7b.

Data from the Line-intercept method was used in estimating percentage cover of each species as follows:-

$$\text{Percentage cover} = \frac{\text{total of lengths of line occupied by a species} \times 100}{\text{total length of line}}$$

Results of percentage cover analysis are given in table 7a

In order to combine all the dominance characters into a single expression the importance value index (IVI) originally used by Curtis and McIntosh (Cain, and Castro, 1959) in analysing data from an upland forest in Wisconcin in the United States was calculated. In the index, the relative density, relative dominance and relative frequency are added up. The values are obtained as follows:-

$$\text{Relative density (RDE)} = \frac{\text{density of a species in the whole stand} \times 100}{\text{density of all species in the whole stand}}$$

$$\text{Relative dominance (RDO)} = \frac{\text{percentage cover of a species in the whole stand} \times 100}{\text{percentage cover of all species in the whole stand}}$$

$$\text{Relative frequency (RF)} = \frac{\text{Percentage frequency of a species in the whole stand} \times 100}{\text{percentage frequency of all species in the whole stand}}$$

The Importance Value Index (IVI) = RDE + RDO + RF
The results of the important value index are given on table 7b.

The most dominant species in the grassland is Digitaria macroblephara. The average height of this species was 18 cm. and this falls in the short grass category proposed by Pratt et al, (1966). It had the highest dominance values in all the transects sampled. The density varied between 3.4 and 7.02 plants/M^2. Its average ground cover in sampled areas was 14.7% and it constituted about one third of the total plant cover within the grassland. The high frequency recorded for this species meant that it is more or less evenly distributed throughout the grassland. Its Importance Value Index was 61.77 and again the highest recorded. The next species in dominance within the grassland is Panicum coloratum. The average height was about the same as that of the preceding species thus conforming to the short grass category. The average height of this species in Simanjiro is below the expected average height. It is normally found growing at heights of over 60 cm. However Napper (1965) points out that it is a very variable perennial found growing from 8 to over 100 cm. high. Its density was somewhat lower than that of Digitaria macroblephara varying between

1 and 5 plants/M^2. It was widespread throughout the grassland but its percentage frequency in one locality was 28%. Its percentage ground cover was between 0.85 and 9.45. The Importance Value Index was just over half of that of the preceding species thus attaining second rank.

Ranking third in dominance in the grassland is Eustachys paspaloides. Its Importance Value Index in the sample transect was 36.30 which is just below that for Panicum coloratum. In the transect at Tukusi it had the highest density. The next important species is Pennisetum mezianum commonly known as wire grass. This is a tough clumpy growing species whose distribution is more patchy than any of the preceding grasses. Its frequency varies between 5% and 55%. It is more associated with clay soil. It is also found in dense stands near bomas such as at Olmanie. Another important species with a patchy distribution is Themeda triandra. Its distributions in the plains seemed to be associated with incidence of fire. While its frequency at the Mboreti transect where the incidence of fire is very low was nil, its frequency at Loldnelemet was 80% and the latter area was burnt in each of the years during the study period.

The tufted and short Microchloa kunthii is another common constituent of the Simanjiro short grassland. Its density is high during the rains as the shoots sprout profusely then but die out later on in the season. However its highest recorded percentage cover was 0.21. Another common short grass in Simanjiro is Harpachne schimperi. Its density in the sampled transects was low and had percentage cover ranging between 0.20 and 1.26 and its overall Importance Value Index was 6.38 which was about a quarter of that for the preceding species. Cynodon dactylon is also found in Simanjiro but its distribution like that of Themeda triandra is not uniform. Its frequency varied from nil at Langurale to 90% at Mboreti. The transect run in the latter area was on a ridge and field observation indicated that this species preferred ant-hills, ridges and abandoned Masai bomas. All these localities had more moisture and fertile soil. Eragrostis superba has an even more infrequent and sparse distribution than the preceding species. Bothriochloa radicans is also less common in the main plains as a whole but one of the main constituent at the isolated piece of grassland at Loldnelement where it had percentage cover of 9.72 and percentage frequency of 65%.

There are other perennial grass species which are present but not common in the Simanjiro plains. These include Sporobolus helvolus, S. festivus, Heteropogon contortus and Digitaria scalarum. The uncommon annuals include Aristida adscensionis and Chloris pycnothrix. See Appendix I for a complete list of grasses found in Simanjiro.

Besides grasses, the short-grassland area is well endowed with a variety of shrubs and herbs. The most dominant and characteristic shrub is Barleria ramurosa. This is a spiny and dense growing shrub. The average width of clumps measured was 56.2 cm and the average height was 33.9 cm. It is generally higher than the grasses and hence easily noticeable. The average density was between 0.14 and 0.84 plants/M^2 while its cover was between 3.15 and 6.03 percent. The Importance Value Index was 10.31 and ranked six overall. The only areas where it was absent were some localities at Mboreti, Larkaitial, Lekitejo, Lorbosoit and Langurale, but it was present in over 75% of the grassland area. Another widespread and common shrub in some localities and especially on ridges with woodland regeneration is the large-leaved and white flowered Ipomoea hildebrandtii. This is a much larger shrub than the preceding one. Those measured in Simanjiro had stems about 1 metre long and similar plant width. Its percentage cover in the transects at Langurale and Olmanie was 1.01 and 2.20 respectively and the Importance Value Index was 2.43.

Becium capitatum is commonly found in the shallow depressions within the grassland. In the transect laid within such a depression at Narahangishu it covered 0.48%. Astripomoea hyoscyamoides is very widespread after the rains but dies out later during the dry season. Macrotyloma maranguense is another seasonal species. This is a crawling legume which is very widespread during the rains. The highest density was recorded at Loldnelemet where it had a density of 14.55 plants/M^2 and 80% frequency. This species is rather unique among the wild legumes in that it produces geocarpic pods which are usually not seen. One specimen collected in the study area had these underground pods.

There are other shrubs which are found throughout the plains but at a low density of usually under 1%. Each usually constitute less than 3% of the plant composition. They include Sericocomopsis hildebrandtii, Cassia mimosoides, Indigofera volkensii, Crotalaria spinosa, Tephrosia subtriflora, Sida ovata, Commelina africana, Heliotropium edourdii, Arthroisma psylloides and Pentanisia au[illegible]yne. The low growing white-flowered herb, Rhamphicarpa montana, also known as paper flower, grows profusely in the flat localities at the beginning the rains. Anthericum spp. are also commonly seen during the rains. The red blooms of Haemanthus multiflorus come out just before the rains.

In order to determine the subtypes within the grassland, it was necessary to find out two species which had the highest association within each locality. Data from the transects was used and the presence or absence of the most dominant species taken. It was necessary to match more than a pair for each transect as this would include sufficient data to draw valid conclusions from. Coefficient of Association CAB as proposed by Cole (1949) was calculated and used in determining the sub-types. The presence or absence for both species A and B are tabulated in a 2 x 2 matrix as shown below:-

		Species B		
		Number of times present	Number of times absent	
Species A	Number of times present	a	b	a+b
	Number of times absent	c	d	c+d
		a+c	b+d	a+b+c+d=n

Having tabulated the results Cole's Coefficient of Association, CAB, is calculated as follows:-

When ad $\geq$ bc:

$$CAB = \frac{ad-bc}{(a+b)(b+d)}$$

When bc > ad and d $\geq$ a:

$$CAB = \frac{ad-bc}{(a+b)(a+c)}$$

When bc > ad and a > d:

$$CAB = \frac{ad-bc}{(b+d)(c+d)}$$

The results are shown on table 7(c)

Mathematical calculations show that if two species occur together as many times as they possibly could have, the positive association is perfect or +1. If they occured together the minimum possible number of times the association is perfectly negative or -1. If the number of joint occurences is exactly what would be expected on the hypothesis of independent scattering of the two species, no association is indicated and the association value is 0. See Cole (1949) for the full explanation.

Since the value of the highest possible association is +1, it was decided that any two species which had the nearest value to +1 formed the association and hence the sub-type. Results show that Digitaria macroblephara and Panicum coloratum had the highest positive association at Olmanie, Mboreti and Narahangishu with values of 0.07, 0.11, and 0.13. All these localities fall on the extremeties of the main grassland and hence the main sub-type for the Simanjiro short grassland is formed by these two species.

A minor association occurs in the Tukusi area in the southeast. Although the species composition is the same as in the major subtype the species showing the highest coefficient of association are Eustachys paspaloides and Digitaria macroblephara, the value being 0.16. Both species show the highest densities and percentage frequencies and Panicum coloratum ranks third. Another minor association occurs between Digitaria macroblephara and Bothriochloa radicans. It occurs in the isolated piece of grassland in the northeast at Loldnelemet adjacent to the Acacia-Commiphora woodland. It is separated from the major grassland by the Acacia bushland (see figure 6). The other two isolated pieces of grasslands at Mboreti and Lekitejo and the portion in the southwest have all the dominant association between Digitaria macroblephara and Panicum coloratum.

Within the grassland, there are some ridges

Table 1

Plant density, percentage composition and percentage frequency in the shortgrassland at Olmesie Sinamjiro.

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Cynodon dactylon	39	3.12	3.00	8
Digitaria sp.	1	0.08	0.08	2
Digitaria macroblephara	253	20.24	20.00	56
Digitaria velutina	5	0.40	6.39	4
Eragrostis superba	3	0.24	0.23	2
Eustachys paspaloides	189	15.12	14.80	30
Harpachne schimperi	29	2.32	2.00	16
Michrochloa kunthii	402	32.16	31.48	52
Panicum coloratum	51	4.08	4.00	28
Pennisetum mezianum	98	7.84	8.00	48
Themeda triandra	7	0.56	1.00	4
Cyperus bulbosus	14	1.12	1.10	14
Kylinga alba	3	0.24	0.23	4
Antherioum sp.	1	0.08	0.08	2
Astripomea hyoscyamoides	61	4.88	5.00	34
Barleria ramulosa	7	0.56	0.55	14
Cassia mimosoides	9	0.72	0.70	10
Commelina africana	6	0.48	0.47	6
Crotalaria spinosa	13	1.04	0.01	14
Digera muricata	2	0.16	0.16	2
Euphorbia inaequilatera	31	2.72	3.00	30
Heliotropium edwardii	1	0.08	0.08	2
Hermannia uhglii	1	0.08	0.08	2
Indigofera arrecta	2	0.16	0.16	4
Indigofera basiflora	2	0.08	0.16	4
Ipomea longituba	3	0.24	0.23	4
Macrotyloma maranguense	1	0.08	0.08	2
Monsonia angustifolia	1	0.08	0.08	2
Oxygonum sinuatum	12	0.96	0.94	10
Pentanisia ouranogyne	5	0.40	0.39	4
Portulaca oleracea	2	0.16	0.16	4
Rynchosia minima	20	0.16	1.57	16
TOTAL	1277	100.64	100.00	432

Table 2

Plant density, percentage composition and percentage frequency in the shortgrassland at Naberagishe, Simanjiro.

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Bothriochloa radicans	2	0.16	0.18	9
Cynodon dactylon	53	4.24	4.77	26
Digitaria macroblephara	181	14.48	16.41	66
Digitaria scalarum	11	0.88	0.99	8
Eustachys paspaloides	246	19.68	22.16	61
Microchloa kunthii	121	9.68	11.62	26
Panicum coloratum	136	10.88	12.25	68
Pennisetum mezianum	83	6.64	7.48	30
Sporobolus sp.	9	0.72	0.82	8
Sporobolus festivus	2	0.16	0.18	4
Themeda triandra	104	8.32	9.37	56
Cyperus teneristolon	1	0.08	0.09	2
Aristida adscensionis	3	0.24	0.27	4
Astripomoea hyoscyamoides	1	0.08	0.09	2
Anthericum sp.	21	1.68	1.89	14
Barleria ventricosa	16	1.28	1.44	24
Becium capitatum	2	0.16	0.18	4
Blepharis maderaspatensis	3	0.24	0.27	4
Chlorophytum sp.	1	0.08	0.09	2
Commelina africana	3	0.24	0.27	4
Euphorbia inaequilatera	2	0.16	0.18	4
Indigofera sp.	33	2.64	2.97	24
Monsonia angustifolia	1	0.08	0.09	2
Pentanisia ouranogyne	10	0.80	0.90	10
Polygala usambarensis	1	0.08	0.09	2
Portulaca sp.	1	0.08	0.09	2
Sporobolus nitens	50	4.00	4.51	30
Sida ovata	7	0.56	0.63	32
TOTAL	1103	77.52	100.00	

Table 3

Plant density percentage composition and percentage frequency in the shortgrassland at Engurale, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Aristida adscensionis	1	0.40	0.40	10
Digitaria macroblephara	34	13.60	13.34	70
Digitaria scalarum	2	0.80	0.79	10
Eragrostis superba	22	8.80	8.60	100
Eustachys paspaloides	18	7.20	7.11	30
Heteropogon contortus	2	0.80	0.79	10
Microchloa kunthii	35	14.00	13.73	40
Panicum coloratum	1	0.40	0.40	10
Sporobolus festivus	9	3.60	3.56	30
Sporobolus helvolus	33	13.20	13.04	40
Sporobolus sp.	5	2.00	1.98	10
Themeda triandra	10	4.00	3.95	40
Kyllinga alba	3	1.20	1.19	20
Asystasia sp.	3	1.20	1.19	10
Anthericum sp.	16	6.40	6.22	80
Athroisma psyllioides	5	2.00	1.98	30
Becium capitatum	25	10.00	9.87	30
Blepharis maderaspatensis	8	3.20	3.16	30
Cassia mimosoides	3	1.20	1.19	20
Commelina africana	1	0.40	0.40	10
Conyza sp.	4	1.60	1.57	30
Euphorbia inaequilatera	3	1.20	1.19	10
Indigofera volkensii	1	0.40	0.40	10
Pentanisia ouranogyne	4	1.60	1.57	10
Rhamphicarpa ajugifolia	2	0.80	0.79	20
Rhynchosia minima	3	1.20	1.19	30
Sida ovata	1	0.40	0.40	10
TOTAL	254	101.60	100.00	

Table 4

Plant density, percentage composition and percentage frequency in the shortgrassland at Mbereti, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Cynodon Dactylon	88	8.80	25.36	90
Digitaria macroblephara	126	12.60	36.31	100
Panicum coloratum	80	8.00	23.05	80
Pennisetum mezianum	4	0.40	1.15	20
Abutilon mauritianum	3	0.30	0.87	20
Commelina benghalensis	10	1.00	2.88	70
Euphorbia inaequilatera	4	0.40	1.16	20
Sida ovata	28	2.80	8.07	35
Indigofera volkensii	3	0.30	0.86	30
Tephrosia subtriflora	1	0.10	0.29	10
T O T A L	347	34.70	100.00	

Table 5

Plant density, percentage composition and percentage frequency in the shortgrassland at Tukusi, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Aristida adscensionis	431	86.20	27.12	75
Bothriochloa insculpta	3	0.60	0.18	5
Brachiaria eruciformis	46	9.20	2.89	55
Chloris pycnothrix	105	21.00	6.60	25
Cynodon dactylon	10	2.00	0.62	35
Dactyloctenium aegyptium	7	1.40	0.44	5
Digitaria macroblephara	131	26.20	8.24	95
Eustachys paspaloides	550	110.00	34.61	65
Microchloa kunthii	36	7.20	2.26	25
Panicum coloratum	49	9.80	3.08	70
Themeda triandra	3	0.60	0.18	5
Tragus berteronianus	5	1.00	0.31	10
Cyperus sp.	17	3.40	1.06	15
Kyllinga alba	4	0.80	0.25	5
Astripomoea hyoscyamoides	2	0.40	0.12	5
Athroisma psylloides	5	1.00	0.31	10
Barleria ramulosa	4	0.80	0.25	10
Cassia mimosoides	3	0.60	0.18	15
Crotalaria spinosa	5	1.00	0.31	15
Erlangea cordifolia	117	23.40	7.36	90
Euphorbia inaequilatera	33	6.60	2.07	60
Indigofera basiflora	9	1.80	0.56	20
Ipomoea sp.	4	0.80	0.25	15
Oxygonum sinuatum	3	0.60	0.18	10
Tribulus terrestris	7	1.40	0.44	5
TOTAL	1589	317.80	99.87	

Table 6

Plant density, percentage composition and percentage frequency in the shortgrassland at Loldaalenet, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Aristida adscensionis	3	0.30	0.30	10
Bothriochloa radicans	72	7.20	7.22	65
Cynodon dactylon	41	4.10	4.11	20
Digitaria macroblephara	60	6.00	6.05	70
Digitaria scalarum	32	3.20	3.21	50
Harpachne schimperi	49	4.90	4.91	60
Microchloa kunthii	140	14.00	14.05	55
Panicum coloratum	37	3.70	3.71	65
Pennisetum mezianum	2	0.20	0.20	5
Sporobolus fimbriatus	49	4.90	4.91	65
Sporobolus festivus	16	1.60	1.60	25
Themeda triandra	124	12.40	12.44	80
Cyperus sp.	10	1.00	1.00	20
Anthericum sp.	14	1.40	1.40	70
Barleria ramulosa	4	0.40	0.40	20
Commelina benghalensis	3	0.30	0.30	10
Crotalaria spinosa	2	0.20	0.20	10
Euphorbia sp.	6	0.60	0.60	10
Indigofera basiflora	9	0.90	0.90	5
Indigofera spicata	20	2.00	2.00	30
Ipomoea hildebranditii	9	0.90	0.90	30
Macrotyloma maranguense	291	29.10	29.21	80
Less important species	3	0.40	0.30	
TOTAL	996	99.70	99.92	

Table 7a

Percentage cover from 3 transects in the Simanjiro grassland obtained by the Line-interception Method

Species	Percentage Cover		
	Loldoelenet	Engurale	Olmenie
Aristida adscensionis	0.45	0.02	0.09
Brachiaria sp.	0.10	0.58	0.05
Bothriochloa radicans	7.92	0.01	1.00
Chloris pycnothrix	0.61		0.40
Cynodon dactylon	1.87	0.22	3.50
Digitaria macroblephara	2.49	16.93	14.37
Eragrostis cilianensis	-	0.01	0.17
Eragrostis superba	-	0.01	0.73
Eustachys paspaloides	-	5.41	1.09
Harpachne schimperi	1.62	0.20	1.26
Microchloa kunthii	0.45	0.03	0.21
Panicum coloratum	0.85	9.45	2.94
Pennisetum mezianum	0.82	4.30	3.96
Sporobolus festivus	0.75	0.01	0.40
Themeda triandra	25.49	2.21	1.84
Kyllinga sp.	-	0.25	0.01
Astripomoea hyoscyamoides	-	2.00	0.71
Barleria ramulosa	0.85	3.15	6.03
Cassia mimosoides	0.39	0.55	0.53
Crotalaria spinosa	1.12	0.02	0.39
Cyathula cylindrica	-	0.60	0.74
Erlangea cordifolia	0.33	0.02	2.83
Euphorbia inaequilatera	0.42	0.32	-
Indigofera arrecta	0.11	0.25	0.19
Indigofera spp.	0.01	0.02	0.28
Ipomoea hildebrandtii	2.80	1.01	2.20
Macrotyloma maranguense	0.05	0.90	0.30
Total % plant cover	47.50	48.48	47.02
Total % ground cover	52.50	51.52	52.98

Table 7b

Important plant dominance values within the short grassland in the Simanjiro Plains

Species	Relative Density	Relative Dominance	Relative Frequency	Importance Value Index
Aristida adscensionis	0.05	0.04	0.25	0.34
Bothriochloa radicans	0.05	0.02	0.25	0.32
Cynodon dactylon	3.05	0.45	1.85	5.35
Digitaria macroblephara	19.32	32.99	12.46	64.77
Eragrostis superba	0.23	0.02	0.46	0.71
Eustachys paspaloides	14.01	14.35	6.94	35.30
Harpachne schimperi	2.27	0.41	3.70	6.38
Microchloa kunthii	11.45	0.06	12.05	23.32
Panicum coloratum	11.35	19.36	6.01	37.42
Pennisetum mezianum	7.60	10.99	11.11	29.70
Sporobolus festivus	0.05	0.02	0.25	0.32
Sporobolus helvolus	0.05	0.02	0.25	0.32
Themeda triandra	0.54	4.58	0.92	6.04
Kyllinga erecta	0.43	0.31	0.92	1.66
Barleria ramulosa	0.54	6.55	3.24	10.31
Commelina africana	0.47	0.08	1.38	1.93
Heliotropium steudneri	0.05	0.02	0.46	0.53
Hermannia uhligii	0.05	0.02	0.46	0.53
Indigofera basiflora	0.07	0.02	0.92	1.01
Ipomoea hildebrandtii	0.11	2.09	0.25	2.45
[illegible]	0.07	2.05	0.92	3.04
[illegible] ovata	0.05	0.02	0.25	0.32
Monsonia angustifolia	0.05	0.04	0.25	0.34
Rhynchosia minima	0.07	0.15	0.23	0.45
Solanum incanum	0.05	0.02	0.25	0.32
Tephrosia subtriflora	0.05	0.10	0.25	0.40

Table 7c

Cole's coefficient of association between important grass species in the Simanjiro grassland

ASSOCIATED SPECIES	LOCALITY	COEFFICIENT OF ASSOCIATION
Digitaria macroblephara/Panicum coloratum	Olmenie	0.07
Digitaria macroblephara/Pennisetum mezianum	"	0.01
Digitaria macroblephara/Eustachys paspaloides	"	0.02
Digitaria macroblephara/Bothriochloa radicans	Lolbulemet	-0.02
Themeda triandra/Bothriochloa radicans	"	-0.39
Themeda triandra/Digitaria macroblephara	"	-0.03
Eustachys paspaloides/Panicum coloratum	Tukusi	0.46
Eustachys paspaloides/Digitaria macroblephara	"	0.19
Digitaria macroblephara/Panicum coloratum	"	-0.09
Digitaria macroblephara/Panicum coloratum	MborETI	0.11
Digitaria macroblephara/Cynodon dactylon	"	0.06
Digitaria macroblephara/Panicum coloratum	Narakauyishu	0.13
Digitaria macroblephara/Pennisetum mezianum	"	-0.26

which have some regeneration of woody species. These are Acacia tortilis, Commiphora schimperi and Commiphora sp. In these areas Themeda triandra has high dominance. Most of these regenerating trees have charred portions indicating a past history of fire. In one particular area, the woodland patch contains Acacia tortilis trees over 6 metres high. Ipomoea hildebrandtii is the dominant shrub.

Balanites aegyptiaca is sparsely dotted throughout the grassland. It grows on ant-hills. Also Erythrina burtii is found dotted in some areas in the grassland mainly in the southern part.

(ii) Acacia-Commiphora woodland

This is the next largest vegetation type occuring in Simanjiro. It covers 149 square kilometres or 26.10% of the total study area. It is found on the fringes of the plains (see figure 6). The woodland occupies ridges, and sloping ground with good drainage. The sub-types were easily distinguished without an association analysis like that calculated for the grassland. It was therefore decided to work out species association by mere reconnissance within each sub-type and carry out dominance analysis. Unlike the grassland where there are many species and the sub-types difficult to identify, the woodland contains few species and the associations are easy to identify.

In order to determine dominance among the tree species of a given woodland subtype, data collected by the plot-less sampling method was analysed to obtain the following parameters:

$$\text{Basal area in } M^2/\text{hectare} = \frac{\text{Number of trees subtended by the angle gauge} \times 2.29}{\text{total number of plots sampled}}$$

$$\text{Percentage frequency} = \frac{\text{Number of plots occupied by a species} \times 100}{\text{total number of plots sampled}}$$

$$\text{Crown cover \%} = \frac{\text{Total number of crowns subtended by angle gauge} \times 100}{\text{total number of plots sampled.}}$$

The results of these parameters are given on table 8a-10. The understory of the woodland was analysed by the same methods as those used in the grassland and the results are given on table 11-14.

There are 3 woodland sub-types which were identified

<u>Acacia tortilis - Commiphora schimperi woodland</u>

This is the main woodland sub-type in the study area. It is found on the ridges both in the east and west and in the northeast at Terrat. This is a tall canopy woodland with <u>Acacia</u> <u>tortilis</u> ssp. <u>spirocarpa</u>, the tallest species reaching heights of over 15 metres. The woodland is found on completely drained sites.

The dominant species in the association is Acacia tortilis ssp. spirocarpa. Its density at Ngusero within a mature woodland was 29 trees/ha while in a young stand at Terrat it was 146 trees/ha. Most of the trees in the latter area were new regeneration and are hence not representative of the type. However the basal area cover in the mature stand at Ngusero was 4.11 M^2/ha and measurements taken outside the study area at Terrat in a similar mature stand indicated a basal area of 4.58 M^2/ha. This is about four times the basal area of this species within the regeneration area. The crown cover in the mature stand was 30.42 while in the young stand it was 15.75. The differences as are those of the basal area between the two areas are obviously due to tree size.

The next dominant tree in this sub-type is Commiphora schimperi. Its percentage crown cover varied between 4.40 and 8.07 while its density was 16 and 41/ha respectively. The percentage crown cover of this species is much lower than that of the preceding species. While the former species has a large umbrella-like canopy this species has a narrow canopy. This is accentuated further by the fact that Acacia tortilis has leaves during most of the year while Commiphora schimperi grows leaves during a shorter period during the rains. That is why the former is usually the tree camped under by most safaris while the latter is rarely used.

Commiphora africana is another important species growing within this woodland sub-type. Its growth characteristics are very similar to C. schimperi and it is only differentiated from it by its lack of the characterist resin scent of the former species and its branchlets have pilose hairs as opposed to the glabrous nature of the other species (Brenan and Greenway, 1949). In Simanjiro the two species grow together. In spite of the fact that Acacia tortilis has a high association with Commiphora schimperi with regard to common occurence at sampled plots, when C. pilosa grew in the same plot as C. schimperi, they were much closer. The association of these species is commonly found on flatter areas. Another common species on these areas is C. madagascariensis. Acacia seyal and A. ancistroclada also grow within this woodland sub-type. The former favours sites with a more clay soil together with Acacia mellifera which grows in this type though its percentage composition is about half of the former species. The association between these species is commonly found at Terrat in the northeast of the study area. Some specimens of A. mellifera growing here attain heights of over 5 metres. Two forms of A. senegal grow in this woodland sometimes side of side. One type is high and pillarlike, the typical shape of the species, while another form has the typical Acacia umbrella shape. Acacia nilotica subsp. subalata grows within this association. It is found scattered in different sites tending to favour flatter sites. It is especially common in the west and southwest. Balanites aegyptiaca grows throughout the association although it has low dominance. Its distribution similar to that in the grassland is commonly around ant-hills. It also favours areas within drainage lines. Fagara chalybea is sparsely distributed within this association. In the northern part around Loiborsoit, the Acacia tortilis - Commiphora schimperi association merges into the Dombeya - Combretum - Omocarpum woodland which is outside the study area. Where this transition occurs there is dominance by Combretum sp. Dombeya sp., and Ormocarpum kirkii. The less dominant species here are Lannea stuhlmannii, Terminalia sp., Albizia harveyi and Sclerocarya birrea. Erythrina abysinica is found in the higher attitudes particularly around Loiborsoit ridge where the altitude is around 1600 metres. Erythrina burtii is very sparsely distributed throughout the association and is particularly common in the southwest and southeastern corners of the study area. In an outside patch adjacent to the later mentioned area the species becomes dominant. The total canopy cover is 26.70%.

The dominant big shrub in this type is Rhus natalensis. Although this shrub has a low density its large canopy gives it high dominance. Other common species in the area are Maerua johannis and Grewia bicolor. Capparis tomentosa is found in the area growing on ant-hills like Balanites to which it is often associated. Dichrostachys cinerea and Boscia fischeri are other big shrubs found in the area. Securinega virosa is commonly found in the shallow valleys especially around Terrat.

The low stratum in the shrub layer is dominated by Ipomoea hildebrandtii. This species which is also found in same localities within the grassland is very widely distributed in the woodland. In certain sites it occurs in almost pure stands. This species has a large ground cover. It is almost evergreen and is especially noticeable when in flower because of its large white showy flowers which literally cover the landscape when in season. Sericocomopsis hildebrandtii is sub-dominant. Other common species in this stratum are Lippia javanica, Leucas pododiskos and Aspilia mossambicensis. The last but one species favours sites near drainage lines. Smaller shrubs found in this vegetation sub-type include Abutilon longicuspe, A. mauritanum, Hibiscus spp., Sida ovata, Crotalaria spp., and Indigofera spp.

Table 8a

Density, percentage crown cover, composition, frequency and basal area within the Acacia tortilis – Commiphora schimperi woodland at Terret, Simanjiro

Species	Density per Hectare	Percentage Crown cover	Percentage Composition	Percentage Frequency	Basal area M^2/ha
Acacia mellifera	16	0.32	4.85	40	0.02
Acacia nilotica	12	0.01	10.89	30	0.06
Acacia senegal	6	0.11	1.98	10	0.0001
Acacia seyal	3	0.01	0.99	20	0.0001
Acacia tortilis	146	15.75	45.01	100	1.00
Balanites aegyptica	41	0.90	12.00	20	0.17
Commiphora africana	16	0.14	5.94	20	0.01
Commiphora schimperi	41	9.07	11.88	60	0.41
Commiphora madagascariensis	3	0.01	0.53	20	0.001
Fagara chalybea	13	0.17	2.96	10	0.0075
Grewia bicolor	6	1.19	1.98	20	0.05
Rhus natalensis	3	0.02	0.99	10	0.002
T O T A L	306	26.70	100.00		1.7089

Table 8b

Density, percentage crown cover, composition, frequency and basal area within the Acacia tortilis – Commiphora schimperi woodland at Ngasero, Simanjiro

Species	Density per Hectare	Percentage Crown cover	Percentage Composition	Percentage Frequency	Basal area M^2/ha
Acacia mellifera	3	3.13	10.53	10	0.30
Acacia tortilis	29	30.42	47.36	50	4.11
Commiphora africana	6	4.37	10.53	20	0.35
Commiphora schimperi	16	4.40	21.05	50	1.03
Commiphora madagascariensis	6	3.91	10.53	20	0.12
T O T A L	60	46.25	100.00		5.91

A number of grasses and low shrubs and herbs occupy the ground stratum within this Acacia-Commiphora woodland. This stratum is sometimes referred to as the field layer (Greenway and Vesey-Fitzgerald, 1969). Grasses predominate and the most dominant species is Themeda triandra. Digitaria macroblephara is common particularly in areas adjacent to the grassland where the woodland is more open often associated with Panicum coloratum. Sporobolus pyramidalis is another common species found throughout the woodland together with Eragrostis superba, and Cenchrus ciliaris the last one attaining sub-dominance in some localities. Pennisetum mezianum grows in patches similar to those found in the grassland and favours pockets of clay soil where there is incomplete drainage. Hyparrhenia filipendula is the dominant grass in the northwest where it is associated with Combretum, Lannea and Ormocarpum. Cynodon dactylon is more common on the disused Masai boma sites in the more open woodland areas. Another species found in this area is Panicum maximum. There is a number of annuals in the sub-type and these include Tragus berteronianus, Aristida adscensionis, Harpachne schimperi and Chloris pycnothrix. It should however be noted that on the whole species growing in the woodland are taller than those growing in the grassland.

The low growing shrubs and herbs on the ground stratum are dominated by *Indigofera endecalypha* and *Indigofera spp.* Several species of Crotalaria are also commonly found. *Solanum incanum* is another widespread species often growing in dense patches. *Crossandra subcaulis* is common and especially conspicuous when in flower. *Ocimum kilimandscharicum* is widespread during the rains. Other common species are *Tribulus terrestris* which prefers more sandy sites, *Hermannia exappendiculata*, *Cyathula sp.* *Aerva lanata*, *Heliotropium sp.*, *Justicia exigua* and *Melhannia ovata*. The common crawlers are *Commicarpus pedunculosus* and *Thunbergia alata* (see table 11 for full details).

Within this woodland association there are drainage lines which contain dense woodland and thickets. The dominant trees in these areas are *Acacia tortilis*, *Balanites aegyptiaca* and *Ziziphus mucronata* which commonly grows as a dense shrub but sometimes attains tree size. In certain parts the drainage lines deepen and become ravine-like (see plate 6) Other species commonly growing in these formations are *Euphorbia candelabra*, *Cussonia sp.*, *Terminalia sp.*, and *Albizia harveyi*. *Ficus* is found where the water table is high. Such drainage line formations are common in the northwestern part of the study area. At Loiborsoit water seeps out at one site providing the only permanent water in the area. The sides of the drainage lines are covered with dense thickets composed of *Ziziphus mucronata*, *Carissa edulis*, *Ocimum* sp., *Cordia ovalis*, *Lonchocarpus* sp., *Maerua triphylla*, and *Achyranthes* aspera. Also *Acacia mellifera*, *A. brevispica* and *Sansevieria* sp. are found in some of the areas.

Acacia clavigera subsp. usambarensis-Ficus sp. ground water forest

The drainage line at Terrat contains some springs with several water pools. The vegetation in this narrow piece is ground water forest characterised by tall trees and dense undergrowth (see plate 5). The ground cover is almost 100%. The dominant tree growing in this formation is *Acacia clavigera* subsp. *usambarensis*. This is a very tall tree with a large trunk. Most of the trees measured at Terrat were over 20 metres and the largest tree measured had a diameter at breast height of 1.1 metres. *Ficus* sp. is the co-dominant species. *Acacia tortilis* grows on the out-fringes of the banks. It was not possible to take measurements but casual observations showed a dense canopy of over 70%.

The shrub layer in the ground water forest is dominated by *Cordia ovalis*. *Cordia sinensis* together with *Grewia platyclada* are subdominant. Other

Plate 4

An oblique view of a young stand of *Acacia tortilis*

Plate 5

An aerial view of the *Acacia clavigera* subsp. *usambarensis* ground water forest with cattle going to water

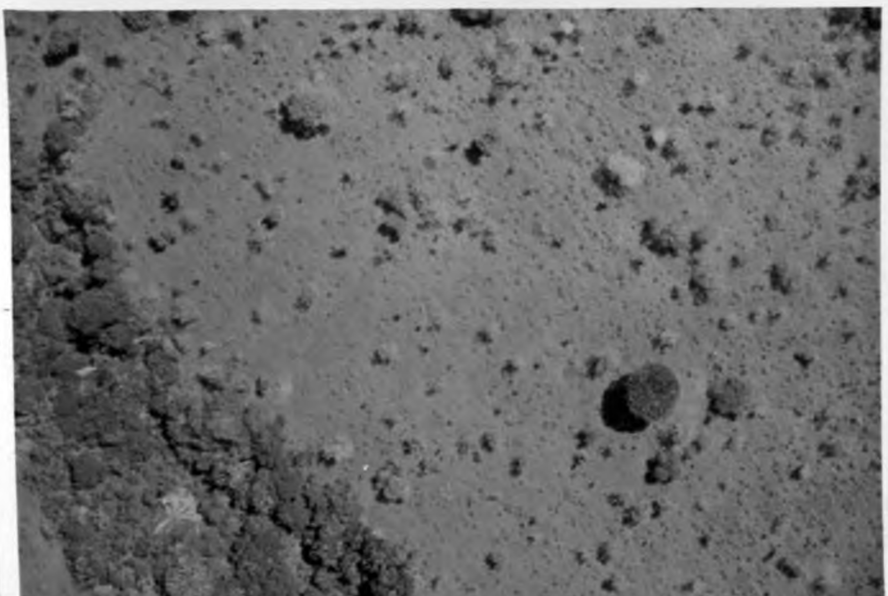


Plate 6

An aerial view of a wooded grassland with drainage line woodland on the left common shrubs include Ximenia americana, Grewia bicolor, Maerua triphylla and Ocimum suave. The undershrubs consist of Achyranthes aspera, Pupalia lappacea, Abutilon longicuspe and Pavonia patens. Grasses growing on the fringes include Panicum maximum, Cynodon dactylon and Setaria verticillata. Cyperus papyrus grows on the finges of the pools together with Typha capensis.

Acacia nilotica subsp. subalata - Commiphora schimperi Woodland

This is the next largest association in the woodland community within the Simanjiro Plains study area. It is found mainly in the northwest around Kiloriti (see figures 6). This woodland occupies much flatter sites than those occupied by the major sub-type. Drainage in this area is rather slow. This is a low woodland with the tallest canopy not exceeding 10 metres. Acacia nilotica subsp. subalata is the dominant species. It had a percentage composition of 58.85 within the sampled area and a basal area cover of 2.63 M^2/ha which was one and two thirds times that of the associated species. The species is so characteristic of the site that the Masai have named the area Kiloriti after it. This is the tree whose bark the Masai use in a soup concoction. It supposedly speeds up digestion and increases aggressive tendencies! It is especially chorised by the Moran who take it during their meat eating retreats into the bush which last up to a month.

Associated with the dominant species is Commiphora schimperi which is codominant in the major sub-type. Its basal area was 1.58 compared to 5.73 in the previous woodland. Other species found in this area were Commiphora africana and Commiphora sp.

On the whole this woodland was more open than the dominant sub-type. The total basal area density in M^2/ha was under half of that of the other. Also this association contains few tree species and the 2 dominant species make 94.26% of the total percentage composition. Where this type borders the Lannea-Ormocarpum woodland outside the study area, there is a larger variety of species. They are similar to those found where the same situation occurs with the Acacia tortilis - Commiphora schimperi woodland.

Similarly this woodland has a few tall shrubs. Rhus natalensis is the dominant one but is sparsely distributed throughout the area. Ipomoea hildebrandtii is the only medium growing shrub found and it forms quite dense stands on localized sites. The dominant grasses are the same as those dominating the grassland namely Digitaria macroblephara and Panicum coloratum. The only difference is that Themeda triandra is very widespread and sub-dominant. Sporobolus fimbriatus is also widespread. Most of the low growing shrubs and herbs are seasonal mainly appearing during the rains. They include Rhamphicarpa montana, Crossandra subcaulis, Heliotripium sp. and Arthroisma psylloides. Becium capitatum, a clumpy perennial shrub, is found in distinct groupings. Where the woodland merges with Lannea-Combretum-Ormocarpum type, Hyparrhenia fillipendula is dominant.

Commiphora schimperi - Commiphora madagascariensis Woodland

This is the last and the smallest association within the woodland. Like the preceding one, it is a low canopy woodland. It is found at Osilale in the mid-northwest and north of Sukuro dam. It occurs almost as a pure stand at Osilale where Commiphoras constitute 94.75 of the percentage tree composition. Indeed the genera is so characteristic of the area that Osilale the current Masai name for the area means Commiphora. This shows that most of the Masai names have some ecological connotation.

The dominant species in this association is Commiphora schimperi whose density and canopy cover at Osilale were 70 tree/ha and 8.62%. This is the highest density for this species within the whole woodland. The total tree density within the sub-type at Osilale was 182 trees/ha which is more dense than any other mature stand of trees within the whole woodland. Next in dominance is C. madagascariensis whose density and canopy cover are nearer to those of the former species. There is another Commiphora which is found within this area at a density of 15 trees/ha. It was provisionally identified as C. africana. Field identification of the genera is a very painful process as the leaves and flowers usually do not appear at the same time. One has literally to camp by the tree for almost the whole year before positively identifying it! Erythrina burtii is sparsely distributed within this woodland. Its density at Osilale was 3 trees/ha and its crown cover was 1.04%. Rhus natalensis is a large shrub which is also sparsely distributed in the area.

The woodland at Sukuro is somewhat different from the one at Osilale in that Acacia mellifera is associated with the Commiphoras. The land surface at Sukuro is more flat than at Osilale and hence the drainage is considerably impeded with the soil containing more clay.

The herb layer in the almost pure stand at Osilale has almost an identical composition as that found within the Acacia nilotica ssp. subalata dominated subtype. Only that at Osilale, Barleria ramulosa is an important shrub especially where the woodland merges with the grassland. The dominant perennial grass at Sukuro is Eragrostis superba followed by Digitaria macroblephara. Although Microchloa kunthii has the highest density of $17.5/M^2$ it has already been explained that the numerous slender shoots which grow at the beginning of the rains soon die out. Another difference between this sub-type and the one at Osilale is that the former had a lower density within the herb layer the value being 15.07 plants/M^2 compared to $60.3/M^2$ in the latter area. Also

Table 9

Plant composition, basal area cover and percentage frequency within the *Acacia nilotica* subsp. *subalata* - *Commiphora schimperi* association at Kiloriti, Simanjiro

Species	Percentage Composition	Basal area M^2/hectare	Percentage Frequency
Acacia nilotica	58.85	2.63	79
Commiphora schimperi	35.41	1.58	52
Commiphora africana	5.74	0.25	4
TOTAL	100.00	4.46	

Table 10

Density, percentage crown cover, composition, frequency and basal area within the Commiphora woodland at Ositale, Simanjiro

Species	Density/ha	Percentage Crown cover	Percentage Composition	Percentage Frequency	Basal area M^2/ha
Commiphora africana	22	1.38	12.29	40	0.54
Commiphora schimperi	70	8.65	38.60	70	3.05
Commiphora madagascariensis	63	4.92	35.08	50	1.65
Commiphora sp.	15	2.16	8.78	30	0.21
Erythrina burtii	3	1.04	1.75	10	0.11
Rhus natalensis	6	1.07	3.50	20	0.14
TOTAL	182	19.22	100.00		5.70

Table 11

Plant density, percentage composition and percentage frequency of the ground layer within the Acacia tortilis - Commiphora schimperi woodland at Terrat, Simanjiro

Species	Number	Density/M²	Percentage Composition	Percentage Frequency
Aristida adscensionis	23	1.36	4.80	18
Bothriochloa radicans	1	0.06	0.21	6
Brachiaria scalaris	2	0.12	0.42	12
Brachiaria sp.	1	0.06	0.21	6
Chloris pycnothrix	1	0.06	0.21	6
Cynodon dactylon	54	3.18	11.27	24
Digitaria macroblephara	37	2.18	7.72	24
Digitaria sp.	2	0.12	0.42	6
Eragrostis aspera	1	0.06	0.21	6
Eragrostis superba	54	3.18	11.27	41
Heteropogon contortus	4	0.24	0.84	6
Panicum maximum	3	0.18	0.63	12
Pennisetum mezianum	19	1.12	3.97	18
Sporobolus fimbriatus	2	0.12	0.42	12
Sporobolus pyramidalis	30	1.76	6.26	29
Themeda triandra	17	1.00	3.55	29
Tragus berteronianus	36	2.12	7.52	18
Cyperus sp.	8	0.47	1.67	6
Kyllinga alba	2	0.12	0.42	6
Aerva lanata	6	0.35	1.25	6
Aspilia mossambicensis	5	0.29	1.04	12
Blepharis sp.	2	0.12	0.42	6
Commelina benghalensis	3	0.18	0.63	12
Crabbea velutina	1	0.06	0.21	6
Crossandra sp.	1	0.06	0.21	6
Crotalaria sp.	5	0.29	1.04	6
Ecbolium revolutum	2	0.12	0.42	6
Erlangea cordifolia	3	0.18	0.63	12
Heliotropium steudneri	4	0.24	0.84	6
Hibiscus flavifolius	3	0.18	0.63	6
Indigofera arrecta	77	4.53	16.08	53
Ipomoea hildebrandtii	6	0.35	1.25	18
Ipomoea sp.	1	0.06	0.21	6
Justicia sp.	5	0.29	0.04	12
Lippia sp.	3	0.18	0.63	6
Melhania ovata	4	0.24	0.84	18
Oxygonum sinuatum	6	0.35	1.25	12
Pentanisia ouranogyne	2	0.12	0.42	6
Plumbago sp.	2	0.12	0.42	6
Solanum incanum	7	0.41	1.46	18
Thunbergia alata	35	2.06	7.31	29
TOTAL	[illegible]	[illegible]	100	

Table 12

Plant density, percentage composition and percentage frequency of the ground layer within the <u>Acacia nilotica</u> ssp. <u>subalata</u> - <u>Commiphora schimperi</u> woodland at Loiborsoit, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Digitaria macroblephara	150	10.71	27.77	70
Panicum coloratum	86	6.14	15.94	64
Sporobolus sp.	205	14.64	37.96	78
Themeda triandra	53	3.79	9.82	35
Euphorbia sp.	2	0.14	0.37	7
Justicia exigua	35	2.50	6.48	42
Ipomoea hildebrandtii	2	0.14	0.37	7
Rhamphicarpa sp.	27	0.14	0.37	7
T O T A L	540	35.85	100.00	

Table 15

Plant density percentage composition and percentage frequency in the ground stratum of the Commiphora woodland at Osilale, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Aristida adscensionis	4	0.4	1.36	10
Digitaria macroblephara	115	14.2	38.98	100
Eragrostis superba	28	2.8	9.49	10
Panicum coloratum	85	10.4	28.82	90
Pennisetum mezianum	13	1.3	4.41	50
Themeda triandra	14	1.4	4.75	50
Barleria ramulosa	10	1.0	3.38	30
Euphorbia sp.	2	1.0	0.68	20
Ipomoea hildebrandtii	1	0.1	0.34	10
Justicia exigua	13	1.3	4.41	40
Melhania ovata	2	0.2	0.68	10
Pavonia patens	1	0.1	0.34	10
Rhynchosia minima	2	0.2	0.68	20
Sida ovata	5	0.5	1.68	30
T O T A L	295	29.5	100.00	

Table 14

Plant density, percentage composition and percentage frequency of the ground layer within the Commiphora woodland at Sukuro, Simanjiro.

SPECIES	NUMBER	DENSITY/M²	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Aristida adscensionis	1	0.1	0.16	10
Bothriochloa radicans	4	0.4	0.65	20
Brachiaria scalaris	11	1.1	1.80	30
Chloris pycnothrix	54	5.4	8.83	30
Cynodon dactylon	3	0.3	0.49	20
Digitaria macroblephara	28	2.8	4.58	50
Digitaria scalarum	13	1.3	2.12	10
Digitaria velutina	8	0.8	1.31	10
Eragrostis superba	42	4.2	6.87	50
Eustachys paspaloides	22	2.2	3.60	40
Harpachne schimperi	4	0.4	0.65	
Microchloa kunthii	175	17.5	28.60	50
Panicum coloratum	10	1.0	1.63	30
Pennisetum mezianum	5	0.5	0.82	10
Sporobolus festivus	12	1.2	1.96	30
Tragus berteronianus	6	0.6	0.98	10
Cyperus sp.	12	1.2	1.96	40
Astripomoea hyoscyamoides	1	0.1	0.16	10
Athroisma psyllioides	10	1.0	1.63	30
Asystasia sp.	4	0.4	0.65	20
Blepharis integrifolia	1	0.1	0.16	10
Crabbea velutina	4	0.4	0.65	30
Commelina africana	3	0.3	0.49	10
Erlangea cordifolia	118	11.8	19.29	60
Euphorbia inaequilatera	19	1.9	3.10	50
Indigofera spinosa	2	0.2	0.33	10
Indigofera sp.	12	1.2	1.96	60
Ipomoea hildebrandtii	1	0.1	0.16	10
Ipomoea longituba	1	0.1	0.16	10
Ipomoea sinensis	3	0.3	0.49	30
Leucas glabrata	10	0.1	1.63	10
Macrotyloma maranguense	5	0.5	0.82	30
Rhamphicarpa ajugifolia	3	0.3	0.49	30
Ruellia patula	5	0.5	0.82	30
TOTAL	612	60.30	100.00	

Sukuro had more annuals the most common being Chloris pycnothrix and Tragus berteronianus. The area also contained a relatively high portion of Cyperus sp. and shrubs and herbs. The common ones were Erlangea cordifolia Athroisma psyllioides, Indigofera sp, and Leucas glabrata. Others found in the area included Crabbea velutina, Ruellia patula, Macrotyloma maranguense and Rhampicarpa ajugifolia (See table 13 & 14 for full details).

(iii) Acacia bushland

This vegetation community occupies a much smaller area than that occupied by the woodland. It covers 69 km^2 or 12.19% of the total study area. This type mainly occupies a narrow but long belt enclosing the grassland both in the northwest and southwest and also occurs in two smaller areas in the west. It occupies low lying sites where there is seasonal impeded drainage and the soil contains more clay than that in the Commiphora woodland. The bushland occurs in two major distinct sub-types. These sub-types were easily differentiated because they are usually dominated by only one species and at the most two. Therefore there is no bush species complexity.

Acacia stuhlmannii bushland

This is the main bushland sub-type covering most

Plate 7
An aerial view of the seasonally water logged bushed grassland with wildebeest running through it

Plate 8
Acacia stuhlmannii bushland with Grant's gazelle in the background

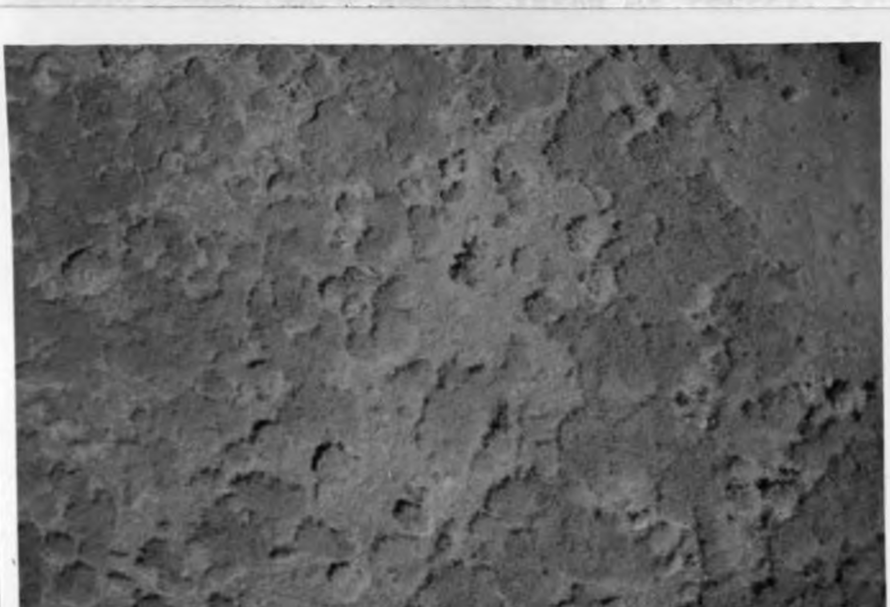


Plate 9
An aerial view of the Acacia stuhlmannii bushland

of the northwestern and southern parts of the study area. The dominant species is Acacia stuhlmannii. It is a low growing spreading bush with branches radiating from the base and terminating in an obconical crown (see plate 8). This species grows as a pure stand in most of the bushland forming dense growth whose cover is more than 60%. This bushland is uniform in height and forms a flat monotonous expanse especially when viewed from the air. It is very easy for one to get lost in such vegetation if one is not familiar with the area.

In some localities the dominant species is associated with Acacia drepanolobium. In fact there are a few sites where the latter species has a higher percentage composition. In one such place at Terrat, A.drepanolobium constituted 64.78% of the total bushes. Another species associated with A. stuhlmannii to a limited extent is A. mellifera. Growing throughout the bushland is Capparis sp. In a sample taken at Terrat, it constituted 8.26% of the bush composition. Just as in the other vegetation types, ant-hills are the favourite sites. Closely associated with this species is Balanites aegyptiaca. This is the only tree growing in the bushland and it stands out above the bush canopy (see plate 8). Also Dichrostachys cinerea grows in a few patches within the more open spaces.

Scattered throughout the bushland is a mosaic of open patches where low shrubs, herbs and grasses grow. The dominant shrubs especially in areas where Acacia

Table 15a

Percentage composition and frequency within
Acacia stuhlmannii – A. drepanolobium bush-
land at Terrat.

SPECIES	No. of Plants	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Acacia drepanolobium	149	64.78	100
Acacia stuhlmannii	49	21.31	60
Acacia mellifera	4	1.74	5
Capparis sp.	19	8.26	20
Balanites aegyptiaca	9	3.91	15
TOTAL	230	100.00	100

drepanolobium is abundant are Ecbolium revolutum and Disperma trachyphyllum. The dominant and practically the only perennial grass growing throughout the bushland is Pennisetum mezianum. Cynodon dactylon is occasionally found growing on termite mounds. All these perennial shrubs and grasses occupy less than 20% of the ground cover and the open patches are quite bare during the dry season. As soon as it rains annual shrubs, herbs and grasses sprout and by the middle of the rain season most of the open spaces within the bushland are covered with greenery. Even then Pennisetum mezianum is still the dominant grass. In a sample taken at Terrat it constituted 9.43% of the ground stratum composition. It is closely followed by Dactyloctenium aegyptium which commonly grows in the bushland at this time. Other grasses found in the area include Lintonia nutans, Cynodon dactylon, and Digitaria velutina. However broad-leaved dicots form the bulk of the plants growing in the open space mosaic during the rains. The most abundant species is Cyathula orthocantha. In a sample taken at Terrat, it constituted 35.61% of the percentage composition. Next in abundance were Hirpicium diffusum and Oxygonum sinuatum. The former has flowers which open when there is sunshine and close during the night. Observations from the air showed that they also delay opening on cloudy days (see tables 15b for details).

Table 15 b

Plant density, percentage composition and percentage frequency in the *Acacia stuhlmannii* bushland at Terrat, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Dactyloctenium aegyptium	69	3.45	8.48	50
Digitaria velutina	16	0.80	1.97	15
Lintonia nutans	7	0.35	0.86	10
Pennisetum mezianum	61	3.05	7.49	50
Cyperus bulbosus	5	0.25	0.61	20
Abutilon mauritanum	22	1.10	2.70	50
Aeschynomene indica	37	1.85	4.55	45
Amaranthus sp.	9	0.45	1.11	15
Asystasia sp.	8	0.40	0.98	15
Commelina africana	21	1.05	2.58	30
Commicarpus pedunculosus	10	0.50	1.23	15
Cyathula cylindrica	275	13.75	33.78	85
Ecbolium revolutum	6	0.30	0.74	15
Erlangea cordifolia	11	0.55	1.35	20
Erucastrum arabicum	9	0.45	1.11	30
Euphorbia inequilatera	6	0.30	0.74	10
Gnaphalium declinatum	10	0.50	1.23	30
Hirpicium diffusum	64	3.20	7.86	35
Indigofera sp.	19	0.95	2.33	30
Ipomoea sp.	27	1.35	3.32	25
Leucas sp.	2	0.10	0.25	5
Ocimum kilimandscharicum	8	0.40	0.98	10
Oxygonum sinuatum	74	3.70	9.09	70
Phyllanthus sp.	5	0.25	0.61	15
Plumbago sp.	1	0.05	0.12	5
Portulaca oleracea	29	1.45	3.56	35
Rhynchosia minima	2	0.10	0.25	5
Solanum incanum	1	0.05	0.12	5
TOTAL	814	40.70	100.00	

Table 16

Plant density, percentage composition and percentage frequency in the <u>Acacia</u> <u>stuhlmannii</u> bushland at Olmesle, Simanjiro

SPECIES	NUMBER	DENSITY/M^2	PERCENT PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Lintonia nutans	3	0.3	0.80	20
Pennisetum mezianum	80	8.0	21.39	100
Setaria incrassata	11	1.1	2.94	30
Cyperus sp.	22	2.2	5.88	50
Abutilon mauritanum	5	0.5	1.34	50
Aeschynomene indica	3	0.3	0.80	10
Amaranthus sp.	4	0.4	1.07	20
Commelina benghalensis	4	0.4	1.07	20
Commicarpus pedunculosus	3	0.3	0.8	20
Cyathula orthocantha	67	6.7	17.92	100
Digera muricata	12	1.2	3.21	20
Ecbolium revolutum	6	0.6	1.60	40
Erlangea cordifolia	10	1.0	2.67	30
Euphorbia inaequilatera	1	0.1	0.27	10
Hirpicium diffusum	20	2.0	5.35	70
Ipomoea sp.	2	0.2	0.54	10
Ipomoea sinensis	34	3.4	9.09	80
Oxygonum sinuatum	6	0.6	1.60	30
Pentas sp.	33	3.3	8.82	40
Plumbago sp.	1	0.1	0.27	10
Rhynchosia minima	15	1.5	4.01	40
Solanum incanum	2	0.2	0.54	10
Tephrosia subtriflora	14	1.4	3.74	60
Thunbergia sp.	4	0.4	1.07	20
Wedelia sp.	12	1.2	3.21	40
TOTAL	374	37.4	100.00	

Acacia mellifera bushland

This is another sub-type of the bushland dominated by *Acacia mellifera* and occupies a much smaller area. It is found west of Mboreti and southwest of Tukusi. In the area west of Mboreti it occurs almost as a pure stand occasionally interspersed with *A. stuhlmannii*, *A. drepanolobium*, *Commiphora sp.*, *Balanites aegyptiaca* and *Capparis sp.* In the area southwest of Tukusi, the dominant bush is highly associated with *Commiphora schimperi*. *Salvadora persica* is also found in the area.

The shrubs, grasses and herbs growing in this sub-type are similar to those growing in the preceding bushland.

(iv) Seasonally water-logged bushed grassland

This is the smallest vegetation type having almost the same size as the bushland. It covers 61 km^2 and constitutes 10.63% of the total study area. This type occupies the lowest lying areas which become water-logged during the rains because run-off from the surrounding higher areas accumulates here. The soil has a high clay content. The predominant vegetation feature is open grassland interspersed with Acacia bushes. This type has exactly the same species composition as bushland only that the open spaces dominate. There are two distinct associations with minor variations. The results of a sample area analysed with the list count quadrat method are given on table 17a&b.

Pennisetum mezianum - Acacia stuhlmannii seasonally water-logged bushed grassland

This is the major association within this vegetation type. It is found in the middle of the grassland in two interconnected blocks, and also in the Ngusero depression to the west (see figure 6). The dominant species is Pennisetum mezianum. In a sample taken at Ngusero, it constituted 21.39% of the total percentage composition. Other grasses growing in this sub-type are Lintonia nutans and Setaria incrassata. The former species is dominant in a narrow strip of this sub-type along the Engaraji drainage line (see table 17b). The latter species grows on the edges of the sump adjacent to the shortgrassland. During the rains similar annual species to those in the bushland appear in this sub-type. Hirpicium diffusum constitutes an even higher percentage composition especially where Lintonia is more dominant. The main bush species growing in this type is Acacia stuhlmannii. Although lightly interspersed within the area, it grows more compactly in narrow belts encircling the main body of the association. Other bush species lightly distributed within this area are A. drepanolobium and occasionally A. mellifera. The main shrubs growing

Table 17 a

Plant cover, density, percentage composition and frequency in the main seasonally water-logged bushed grassland, Simanjiro

SPECIES	% Cover	% Composition	% Frequency
Cynodon dactylon	0.10	0.46	5
Dactyloctenium aegyptium	0.01	0.04	5
Digitaria velutina	0.05	0.25	5
Pennisetum mezianum	10.68	52.58	60
Abutilon mauritianum	0.55	2.54	10
Blepharis integrifolia	0.10	0.04	5
Commicarpus pedunculosus	0.44	2.05	25
Crotalaria sp.	0.05	0.25	5
Cyathula orthocantha	0.76	0.76	20
Disperma kilimandscharicum	4.91	22.70	20
Ecbolium revolutum	2.00	9.25	15
Erlangea cordifolia	0.51	2.35	25
Euphorbia sp.	0.12	0.57	5
Hirpicium diffusum	0.74	3.44	30
Indigofera sp.	0.10	0.46	5
Monechma debile	0.06	0.27	5
Rhynchosia minima	0.15	0.69	5
Solanum sp.	0.30	1.38	5
T O T A L	22.14	100.00	

Table 17 b

Plant density, percentage composition and percentage frequency in a variant of the seasonally water-logged bushed grassland, Simanjiro.

SPECIES	NUMBER	DENSITY/M^2	PERCENTAGE COMPOSITION	PERCENTAGE FREQUENCY
Brachiaria Scalaris	5	0.50	0.81	30
Eriochloa nubica	2	0.20	0.32	10
Lintonia nutans	22	2.20	3.56	60
Setaria incrassata	49	4.90	7.93	90
Bidens schimperi	3	0.20	0.49	20
Blepharis sp.	35	3.50	5.66	50
Commelina africana	11	1.10	1.78	40
Commicarpus pedunculosus	1	0.10	0.16	10
Cythula orthocantha	16	1.60	2.59	40
Heliotropium steudneri	7	0.70	1.13	30
Hirpicium diffusum	439	43.90	71.04	100
Indigofera sp.	1	0.10	0.16	10
Oxygonum sinuatum	15	1.50	2.43	40
Rhynchosia minima	12	1.20	1.94	50
T O T A L	618	61.70	100.00	

in this area are *Disperma trachyphyllum* and *Ecbolium revolutum* with the former dominant in some localities. *Rhynchosia minima var nuda* is also found in the area together with *Pavonia patens*.

Pennisetum mezianum - Acacia drepanolobium seasonally water-logged bushed grassland

This is a minor association within the major type growing in the west in a narrow belt stretching from south of Loiborsoit to Larkaitial. The difference between this and the former sub-type is that *Acacia drepanolobium* is the dominant bush associated with *Pennisetum mezianum*. Still *A. stuhlmannii* grows in this formation but only as a narrow belt encircling the area. The rest of the plant composition is very similar to the other sub-type.

(b) Woodland tree size distribution and regeneration.

Data on tree size distribution was analysed to assess the regeneration of tree species and the results are presented on table 18. The largest tree in the main woodland sub-type was *Acacia tortilis* whose average diameter at breast height was 23.14 cm and the largest was 80 cm. One site at Terrat favoured by hunters for camping had predominantly large trees together with the woodland just adjacent to the Ngusero depression. The rest of the areas had medium sized and small trees whose diameters at breast height were between 5 and 25 cm. Most of the small trees consisted of regeneration and were more or less on the ground and their diameters were taken around the middle of the stem. There was a continuous distribution of trees throughout the different sizes. The majority were within the smaller sizes while the number decreased with increase in sizes until there were a few trees remaining in the maximum size.

It should be noted that tree sizes varied according to locality. The diameters of trees just south of the Game Division Camp were the smallest. This indicates that this is the main area where *Acacia tortilis* is regenerating. The stem diameter of the smallest sapling was 0.5 cm and the largest one had a dbh of 37 cms. The average dbh was 14.33. The incidence of fire at Terrat is very low there being low grass cover of under 15%. This enabled seedlings, saplings, and medium trees to grow. Another area with *Acacia tortilis* regeneration was on a ridge within the grassland between Olmanie and Engurale Most of the Acacias had a dbh of less than 5 cm. The measurements of heights taken at this ridge varied from 1 - 2.5 metre. An assessment of the effect of fire on these will be discussed later but it should be pointed out that there were no saplings with a height of less than 1 metre.

The localities at Terrat across the springs from the area with young regeneration had only large mature trees and it was the favourite camping ground for professional hunters and their clients while hunting in the area. Most of trees had dbh varying between 20 and 40 cm. The average dbh was 33.20 cm. Only 4% of the trees sampled had a dbh between 3 and 4 cm. The largest tree had 80 cm. Similarly the Acacia-Commiphora woodland to the east had large mature trees. In a transect run through the area, the dbh for Acacia tortilis varied from 25-54 cm and the average was 40.77 cm. On the whole, this locality had older trees than the locality camped in by hunters.

It can be concluded that the size distribution of Acacia tortilis within the Simanjiro area varies according to localities. Regeneration takes place in specific localities while other localities have mature trees and others mature and old trees. This means that the woodland as a whole is a dynamic environment.

Commiphora schimperi is a smaller tree than Acacia tortilis and the dbh values were correspondingly lower. The average dbh of Commiphora schimperi within the regenerating woodland at Terrat was 14.19 cm. The largest tree measured 56 cm while the largest class size was from 5-15 cm. Measurements from both Osilale and Sukuro gave comparable results. There was plenty of regeneration for this species. Even stumps formed new regeneration. Commiphoras are well known to form coppices and they are extensively used by different tribes for making live fences. Even the Game Division Camp at Terrat used as a base for this research was fenced by Commiphora. Commiphora madagascariensis was the smallest tree in the woodland. Its average diameter at breast height was 8.08 cm. and the maximum was 19 cm. The majority of trees were within 3 to 9 cm. class. Balanites aegyptiaca is a little bit bigger than the preceding species and its average diameter at breast height was 11.07 cm. Over half of the trees were within the 3 to 9 cm. class. Similar to the preceding species, Balanites had ample regeneration. Forty percent of the sampled Balanites were very young regeneration under 2 cm in diameter. Also of the bigger trees which had been completely cut, about 60% were sprouting. So it was concluded that this species produced ample regeneration.

Other species in the Acacia-Commiphora woodland were of lesser importance and were not observed in detail. Morover there seemed to be sufficient regeneration as shown by the diameter measurements. Species included in this category were Acacia mellifera, A. senegal, A. seyal and A. ancistroclada.

The size distribution in the ground water forest patch at Terrat was different. Acacia clavigera subsp. usambarensis was the largest tree. The average diameter at breast height was 51.86 cm. while the largest specimen measured was 113 cm. However, the major difference with the previously discussed species is in the size distribution within different classes. The majority of trees for this species were either seedlings measuring under 2 cm. or mature trees over 30 cm. There were none in the middle range between 10 and 19 cms.

Such a distribution indicates that there has been ample new regeneration taking place. Unfortunately it has been dying out. Only the current mature trees went through from regeneration to maturity without dying out. Since the gap represents a number of years it means that the die out of regeneration is almost a yearly or biennial affair and certainly of not more than 3 yearly intervals.

The distribution within the Acacia nilotica subsp. subalata-Commiphora schimperi was similar to that in the rest of the woodland community. Only that Acacia nilotica is a small tree and the average diameter at breast height in Simanjiro was 15.85 cm. and the maximum was 38 cm. Most of the trees were within 10 - 19 cm class. Those under 10 cm. constituted 25.53%. There was ample regeneration of this species similar to that shown by A. tortilis.

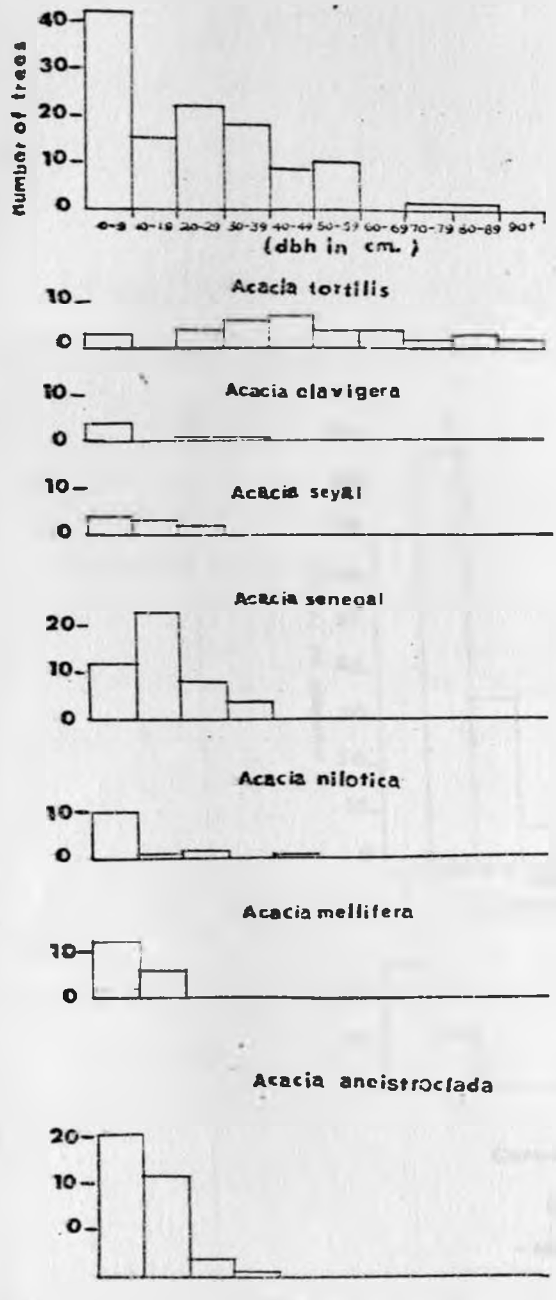
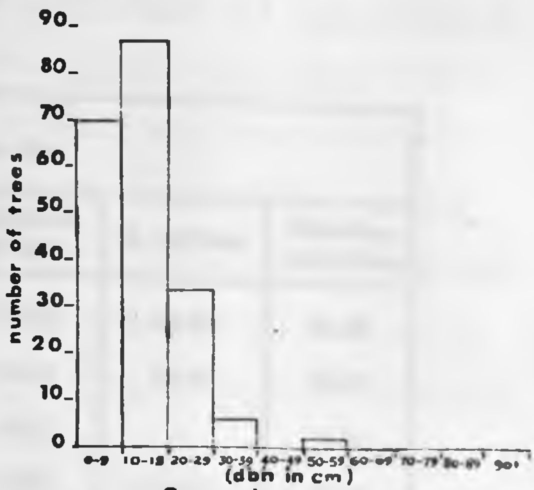


Figure 7

Tree size distribution in the woodland of Simanjiro



Commiphora schimperi

Commiphora africana

Figure 7

- continued -

Table 18

Tree size distribution of the main species in the Acacia - Commiphora woodland in Simanjiro

Class size dbh (cms)	Percent in class size					
	Acacia tortilis	A clavigera	A. nilotica	Commiphora schimperi	C. africana	Balanites aegyptiaca
0 - 9	31.14	49.20	25.53	35.35	69.23	53.44
10 - 19	12.19	-	48.93	43.43	30.77	37.93
20 - 29	17.88	6.34	17.02	17.17	-	6.89
30 - 39	14.63	9.52	8.51	3.03	[illegible]	1.72
40 - 49	7.31	11.11	-	-	-	-
50 - 59	8.13	6.34	-	1.01	-	-
60 -	3.23	-	-	-	-	-
70 -	0.81	3.17	-	-	-	-
80 -	0.81	4.76	-	-	-	-
90 +	-	3.17	-	-	-	-
Average dbh	23.14	51.86	15.85	14.19	8.08	10.69

(c) Tree mortality

The data collected on fire marks, tree cuts, ant-infestation and mortality was tabulated and the results are given on table 19a. Most of the damage to trees was caused by fire and cutting. The Masai use small trees and bushes for making bomas and species used in Simanjiro were mainly *Acacia mellifera*, *A. stuhlmannii*, *Balanites aegyptiaca* and young *Acacia tortilis*. Most of the *A. tortilis* cut were within the 5-10 d.b.h. range. Also *Balanites aegyptiaca* was cut for making handles mainly for axes. In addition to completely cut trees, a large proportion of trees had chip marks. Such marks are usually caused by Masai Moran or elders while idling during the day. Since Moran and elders do not look after cattle and there are no more wars and gallant lion hunts to occupy the Moran, they have nothing to do during the day except lie around, go to eat meat, make long journeys or stand around. So chipping of trees is a handy pass time to kill the monotony. The temptation is there as Morans usually carry very sharp simis but unfortunately there are neither human or feline enemies to use them on! Most of the trees with such marks had medium to large trunks. *Acacia tortilis* suffered more from such chipping. *Acacia nilotica* ssp. *subalata* suffered from debarking and chipping for culinary purposes. This is the famous "Kiloriti" whose bark the Masai use in a soup

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Between 3 and 5% of the mature Acacia tortilis trees with d.b.h. above 45 cm. were completely cut down at Terrat. This was for charcoal burning. It was being done by a Mbulu tribesmen to supply the traders at the trading centre. Fortunately the business did not pay and the venture was abandoned. Occasionally Masai women fired the base of mature Acacias thus eventually felling them for obtaining firewood. This was negligible as the portion of trees affected was less than 1%.

Most of the trees had small holes on trunks which were inhabited by a species of black ants. The ants could be seen at any time scurrying about on the trunks. Both Acacia tortilis and Commiphora schimperi were much affected. The large trees were more affected than small ones and nearly all holes were on old cut wounds. One large Acacia had as many as 200 ant-holes. A few such trees including both Acacia and Commiphora had dried out and were completely dead. Also some Commiphoras and Acacias had the bark of their trunk bases gnawed away by termites. However no attempt was made to quantify such effect.

Table 19 a

Tree damage and mortality on *Acacia tortilis* in Simanjiro

Diameter (cm)	Percentage with cut marks (25% or over)	Percentage with ant-holes	Percentage with fire marks (50% or above)	Percentage dead
0- 5	1	3	45	48
6-10	50	50	20	40
11-15	50	50	0	10
16-20	57	29	0	24
21-25	36	18	0	5
26-30	44	55	0	19
31-35	57	57	0	21
36-40	43	56	0	24
41-45	50	50	0	5
46-50	33	100	12	35
51-55	34	66	0	26
56-60	33	73	0	5
Average	41%	51%	5%	22%

Fire mostly affected the regenerating trees between 1 - 10 cm. in diameter. However those trees in areas such as near the camp at Terrat where ground cover was low, did not suffer. Areas mostly affected by fire were within the mature stands of the Acacia-Commiphora woodland where there were sufficient medium to tall grass and shrub growth to act as fuel when dry. Both the Ngusero and hunters camp area suffered from fire annually during the study period. This was the main cause for lack of sufficient Acacia regeneration within these areas. In order to deduce the effect of fire on the different age classes of Acacia tortilis saplings, heights of regenerating Acacias with fire marks on a ridge between Olmanie and Engurale were recorded and presented on table 19b below:-

Table 19b

Effect of fire on the different height stages of Acacia tortilis regeneration

Average Height (Metres)	Average Percentage of burns on tree
1.0	95%
1.5	83%
2.0	40%
2.5	24%

These results show that saplings under 2 metres in height were the most affected thus again confirming that fire susceptibility was linked to age. Since there were no regeneration under 1 metre, it indicates that fire was severe after the present saplings had grown to a less susceptible stage. On the other hand there were Commiphora saplings under 2 metres which survived the fire.

Chapter IV

SOILS, RAINFALL AND SURFACE WATER DISTRIBUTION

1. Methods

(a) Soils analysis

(i) Soil sampling

Soil samples were collected from different vegetation types within the study area using a soil auger. Only the top soil down to a depth of 20 cms. was collected. No profile pits were dug for detailed sampling of different horizons as only a general classification was needed for the purposes of this study. Each sample collected was put in a carton supplied by the National Agricultural Laboratories, Nairobi and sent to them for chemical and mechanical analysis. Each sample was given a field designation in the form of a number and the place from where it was collected.

(ii) Chemical analysis

The mass analysis methods for soil fertility evaluation developed by Mehlich et al (1962) at the National Agricultural Laboratories, formerly known as

Scott Agricultural Laboratories were used. In this method a single extraction is carried out in which P, Mg, Mn, Ca, K and Na are analytically measured. An acid extract using a mixture of hydrochloric acid and sulphuric acid is used. The first three elements are analysed colorimetrically while the last ones are analysed flame photometrically. The nitrate content is also analysed colorimetrically. Soil pH and organic carbon are also measured together with exchange acidity arising from the depletion of bases from negatively charged permanent cation exchange capacity sites designated as Hp. See Mehlich et al (1962) for full details.

(iii) Mechanical analysis

This was also done at the National Agricultural Laboratories. The procedure involves the separation of the soil sample into its constituents namely sand, silt and clay. Sand is removed by sieving while the silt and clay percentages are then determined by methods depending upon the rate of settling of these separates from suspension.

(b) Rainfall records

A raingauge similar to those used in the field in Serengeti was made according to specifications given

2. Results

(a) Soils

The results of the chemical analysis are expressed in terms of miiliequivalents[1] per 100 grammes of soil or me %. That is they are expressed in terms of exchangeable cations making up the cation exchange capacity of the soil. The physical components are expressed as percentage of particle size distribution. The general colour of the soils is also given in the classification. The results are presented on table 20.

(i) Red brown soil

The largest portion of the Simanjiro Plains contain this soil type. It occurs on sloping ground where there is free drainage within the grassland and in the Acacia tortilis - Commiphora schimperi woodland. This soil is rather acidic having a pH range of 5.4-6. It has the basic nutrients in sufficient quantities except nitrogen which is defficient. The top of the soil especially where exposed forms a hard crust and a lot of water is lost as run off during the rains. Physically, the red brown soil of Simanjiro contains a high proportion of sand and clay. The higher the site the more sand there is in the soil. It is therefore classified as sandy clay loam or sandy clay depending on the physical constituents.

by Norton-Griffiths (pers. comm.) of the Serengeti Research Institute. Essentially, the raingauge consists of an aluminium cylinder 5 inches (12.7 cm) in diameter and 36 inches (91.44 cm) high and open at one end. It is dug into the ground so that only 8 inches (20.30 cm) protrude above the surface. An Abney level is used so that the mouth of the raingauge sits in a horizontal position. A layer of motor oil was poured in the raingauge to prevent evaporation of rainfall water. Records were taken once every month. The water was never emptied but accumulated in the gauge and measurements made by a dipstick (see figure 8).

(c) <u>Location of surface water</u>

All dams, bore holes, and springs shown on the Tanzania Survey Division Map Series Y742 Scale 1:50,000 were located from the air, and then detailed observations of their location and condition were made on the ground.

In order to locate seasonal water pools formed during the rains, observations were made from the air during aerial censuses. The pools were marked on a map and then detailed inspection made on the ground. They were easy to locate from the ground because of the tell tale animal trails converging on them.

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(ii) Grey soil

The gentler slopes contain soils which are grey in colour. These occur within the *Acacia nilotica* ssp. *subalata* - *Commiphora schimperi* woodlands. Strips of these soils are also found in the shallow valleys within the grassland. These soils are neutral to alkaline with a pH range of 5.5 - 7.0. Where the land is flat, there are dark grey soils with a pH of above 7 thus becoming more alkaline. This is where the Commiphora woodland occurs. These grey soils normally contain a high proportion of clay and sand and are therefore classified as sandy clay.

(iii) Black soil

This soil is found in the low lying areas where drainage is impeded. It is the typical soil of the seasonally water-logged bushed grassland and bushland. It is alkaline in nature and all samples which were analysed had a pH of above 7. This soil also contains the highest level of calcium, magnesium and sodium of all the three Simanjiro soils but the lowest nitrogen. During the rains the water accumulates and these minerals are brought in and they accumulate because of lack of drainage. When it dries up, the soil forms extensive cracks. It has an even higher clay content than the previous soil and is therefore classified as black clay.

Table 20

The average composition of the different soil types in Simanjiro

%	Red Soil	Grey Soil	Black Soil
pH	6.1	7.1	7.7
Na m.e. %	0.12	0.32	1.0
K m.e. %	0.98	1.88	0.52
Ca m.e. %	3.2	27.0	30.0
Mg m.e. %	2.9	5.6	4.0
Mn m.e. %	0.66	Trace	0.02
P p.p.m.	36	195	120
N %	0.11	0.95	0.13
C %	0.11	4.15	1.09
% sand	45	32	33
% Silt	12	24	12
% Clay	43	44	55

(b) Rainfall

Rainfall records were taken from July, 1970 to the end of 1972 and the results are given on table 21. Records could not be taken during the first half of 1970 because that time was used for attending classes and field trips organised by the Zoology Department.

The records showed a distinct rainfall pattern with light rains falling between September and December then receding in January and then having the heaviest rains between February and May. The short rains in 1970 started in September and the amount for that month was the highest for all the years which followed. However, the rainfall for November and December during that year was much less than that recorded during the following two years. The long rains in 1971 had their peak in April when 299 mm were recorded. The rains for that year ceased in May although very light drizzles fell in June. There was a dry spell until September when light drizzles fell. The actual short rains fell in November and December. The rains then receded in January, 1972 and increased in February whose rainfall was only surpassed by that which fell in April. Only 23 mm fell in May and that was the end of the long rains. On the whole the long rains were less than those of the previous year. The short rains in 1972 started with light showers in August and

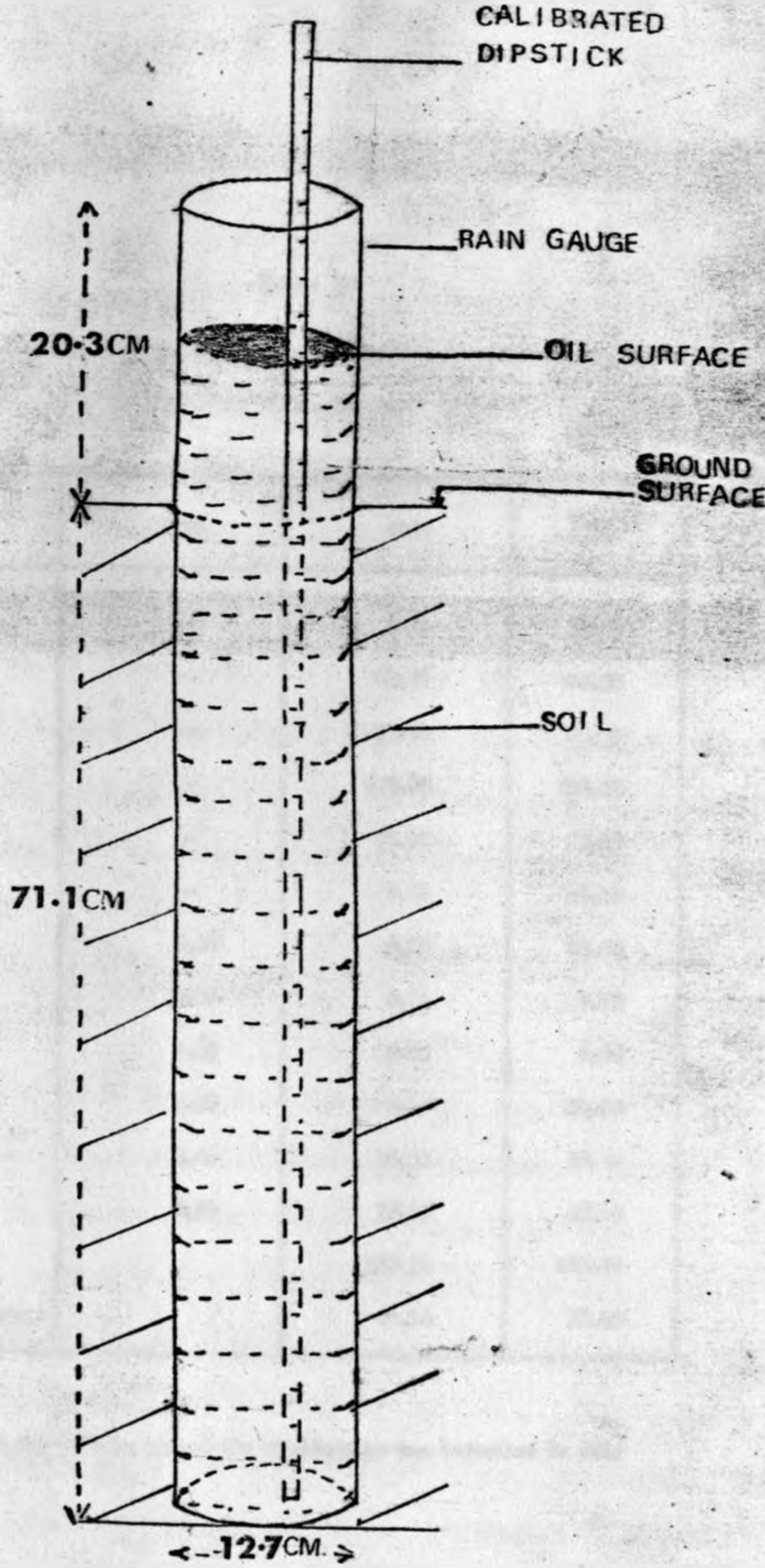


Figure 8

The raingauge used in Simanjiro

Table 27

Rainfall recorded at Surrah, Simanjiro in millimetres

from July 1970 - December 1972

Month	1970	1971	1972
January	-	2.54	25.10
February	-	43.18	110.30
March	-	27.94	64.55
April	-	279.40	146.05
May	-	76.20	25.00
June	-	0.10	00.00
July	0.00	0.00	00.00
August	0.00	0.00	3.00
September	7.62	0.50	8.00
October	3.56	2.50	60.00
November	5.08	30.50	31.10
December	6.35	73.50	37.80
Total		538.36	443.90
Monthly Average		44.86	56.99

Data for 1970 is incomplete as raingauge was installed in July

September with a dry spell in October and the actual rains falling in November and December. The total amount of the short rains and indeed for the whole year was less than that for 1971.

(c) Distribution of permanent water

The aerial reconnaissance and ground surveys showed that the Simanjiro study area has 2 dams, 2 boreholes and 2 natural springs mainly distributed at the peripheries of the study area (see figure 1b and 16). Additional data was obtained from Kametz (1963).

(i) Eluenyenanyuki dam

This dam is situated in the south of the study area southeast of the Mboreti trading centre. It is called Eluenyenanyuki by the Masai because of its reddish brown water caused by the red brown soil which is washed into it from the surrounding grassland and woodland areas comprising of 41 km^2. This dam was constructed in 1954 and its original capacity was 100 million gallons (455 million litres). The length of the crest was 660 metres. The capacity has since decreased due to accumulation of silt.

(ii) Sukuro dam

This dam is also situated in the south of the study area 7.5 km east of Eluenyenanyuki. It was constructed in the same year as the previous one and had a larger capacity of 139 million gallons (628 million litres). However this dam filled up much faster with silt. This is because the major drainage line, Kinopini, draining into the dam collects water from the bushland and seasonally water-logged areas with high silt and clay content soils. It completely dried up in the dry season of 1972.

(iii) Mboreti borehole

This borehole is situated at Mboreti trading centre and it was constructed in the same year as the dams. It is powered by a diesel motor and there is a permanent attendant who intermittently runs it until its storage tank which has a capacity of 10,000 gallons (45,500 litres) is filled and then switches it off. The borehole has a yield of 3800 litres per hour. There is a side trough for livestock and a 500 metre pipeline to the school.

(iv) Lekitejo borehole

This borehole is situated in the west of the study area at Lekitejo. It was constructed in the same year as the other water installations. It has an output of about the same magnitude as Mboreti borehole and a similar sized tank. It has also a side trough for livestock.

(v) Terrat springs

These are a series of springs just a short distance north of the shops at Terrat. The water accumulates in two large pools.

(vi) Loiborsoit springs

These springs are located in a deep ravine-like drainage line just to the northeast of the settlement. They form a small water pool.

(d) Distribution of rain season water pools

There is a total of 22 water pools which form during the rains and their distribution is shown on figure 6. These water pools are formed in depressions mainly within the grassland and the Commiphora and the Acacia nilotica-Commiphora schimperi woodlands. These depressions contain bottoms with high clay soils which make them more or less impervious to water and all water draining into them accumulates as the rains progress. They contain the maximum amount of water between March and May. They start drying up in June and by August most of them are dry.

The water pools are equally distributed throughout the Simanjiro Plains. Taking the Lolkisale-Naberera road as dividing the plains into two equal halves the pools are distributed equally in both halves. However the northern half has pools which persist longer. There are 2 deep water holes in a branch of the Terrat drainage line to the Southwest of Lalulunga which are usually the last ones to dry up.

Chapter V

LARGE HERBIVORE POPULATIONS, DISTRIBUTION AND MOVEMENTS

1. Methods

(a) Selection of Census Method

The most often used methods in censusing large herbivores are ground counting and aerial counting. In the first method, equally spaced observers traverse the area being censused recording animals seen. In the classic King's Census method, the sighting distance is given. This method was originally developed in the United States for censusing grouse (Leopold, 1933). It has been variously modified to include the sighting angle (Mosby et al, 1963). Also road-side counts are used mainly to observe population variations at different times. Road strip counts have been used to estimate the numbers of African ungulates (Dasmann and Mossmann, 1962).

The real pioneer of ground counting in East Africa is Lamprey (1963). He used transect counting in Tarangire for estimating the densities of large herbivores. A visibility profile for each transect was established prior to counting and this varied according to the vegetation type. Lately, the College of African Wildlife Management at Mweka has been using King's method for field exercises (Sindiyo, 1970). A modified version of this method has been used in the Selous Game

Reserve for estimating the population of large berbivores within a Miombo woodland habitat (Rodgers, 1969). More recently ground transect counting within a given strip width has been done from a vehicle in Amboseli to compare with population estimates of the large herbivores obtained from aerial counting (Pennyquick and Western, 1972).

The other method used in censusing large herbivores is by means of aeroplanes. This method like King's census method was first developed in the United States in counting big game (Mosby et al, 1963). The first attempt at counting animals from the air in East Africa was by Zaphiro (1959). However the pioneers of censusing large herbivores by aeroplanes were Grzimek and Grzimek (1960) in the Serengeti. Later on aerial censusing was done in the Serengeti-Mara area (Stewart and Talbot, 1962). Also Lamprey (1964) did aerial counting within the transect area for comparison purposes. He also did a strip through southern Masailand for estimating wet season dispersal density. Later on more aerial censuses were done in Ngorongoro Serengeti (Turner and Watson, 1964; Watson, 1966). Also the populations of rhinos in Ngorongoro was estimated by aeroplane (Goddard, 1967). An aerial census of the Nairobi National Park was done at about the same time (Foster and Kearney, 1967).

Later on, Jolly (1969) introduced a modified method of aerial sampling which included detailed statistical approach. It has since become the classical method of aerial sample censusing throughout East Africa. All large herbivores in Loliondo Game Controlled Area and Mkomazi Game Reserve were censused by the same method (Watson et al, 1969). Sinclair (1969) used it with aerial photography in estimating the buffalo population of Serengeti. It was lately used in Mara for estimating the rhino population (Mukinya, 1973) and in Amboseli for large herbivores (Western, 1973). The details of these methods together with the statistical and mathematical biases and the treatment of errors have been amply discussed (Jolly, 1969; Pennycuick, 1969; Watson, 1969). The most recent and classical treatment of the subject has been presented by Pennycuick and Western (1973). The validity of aerial censusing is so well established that the Serengeti Research Institute has adopted it as the standard method in the ecological monitoring programme (Norton-Griffiths, 1973).

Aerial censusing needs fewer observers than ground counting. It also covers a wider area in a shorter time thus limiting double counting. In relatively open country such as is the case in East Africa's Acacia-Themeda and grassland savannah, it is the only method which permits accurate coverage and photography of herds. It has successfully been applied to even censusing livestock (Watson, 1969). Difficult terrain is also no hinderance to aerial counting. In view of these advantages, this method was adopted for this study.

(b) Aerial censuses

(i) Map preparation

In order to determine the distribution of large herbivores and the subsequent calculation of their population numbers, aerial censuses were carried out. Before carrying out the actual censusing, extensive ground observations were made in order to be familiar with the various land marks of the study area. This would assist in determining the location of animals on a map during flights. The map used was obtained by taking a photograph of a map of the study area obtained by tracing four joined sheets of the Tanzania Survey Division 1:50,000 topographic maps which made up the study area. A print 22 x 29 cm was made and photostat copies made for use as required. The scale of these maps was 1:160,000 (see figure10a).

(ii) Sampling procedure

Since it was not feasible to do a complete census of the study area, sample counting was carried out. The method used in sampling and estimating the populations is that of random, equal sized, strip counting first proposed by Jolly (1969). The study area being 30 kilometres from east to west was conveniently divided into 100 strips each 300 metres wide running from north to south. The divisions were marked on the map by 100 equally spaced dots along the northern and southern boundaries. Before each aerial count was done, 24 strips were chosen out of the 100 from a table of random numbers (Fisher and Yates, 1953). These strips represented 24% of the total study area.

The strips were then drawn on 2 maps in 2 series the first containing 12 strips and marked with blue ink and the remaining half drawn in red. One map was for the pilot and the other one for the observer. Each was attached to a clip board to facilitate easy handling during flight.

(iii) <u>Height determination</u>

The plane used in counting was a Piper PA-12 Cruiser but the first two flights were done in a Super Cub. It was flown at a height of 91 metres above the ground at a speed of 160 kph. In any aerial censusing involving specific strip width, it is important that a constant height above the ground is maintained. This is made easy if the terrain is flat. Pennyquick and Western (1972) describe a method used for Amboseli which has flat terrain. In this method, the altimeter is first checked by flying very low to the ground where the altitude is known and then rising steeply to the required height which is checked on the altimeter by taking the barometric pressure difference. However this method is not suitable for a place like Simanjiro with undulating topography. Therefore a method involving the regulation of height by observing the apparent size of the aircraft's shadow as given by Pennycuick (1973) was used. This method depends on the fact that if an aircraft is flown with its wings level over horizontal ground, and low enough as is the case during aerial censusing, the wingspan of the shadow is equal to that of the aircraft, irrespective of the sun's altitude and the flying height. However the angle which the shadow subtends at the pilot's eye decreases with increasing height. It is through observation of this angle that this method is based. The aircraft is propped on the ground so that it assumes the flying altitude. Then with the pilot sitting in his normal position, the height of his eye above the ground is measured and designated (h). Next the aircraft's wing span (B) is measured and the flying height (H) in this case 91 metres determined. All measurements should be in the same units. The span (b) of the shadow as projected on the ground is calculated from the formula:-

$$b = \frac{Bh}{H}$$

Then the strut is marked with alternating black and white paint marks such that the marks align with the shadow of the aircraft when it is flying at the corresponding altitudes. During the census, the pilot flies upwards or downwards until the wingspan of the shadow appears to be equal to the black or white marks most opposite to it which corresponds to the required height H above the ground.

(iv) Calibration of strip width

Before setting out, the streamers were checked to see if they were in position. The position of the streamers on the struts had earlier been determined and marked at the Serengeti Research Institute using the method described by Pennycuick and Western (1972). The procedure involves the use of geometric calculations involving similar triangles. The calibrations are done when the plane is on the ground with an observer sitting in position and the tail wheel propped up so that the plane is horizontal. Then the height of the observer's eyelevel is measured from the ground. The mark for the inner streamer is put on the strut at a point where there is an alignment between the observer's eyelevel and a point on the ground such that the line of alignment just misses the front wheel on the observer's side. Then the strip width is chosen and the proportionate mark put on the ground so that the ratio of the height of the observer's eyelevel above the

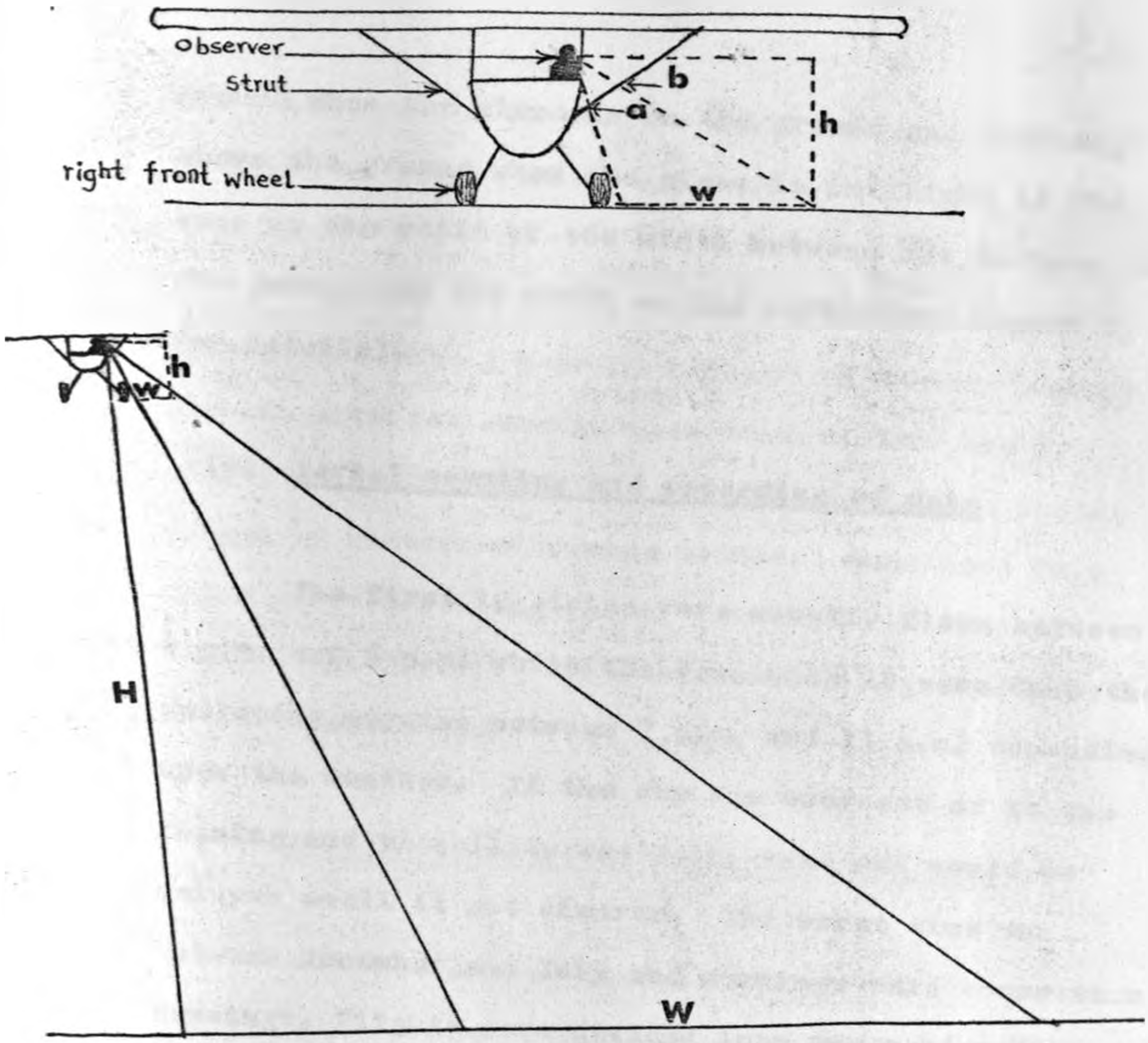


Figure 9

The procedure of marking aeroplane struts for attachment of streamers to show ground strip width.

1. While aircraft is on ground (A) prop it in flying position
2. Put in observer and measure his height above the ground (h)
3. Mark inner streamer (a) on strut so that it just misses the wheel
4. Decide strip width (W) and flying height (H) for flying aircraft (B)
5. Mark out on ground strip width (w) where $w = W\frac{h}{H}$
6. Mark outer streamer (b) on strut

P.S. All measurements must be in the same units.

ground when the plane is on the ground and the height above the ground when the plane is in flight is the same as the ratio of the width between the markers on the ground and the width of the strip (see figure 9 for details).

(v) Aerial counting and recording of data

The first 12 strips were usually flown between 4 p.m. and 6 p.m. while the remaining 12 were done the following morning between 7 a.m. and 11 a.m. depending upon the weather. If the sky was overcast or it was raining and visibility was poor, take off would be delayed until it got clearer. The worst time was between December and July and mornings were worse than evenings. Flights were divided into two series in order to afford some rest to the observer as a maximum of 2 hours was considered about the limit for accurate observations before fatigue set in.

During flight, all animals falling within the streamers' projection on the ground, were marked on the observer's map according to species, number, vegetation type and actual position. Since cattle heards were large and difficult to count, they were also photographed using a Voigtlander Bessamatic camera with a Zoomar 36, 82-200 mm Zoom lens at an aperture of f/2.8 and a speed of 1/500 sec using Kodacolor-X film.

The window on the observer's side was opened during counting to permit wider visibility.

In all, 24 aerial counts were done. Counting time ranged from 1 hour 35 minutes to 2 hours and 19 minutes with the average time being 1 hour and 52 minutes. Wind exerted the greatest influence on the length of time spent during counts. Sometimes rain which started falling during counting resulted in reduced visibility. Fortunately this happened only on a few occasions.

(vi) Aerial census of Tarangire National Park

A sample aerial census was made of the northern part of the Tarangire National Park which constituted the former game reserve where Lamprey (1963, 1964) did his study. This is the area with permanent water during the dry season thus constituting the dry season concentration habitat for migratory herbivores. The census was carried out in order to compare the populations of zebra and wildebeest with those of Simanjiro. The sampling method used was that of stratified strip sampling using unequal-size units usually referred to as Method 2 of Jolly (1969). The park was divided in 4 blocks A,B,C,D with 22 strips 400 metres wide running from east to west. Blocks A & B had 17 strips each spaced 1 km apart while blocks C & D had each 5 strips spaced

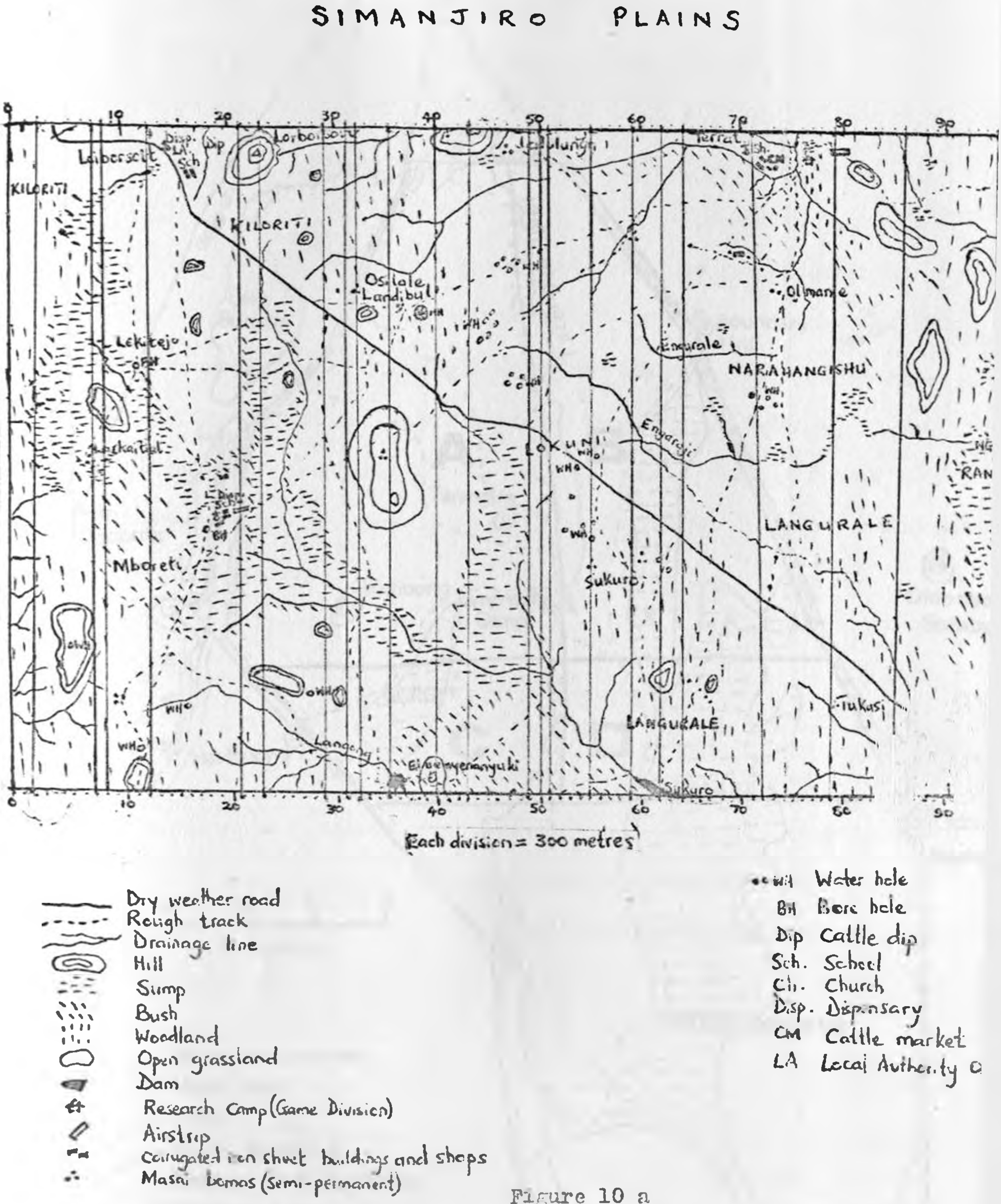


Figure 10 a

A sample map used during aerial counting with 24 strips randomly dra

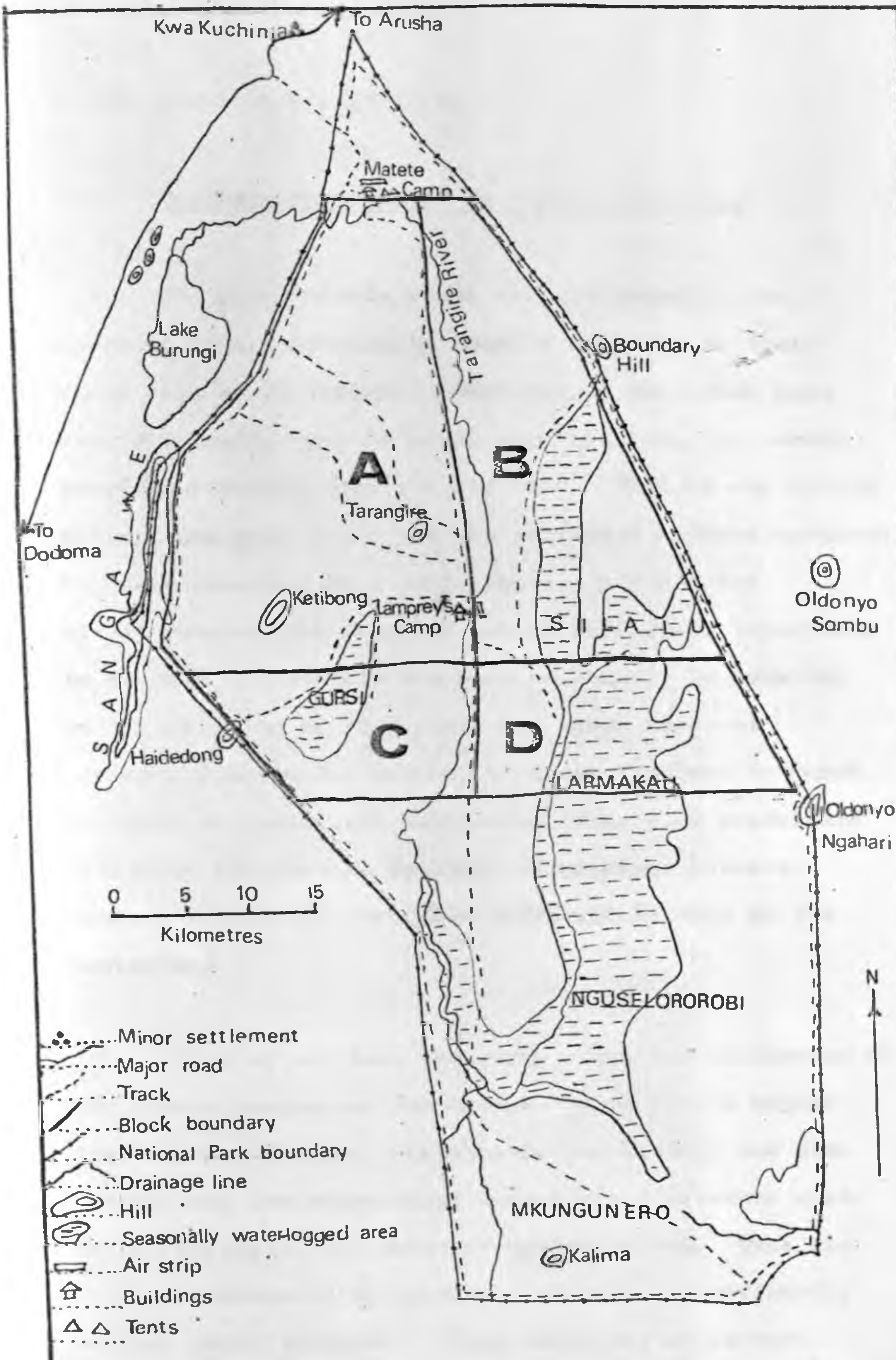


Figure 10 b

Tarangire National Park showing aerial counting blocks

Plate 10
Dr C.J. Pennycuick (without beard) before take - off

Plate 11
J. Kahurananga before take - off

Plate 12

Taking off on an aerial census

1.5 km apart (see figure 10).

(vii) <u>Problems encountered in aerial censusing:</u>

The game animals which were included in the censuses were conveniently counted directly as their herds were small enough. Livestock on the other hand were difficult. Cattle herds were too large to permit accurate counting during a fly over. That is why aerial photographs were taken and the estimated numbers compared to those obtained from photographs. After a few direct counts, the observer gained sufficient experience to be able to estimate the herd reasonably by counting it in multiples of 10. Goats and sheep were not accurately estimated because of their tendency to bunch together on seeing the aeroplane. They were especially difficult to count in bushland or woodland habitat. Thomson's gazelles were also difficult to spot at the beginning.

Also at one time the strip width was calibrated at 400 metres instead of 300 metres. This gave a higher population estimate. Fortunately the mistake was discovered and the appropriate numerical adjustments made. On one occasion, one transect was overflown. This was however discovered in good time because of familiarity of the ground landmarks. This shows why it is very important to be familiar with the different landmarks of any area where an aerial census is to be conducted.

Plate 10
Dr C.J. Pennycuick (without beard) before take - off

Plate 11
J. Kahurananga before take - off

Plate 12

Taking off on an aerial census

Overcast skies and rains caused delays in counting but they were not frequent.

(viii) Observations on game migration

In order to pinpoint the migration route between Simanjiro and Tarangire National Park, four flights were carried out between the western end of the study area and the Tarangire river in the park in 1972. There were four flight paths equally spaced between the two areas (see figures 19-22). Time at the beginning of the flight was noted and animals on the observer's side were counted and the time recorded. Oldonyo Sambu hill marked the southernmost point and Rukuman and Boundary Hill the northernmost point. This demarcation was used after ground observations showed migration trails to be concentrated within this area.

The four flights were carried out in such a way that the whole migration sequence was monitored. One flight was carried out during the middle of the rains when all migratory species were expected to be in Simanjiro Plains. Another one was carried out in the middle of the dry season when the animals were supposed to be in the park. The last two were done at the beginning of the rains when the animals were supposed to be migrating from Tarangire to Simanjiro.

In addition to the four flights, reconnaissance was made in areas between Simanjiro and Loiborserit in the south during the rains. Also reconnaissance was made in areas north of the plains during the dry season.

(c) Field observations

(i) Observations of species present and game migration

Besides detailed research on herbivore populations and distribution it was decided to list all herbivorous species utilizing the Simanjiro Plains either permanently or on a migratory basis. At first, species were observed during the vegetation reconnaissance and recorded. Later on, additional records were made during the aerial censuses. During ground observations, a pair of 7 x 42 Habitch binoculars was extensively used. Night drives were made through the study area in order to observe nocturnal species. The field guide by Dorst and Dandelot (1970) was used in identifying large species. An attempt to trap small species was abandoned after continued damage of traps by Masai herding boys.

Extensive ground observations by vehicle were made in the Ardai Plains and Sanya Plains during the rains to observe migratory species. Similar excursions were made to the Komolo Springs, Loiborserit springs and other areas in southern Masailand during the dry season. Also general observations were done in Masailand east of the rift. (see figure 23).

(ii) Observation of group structure

Extensive coverage of the study area was made in a Land rover vehicle and using the 7 x 42 Habitch binoculars to locate animals. Once located, a group of animals would be observed patiently until it was classified into number of adult males, adult females, subadults and young animals.

(iii) Feeding observations

In order to determine what plant species the Simanjiro herbivores were feeding on and to what extent, ground observations were carried out. A Land rover vehicle was used in locating a group of feeding animals belonging to one species only. It would be difficult to make accurate determination of what ungulates fed on which species if observations were made on a group of different herbivores. After locating the feeding animals they were observed for about 10 minutes with the binoculars and the nearest recognizable objects to the feeding spot noted. This could be an ant-hill, clump of vegetation or a bare patch. Then the vehicle would quickly be driven to the spot and a thorough search for freshly grazed plants made. The clipped plants would then be recorded according to species and height clipped. Each bite was recorded separately, and it was a very cumbersome task indeed. Any clipping at the same height and place is what constituted a bite. The observations were confined to zebra, wildebeest, Grant's gazelle, Thomson's gazelle and cattle. This therefore covered both migratory and resident species.

(iv) Mortality

It was difficult to make direct observations of mortality. The most common way of determining mortality was by indirect observations of skulls, horns, or other skeletal parts and actual carcases. Skulls and particularly lower jaws were the most commonly found because of their durability. Other bones found included scapula, humerus, femur, and the pelvic girdle. The jaws of wildebeest and zebra were the mostly commonly seen as they are large and the hyenas find them cumbersome to crunch. The bones of smaller animals on the other hand were not commonly seen and when seen they were invariably in small fragments. Ostrich bones were the least commonly found. Feathers were sometimes easier to notice.

Occasionally, carcasses were found and on a number of times actual kills by predators were witnessed. Carcasses were always indicated by that great spotter of the East African plains abhorred by the poachers but highly exalted by conservationists, the vulture. The most common ones in Simanjiro were the White backed vulture *Pseudogyps africanus*, White-headed vulture *Trigonoceps occipitalis* and the Hooded vulture *Necrosyrtes monachus*. Others seen were the Lappet faced vulture *Torgos tracheliotus*, the Ruppells Griffon *Gyps ruppelli* and the Egyptian vulture *Neophron percnopterus* the last two of which were rather scarce. Some carcasses were spotted during aerial censuses (see plate 26). Figures for hunting and poaching mortality were obtained from the Game Division, Arusha.

2. Results

(a) Large herbivore population estimates and fluctuations

The populations of the 11 most common species were estimated from the aerial counts. These were zebra, wildebeest, eland, Grant's gazelle, Thomson's gazelle, giraffe, impala, ostrich, cattle, goats and sheep. The appearance of elephant, rhino, oryx, buffalo and hartebeest in the study area was so irregular that they were excluded from censusing. Lesser kudus were omitted because of their very low numbers and their dense bush habitat where observation from the air is obstructed. Lions were seen on a few counts mostly on kills and the rest of the time they were hiding. It was thus considered that they were not sufficiently seen to represent a suitable sample. Jackals and hyenas were left out because of being mostly nocturnal. Leopard and cheetah were not estimated because of their low numbers and secretive behaviour.

The first count was done in April, 1970 during the middle of the rains. Then there was a long interruption because of attending university lectures and field courses. The second flight was in November, 1970. From January, 1971 counts were made on a monthly basis until July, 1971 when the pilot went on leave until October, 1971 when the flights were resumed on a monthly basis to the end of 1972 when the study ended.

The procedure used in estimating the populations is Method I of Jolly (1969) involving equal sized units. The population estimate $\hat{Y}$ of each species and the variance Sy^2 were calculated as follows:-

$$\hat{Y} = \frac{N}{n}\sum y$$

$$Sy^2 = \frac{N(N-n)}{n(n-1)}\left[\sum y^2 - \frac{(\ y)^2}{n}\right]$$

Where y is the number of animals counted in each transect

n is the number of transects contained in one sample

N is the total number of transects required to fill the whole study area.

The standard error $S\hat{y}$ is obtained by taking the square root of the variance. The confidence interval is obtained by multiplying the standard error with the appropriate figure at the 95% level which is obtained from any statistics table of normal distribution.

Population estimates or the total number of a given species in the study area were calculated using a Facit manual calculator and later recalculated on the Olivetti 101 Programma. The program used was written out and is given on Appendix 3. In all, 24 counts were done and the population and total number estimates are given on tables 22a-c. The average seasonal populations are also given and the fluctuations are shown on figures 11 and 12.

(i) Zebra

The population estimates show that zebras have the largest population of all wild herbivores. The first census carried out in April, 1970 gave an estimated zebra population of 5306 which constituted 50.40% of all the wild animals counted. This was the maximum expected zebra population because they all concentrate in the plains during the middle of the rainy season. All migratory movements cease by then. When the next census was carried out in October, 1970 there were only 5 zebra in the sample. Further observations on the ground showed that these were the only zebras in the whole area. So no attempt was made to calculate the population estimate. The population started building up again in January, 1971 and reached a peak in April, 1971 when it was estimated that there were 6298 zebras. The average from February to May, 1971 was 5678. The same pattern was repeated in 1972. The maximum zebra population was reached in March, a month earlier than in the previous years. This time it was 10,576 which was much higher than that for the preceding years. However the average population size during the entire wet season that is from February to May was 5756 which is very similar to the previous years' average.

(ii) Wildebeest

Wildebeest were next to zebra in population size.

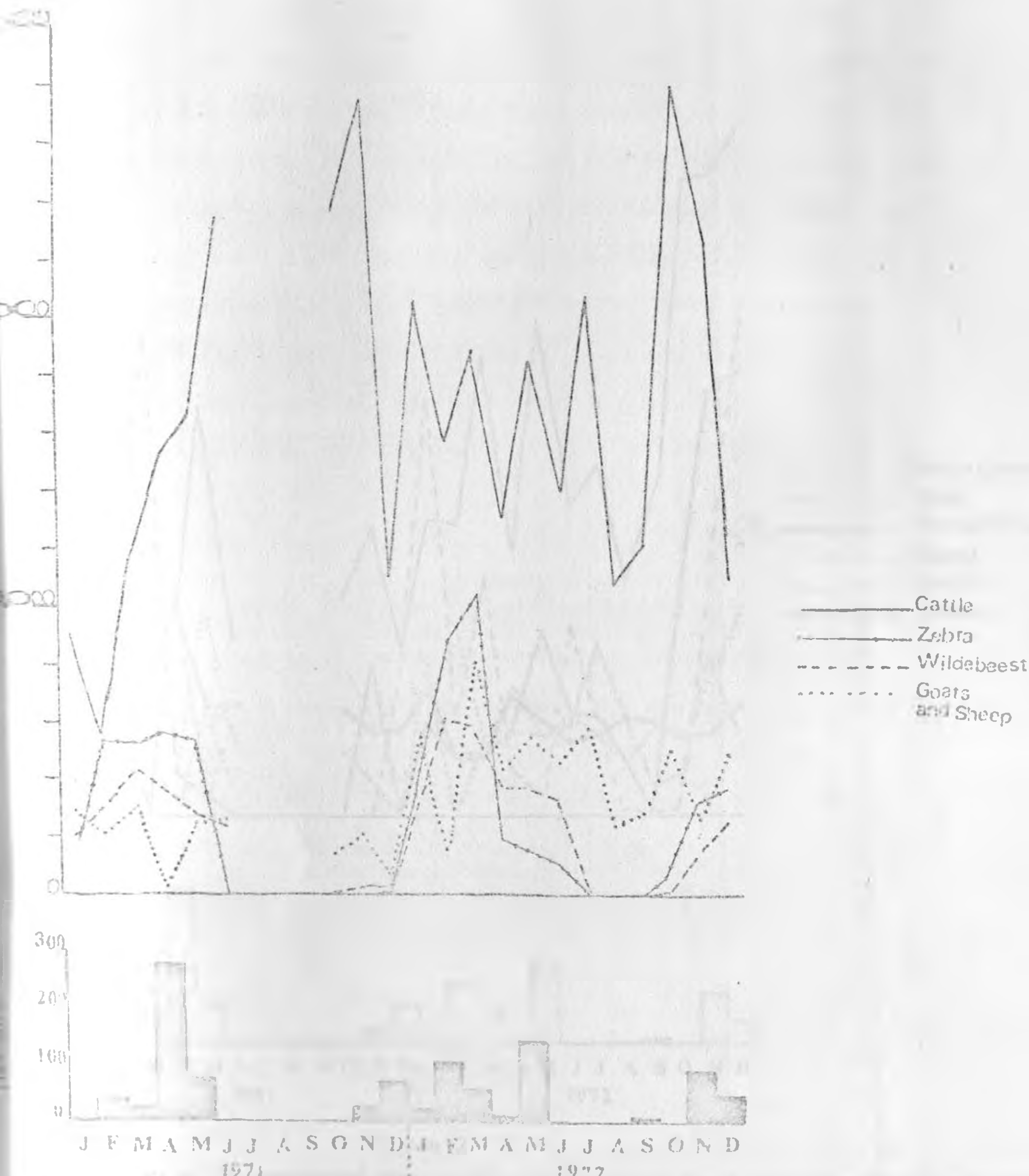


Figure 11

Population fluctuations of the dominant herbivores in the Simanjiro Plains and monthly rainfall from 1971-1972. No censuses were done between July and September 1971.

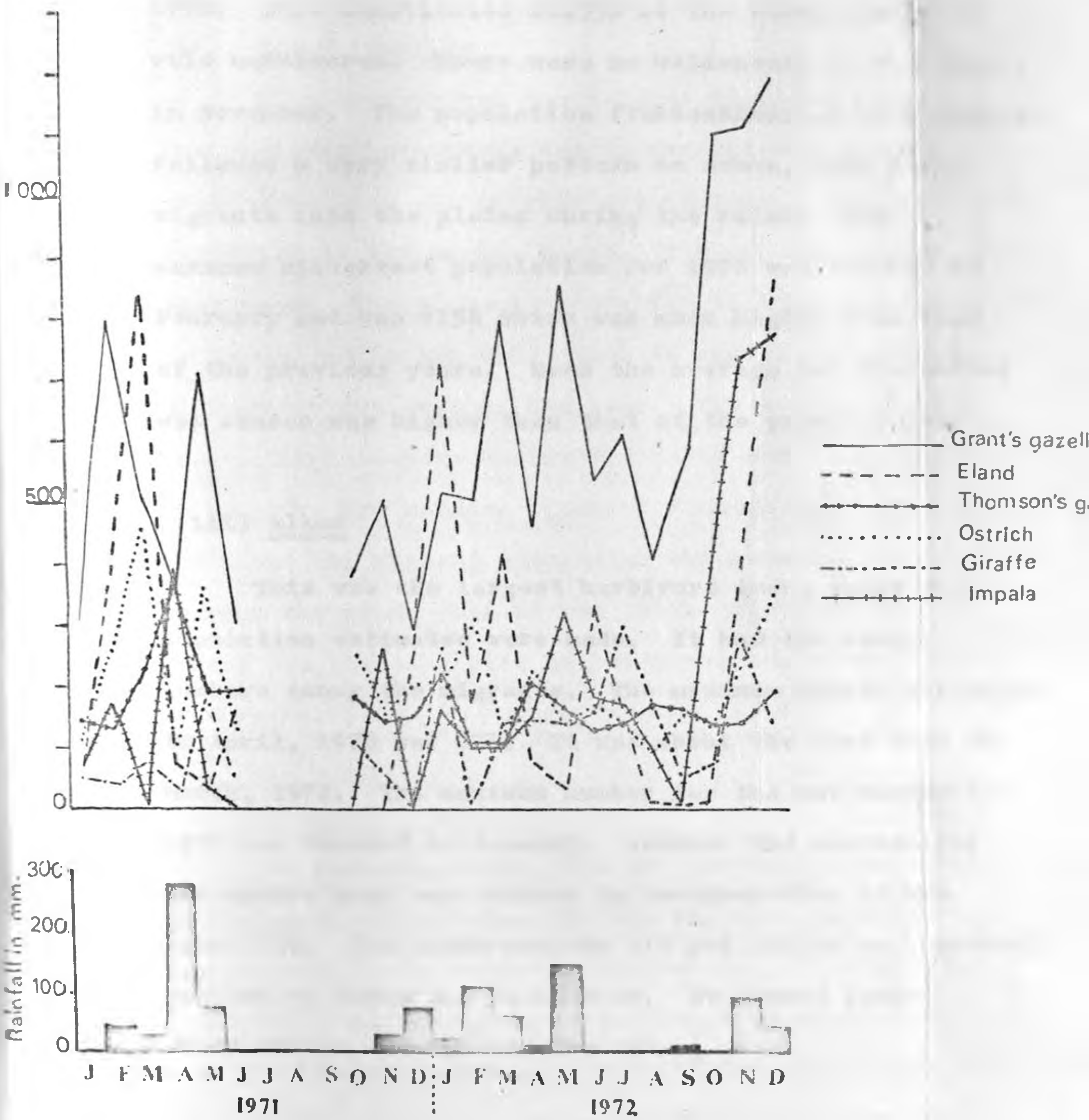


Figure 12

Population fluctuations of the less dominant herbivores in the Simanjiro Plains and mont rainfall from 1971–1972. No censuses were done between July and September 1971.

The maximum population estimated in April, 1970 was 2772. This constituted 26.33% of the total number of wild herbivores. There were no wildebeest in the plains in November. The population fluctuations of this species followed a very similar pattern to zebra, both being migrants into the plains during the rains. The maximum wildebeest population for 1972 was reached in February and was 6156 which was much higher than that of the previous years. Even the average for the entire wet season was higher than that of the previous year.

(iii) Eland

This was the largest herbivore among those whose population estimates were made. It had the lowest numbers among the migrants. The maximum number estimated in April, 1970 was 871. It was about the same size in March, 1971. The maximum number for the wet season of 1972 was reached in January. However the maximum for the entire year was reached in December when it was again 871. The eland numbers did not follow an identical pattern to zebra and wildebeest. It showed large fluctuations even during the rains.

(iv) Oryx

This species appeared in the area during the April, 1970 census. The maximum number in the entire study area was estimated to be 100 animals. None were seen during subsequent counts. Even intensive ground observations showed that they were completely absent.

(v) Grant's gazelle

This species has the largest population among the resident herbivores but it constitutes a small proportion when all species are present. The population estimated at 618 during March, 1970 was the highest for that year. The highest population in 1971 was estimated in March and it was 800. Then it kept on fluctuating throughout the rest of the year. The general trend showed high numbers during the rains and lower ones during the dry season. Similar fluctuations occured in 1972 but the highest population was recorded in December during the rains when it was 1204. Nevertheless the trend was the same with higher numbers occuring during the rains.

(vi) Thomson's gazelle

Thomson's gazelle like the previous species is resident in the plains. It has the next smallest population among the large herbivores. The numbers counted in the samples had fluctuations similar to those of Grant's gazelle. The increase in numbers during the rains was more noticeable than that for the previous species. The population estimated in April, 1970 was 256 which was higher than that recorded in both October and November. The maximum number the following year was 372 and it was reached in April. After that, the numbers kept on declining. The population started increasing in December and reached a maximum of 225 in January, 1972. Then it kept on fluctuating during the rains and gradually dropped down during the dry season and increasing again during the short rains.

(vii) Impala

Impalas are also resident in the study area. Their fluctuation in numbers were more pronounced than that of the two gazelles, sometimes being completely absent. The maximum number recorded in 1971 was 215 compared to 21 estimated in October. The maximum number recorded in 1971 was in April when it was estimated to be 395. Then the numbers dropped down in May and none were seen in the transects after that until November, 1971. The trend was similar the following year except that impala were present in the transects during every count. The highest number recorded during the rains was 325. It had dropped down to 17 by October but increased subtantially the following months during the short rains reaching a maximum of 783 in December.

(viii) Giraffe

Giraffes have the smallest population among the wild herbivores. Its fluctuations followed a trend very similar to that of impalas, but they were present in all counts except in December, 1971. The highest number was estimated in November, 1972 and it was almost the same as that recorded in the previous January which was 266.

(ix)Ostrich

Ostriches are another resident species whose population was similar to that of Thomson's gazelle. It also showed the same fluctuations observed in mammals with higher numbers generally occuring during the rains. The highest number of 464 was reached in March, 1971. The highest number for the following year was 371 and it was reached in December although the number in the previous February was very close to it.

(x) Livestock

Cattle have the highest population among all species in Simanjiro. Their population during the study period showed monthly fluctuations just like the game species. The only difference was that cattle had their peaks during the dry season while game species had their peaks during the rains. While 3081 were recorded in April, 1970, 17,200 were recorded in October during the same year. The lowest number in 1971 was in February. while the highest was in November. Although there were monthly fluctuations in 1972, the numbers during the wet season were proportionately higher than in the previous year. The lowest number was recorded in August while the highest of all time was recorded in October and then

Table 22 a

Population estimates of large herbivores in Simanjiro during 1970

Month	Cattle		Goats & Sheep		Zebra		Wildebeest		Eland		Grant's		Thomson's		Ostrich		Giraffe		Impala	
	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE
January	-		-		-		-		-		-		-		-		-		-	
February	-		-		-		-		-		-		-		-		-		-	
March	-		-		-		-		-		-		-		-		-		-	
April	3081	706	2501	657	5306	786	2771	552	871	271	648	105	236	77	351	121	156	39	215	140
May	-		-		-		-		-		-		-		-		-		-	
June	-		-		-		-		-		-		-		-		-		-	
July	-		-		-		-		-		-		-		-		-		-	
August	-		-		-		-		-		-		-		-		-		-	
September	-		-		-		-		-		-		-		-		-		-	
October	17200	3050	42	36	21	18	0	0	33	29	346	98	225	55	141	60	113	65	21	18
November	7522	1569	672	322	33	19	159	30	0	0	225	71	122	45	228	92	5	4	255	96
December	-		-		-		-		-		-		-		-		-		-	

No censuses were done from January - March and from May - September.

$\hat{Y}$ Population Estimate

SE Standard Error

Table aa b

Population estimates of large herbivores in Simanjiro during 1971

Month	Cattle		Goats & Sheep		Zebra		Wildebeest		Eland		Grant's		Thomson's		Ostrich		Giraffe		Impala	
	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE
January	7056	1655	2933	795	1942	372	2058	337	69	30	309	49	145	38	114	47	55	26	69	43
February	5547	1328	2100	547	5497	1393	3028	573	366	126	800	184	131	39	261	50	45	24	178	76
March	11937	1971	3378	826	5403	1146	4400	998	839	428	550	113	217	65	464	182	78	29	0	0
April	15339	2917	805	441	6298	1244	3030	545	75	34	364	81	372	95	109	36	31	12	395	116
May	16640	2985	2319	521	5512	949	2889	394	31	24	722	192	195	57	364	147	192	50	31	24
June	29177	4156	2583	741	19	16	2467	572	159	75	322	92	197	68	133	70	61	22	0	0
July	-		-		-		-		-		-		-		-		-		-	
August	-		-		-		-		-		-		-		-		-		-	
September	-		-		-		-		-		-		-		-		-		-	
October	25829	3702	1431	549	22	18	95	51	0	0	383	99	183	45	255	90	114	40	0	0
November	27607	4422	2111	571	0	0	239	115	0	0	517	93	145	33	67	21	53	18	272	125
December	11245	3107	864	305	31	24	311	82	255	78	300	69	155	39	205	64	0	0	0	0
Wet season average $\hat{Y}$	12365		2176		5678		3542		328		609		229		300		87		151	
Overall average $\hat{Y}$	15819		2069		2747		2149		199		474		193		219		70		105	

There is no dry season average population as no censuses were done from July - September

The wet season average population includes the period from February - May

The overall average population includes only those months in which censuses were done

$\hat{Y}$ Population estimate

SE Standard Error

Table [illegible]

Population estimates of large herbivores in Simanjiro during 1972

Month	Cattle		Goats & Sheep		Zebra		Wildebeest		Eland		Grant's		Thomson's		Ostrich		Giraffe		Impala	
	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE
January	20860	4191	5589	1446	3876	1007	3195	584	731	382	585	134	225	68	214	66	269	67	187	69
February	15915	2602	1625	546	8876	1701	6456	897	181	76	511	110	103	31	317	102	19	10	109	43
March	18910	1989	0126	2270	10576	1310	5986	999	425	267	805	143	100	44	131	49	147	56	103	92
April	13215	2049	4448	1059	1917	472	3012	607	89	40	469	107	214	91	251	65	150	34	153	72
May	20543	3847	5545	1281	1653	441	3842	464	31	24	855	201	175	75	145	44	142	29	325	143
June	14129	3292	4612	1344	1189	374	3376	782	339	108	545	119	136	43	178	42	107	31	189	73
July	20790	3947	5929	2050	33	27	117	55	150	48	644	135	147	40	145	83	303	65	175	86
August	10945	2591	2431	781	0	0	0	0	14	11	444	96	172	57	100	46	178	46	105	68
September	12176	2459	2303	850	0	0	0	0	0	0	589	163	167	51	161	45	59	15	17	13
October	28028	4439	5032	1406	195	56	645	141	19	6	1114	196	139	44	145	37	78	20	422	144
November	22721	4255	2775	669	1329	466	3354	648	413	305	1125	243	146	45	254	111	288	87	742	241
December	11017	2555	4975	1126	2475	787	3788	690	871	455	1204	252	196	100	371	141	130	39	783	273
Wet season average population	17146		4936		5736		4949		182		660		148		206		155		180	
Dry season average population	17985		4079		47		191		45		683		156		138		155		180	
Overall average population	17437		4501		2690		2856		272		731		160		199		163		274	

$\hat{Y}$ Population estimate

SE Standard Error

Table 25

Average Masses of large herbivores used for calculating biomass

Species	Mass (Kg)	Source of data
Cattle (Masai Zebu)	181	Epstein (1955)
Goat/Sheep	27	French (1944)
Zebra	256	Sachs (1967)
Wildebeest	190	"
Grant's gazelle	53	"
Thomson's gazelle	18	"
Buffalo	599	"
Hartebeest	134	"
Impala	49	"
Giraffe	771	Lamprey (1963)
Eland	400	"
Elephant	2,132	"
Rhino	998	"
Ostrich	100	Nagy (pers. comm.)

Table 24

Seasonal variations in the average biomass densities of large herbivores in Simanjiro during 1971 and 1972

1971

Species	Wet Season		Dry Season	
	Biomass Density (Kg/Km2)	% of total	Biomass Density (Kg/Km2)	% of total
Cattle	3926.34	48.56	7567.61	95.58
Goats and Sheep	103.01	1.27	67.77	0.86
Zebra	2350.56	29.07	9.44	0.12
Wildebeest	1180.38	14.60	32.30	0.41
Eland	229.00	2.83	-	-
Grant's gazelle	56.58	0.70	35.51	0.44
Thomson's gazelle	7.20	0.09	5.76	0.07
Ostrich	52.50	0.65	45.00	0.57
Giraffe	167.14	2.07	154.20	1.95
Impala	12.75	0.16	-	-
Total	8085.46	100.00	7917.59	100.00

1972

Cattle	5444.03	53.51	5710.55	88.95
Goats and Sheep	233.82	2.30	193.12	3.01
Zebra	2383.01	23.42	19.47	0.30
Wildebeest	1649.50	16.21	63.18	0.98
Eland	128.00	1.26	30.00	0.47
Grant's gazelle	61.48	0.60	63.47	0.99
Thomson's gazelle	4.73	0.05	4.91	0.08
Ostrich	36.00	0.35	24.00	0.37
Giraffe	219.20	2.15	295.92	4.61
Impala	15.13	0.15	15.64	0.24
Total	10,174.90	100.00	6420.26	100.00

Data for October, 1971 was used for calculating the dry season biomass as no censuses were done during the dry season proper.

dropping down to almost the August level in December. Donkeys were not counted because of the difficulty of differentiating them from cattle. Also they were not seen in sufficient numbers to warrant an estimate of their population.

Goats and sheep were lumped together in the census. Their numbers showed fluctuations similar to those of wild herbivores. Even the peaks were occuring during the rains. The highest number in 1971 occurred in March when they were estimated to be 3378. The population increased almost three fold during the following year. There were 8126 goats and sheep estimated in March, 1972 which was the highest number ever estimated. The number between April and June oscillated between 4500 and 6000. There was a sharp decline in August and September increasing again in October and declining again the following month and increasing in December at the end of the study. This fluctuation of goats was caused by herding by Masai in order to accommodate the browsing requirements of goats which are different from those of cattle. Normally goats are kept longer in areas when water dries because they have a longer drinking interval than cattle.

(b) Biomass densities

The population size though a good indicator of the abundance of different herbivores in a given area does not give an accurate comparative biological parameter because it does not take size into consideration. Biomass density on the other hand gives such a comparative factor. The animals are converted into the same units. In order to obtain biomass density, the density of each species is first calculated by dividing the population by the area giving a figure of animals per unit area in this case square kilometres. Then the biomass density is obtained by multiplying the density of each species by its average mass in kilograms obtaining a figure of kilograms per square kilometre. The mean masses of game animals used for this study were obtained from those given for Serengeti (Sachs, 1967) with the exception of ostrich whose figure was given by Dr. Nagy (pers. comm.) of the Mount Meru Game Sanctuary, Arusha and giraffe whose average mass was that used by Lamprey (1963). Masses of cattle and goats were obtained from other sources (French, 1944; Epstein, 1955). See table 23 for details. The biomass density of each species was calculated from the census figures and the results are given on table 24.

The monthly biomass densities followed population fluctuations. However the percentage constituted by each species showed a proportionate increase with size. The overall biomass density for 1971 and 1972 was 7337 kg/km^2 and 8450 kg/km^2 respectively. These overall densities were obtained by adding up the total biomass

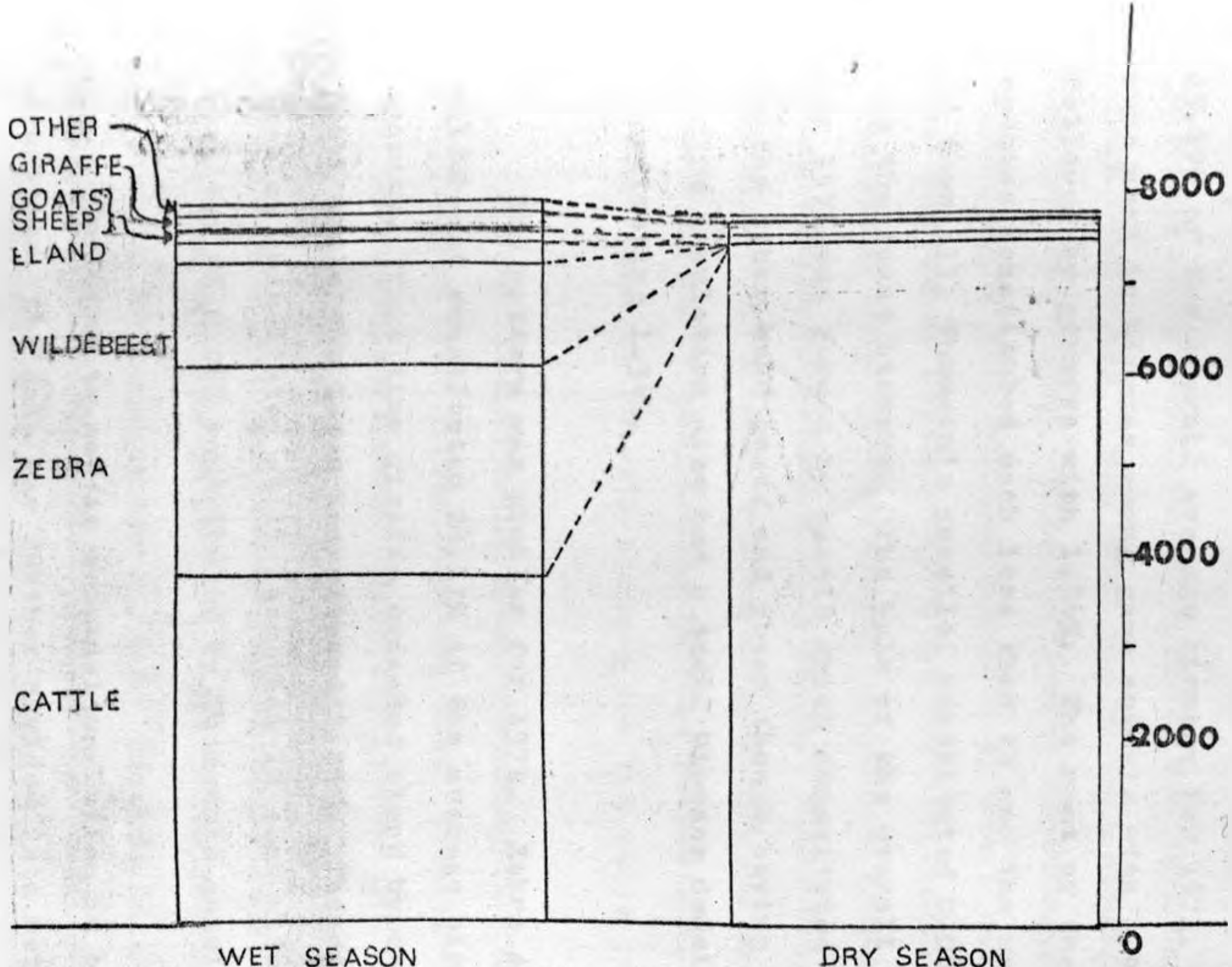


Figure 13

Biomass proportions of the big herbivores in the Simanjiro Plains during 1971 for each count divided by the total number of counts done. Wild herbivores constituted less than half of the overall average biomass. Zebra and wildebeest formed the bulk of the wild herbivores and constituted 25.17% of the overall average biomass for 1971. Eland were next in biomass among game animals with 1.90% followed by giraffe with 1.54%. The rest of the game species constituted each less than 1% and the smallest of them all, Thomson's gazelle, constituted 0.08% which was the least biomass. The bulk of the overall biomass for 1971 was formed by cattle which constituted 68.73%. On the other hand goats and sheep though having a medium population size had a small biomass density constituting 1.34%.

The pattern was similar for 1972. Zebra and wildebeest constituted 24.17% of the average biomass density. This time giraffe exceeded eland by constituting 3.69% while the later constituted 2.25%. The other species constituted still less than 1% each with the smallest of 0.06% contributed by Thomson's gazelle.

In order to assess seasonal variation in biomass densities, the data was further divided into wet season and dry season components. February to May were considered to be typical wet season months and July to October typical dry season months. The biomass densities for these months were added and averaged out. The results are shown on table 24. The dry season biomass for 1971 was worked out from October census as no counts were done from July to September as the pilot was on leave.

The wet season biomass density for 1971 was 8090 kg/km^2 which was higher than the overall biomass density for the whole year. Wild herbivores constituted 50.17% of the total the bulk being formed by zebra and wildebeest. The difference between these species in biomass was more pronounced than the difference in numbers because a zebra weighs more than a wildebeest. Eland was third with 229 kg/km^2 or 2.83%. The other species each constituted less than 1% of the biomass but the percentages were higher than the overall biomass for the whole year.

The wet season total biomass density for 1972 of 10175 kg/km^2 was higher than the total biomass density for the previous wet season. Wild herbivores had 4500 kg/km^2 or 44.19% most of which was constituted again by zebra and wildebeest. The average wet season biomass for zebra was the same as in 1971. That of wildebeest showed an increase of 470 kg/km^2. Giraffe also showed a slight increase while eland showed a slight decrease. The other species were each still constituting less than 1%. Cattle formed the bulk of the biomass constituting 53.51%. Goats and sheep constituted only 2.30%. The dry season biomass density decreased considerably. This was mainly caused by the absence of zebra and wildebeest due to outward migration to Tarangire as will be explained later on. There was only a slight reduction in the biomass of resident species while cattle showed a slight increase and goats and sheep showed a slight decrease. Cattle constituted 88.95% of the average biomass density.

(c) Group size and composition

Data obtained from ground observations was classified into group size, general age class and sexual composition for each species which was seen in sufficient numbers. A group in this context means the total number of animals found together at the same place and time.

(i) Zebra

This species was rather difficult to classify due to the lack of obvious secondary sexual characteristics. The best method used by Klingel (1969) in Ngorongoro was a combination of stripe pattern and marking. Stallions are easier to identify by their large body and neck size. If viewed from behind, they can be spotted by the absence of vulvas. Besides these characteristics the stallions usually bring up the rear in zebra when running and they have a habit of standing and turning to look at the source of danger. Mares are usually accompanied by their foals. The different age groups vary in size.

A total of 1501 zebras were classified and the results

Table 25

Group composition of zebra in the Simanjiro Plains

Group size	Frequency	Total males	Total females	Total sub-adults	Total foals	Total overall
1	4	4	-	-	-	4
2	8	4	6	4	2	16
3	9	3	13	4	7	27
4	5	8	6	1	5	20
5	13	12	25	16	12	65
6	7	15	13	9	5	42
7	10	12	33	7	18	70
8	6	9	21	10	8	48
9	11	12	48	18	21	99
10	8	18	29	20	13	80
11	6	5	34	22	5	66
12	2	8	5	10	1	24
13	3	3	19	9	8	39
14	3	5	23	6	8	42
16	2	2	16	8	6	32
17	2	2	17	11	4	34
18	2	4	20	7	5	36
20	1	3	8	5	4	20
22	1	-	14	5	3	22
23	2	1	26	12	7	46
24	2	7	18	13	10	48
25	1	2	16	5	2	25
27	3	9	39	20	13	81
30	2	-	39	14	7	60
31	1	2	19	6	4	31
34	2	17	31	14	6	68
39	1	6	17	8	8	39
47	1	3	18	15	11	47
51	1	7	27	11	6	51
53	2	12	52	26	16	106
55	1	3	32	12	8	55
58	1	8	22	16	12	58
T O T A L	123	206	706	344	245	1501
Percentage of total		13.72%	47.04%	22.92%	16.32%	100%
Percentage of adults		22.59%	77.41%			
Average herd size =		12.20				
Percentage females with foals 34.70%						
[illegible] =		83.42				

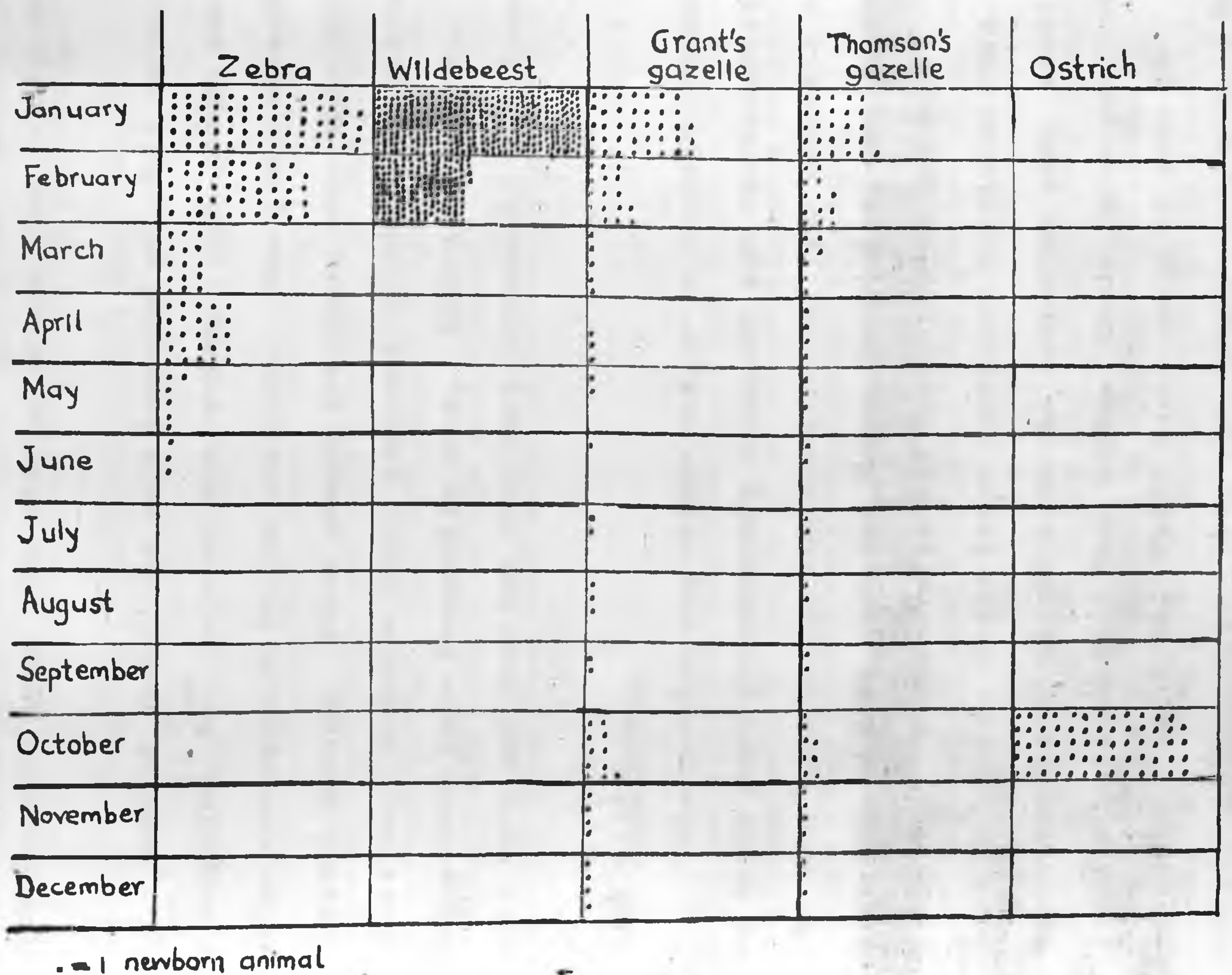


Figure 14

Total number of newborn wild herbivores seen in 1972 in the Simanjiro Plains are given on table 25. There were 123 groups varying from solitary animals to an aggregation of 58 animals. The most frequent groups sizes or mode were between 2 and 11 animals. The large groups were rather infrequently seen. The average groups size was 12.20.

Most of the groups were composed of adult mares, sub-adults, and foals of the season. Such groups were often accompanied by one stallion. These were also the largest groups. Other groups contained more than one stallion. Bachelor herds composed of adult and sub-adult males were less frequently seen. Individual zebras were rare and when met they were invariably stallions.

(ii) <u>Wildebeest</u>

This species was rather easier to classify because of their more conspicuouos secondary sex characteristics and some behavioural characteristics. The criteria used were mainly horn size and shape, body size, and external genitalia. Mature bulls had large bodies and more massive horns. Their large pendulous testicles were unmistakable if viewed from the posterior end. Adult females were smaller than bulls. Their horns were more spread out and thin. Their teats could be seen by careful observation. They were usually accompanied by calves. Sub-adults of both sexes were smaller in size and their horns were narrower and more erect. Calves were the smallest with the horns mere spikes.

Results of group structure are given on table 26. Wildebeest showed the most variable group sizes of all herbivores. A total of 1733 individuals consisting of 148 groups were classified. The group sizes varied from solitary bulls to an aggregation of 117 animals. The most frequent groups were from 1 to 18 animals. The average herd size was 11.70.

The most frequent groups consisted of adult females, sub-adults and calves usually in the company of a single bull. Bachelor groups consisting of mature and immature bulls were the next frequently seen groups more so than those consisting of sub-adult and almost mature females.

Adult females constituted 68.13% of the adults. They constituted 43.33% of all the wildebeest classified. Out of these 40.06% were accompanied by young.

Bulls constituted 23.91% of the adults. They were either solitary or in bachelor herds. The solitary bulls had territories which they defended from others either by threat displays or the classical dropping on front knees and clashing heads. There were constant chases and bellowing among the territorial bulls. The territories were mainly on upper parts of ridges. One ridge east of Togata and another one at Olmanie were especially favoured. Such areas were alive with continuous bellowing noise almost turning into a rumble, and constant movements interspersed with bangs from head clashing. If a nursery herd wandered through a territory the activities increased. The bull in whose territory they were would run around trying to keep them in while the neighbouring territorial bull would be running back and forth trying to herd them in his area. Bulls intruding in such a territory would meet with high aggression. Once the nursery herd moved into another territory the bull in whose territory they had left would not pursue them there otherwise he would be chased vigorously.

Territorial bulls occupied the same territories for considerable lengths of time. One bull with a clipped tail probably the result of a narrow escape from a lion, occupied a territory for 2 months and was never seen again while another one with a characteristic ear notch occupied a territory for 3 months. Such territories had large heaps of droppings where the bulls defecated and bare patches where they lay.

Table 26

Group composition of wildebeest in the Simanjiro Plains

Group size	Frequency	Total bulls	Total cows	Total sub-adults	Total calves	Total overall
1	66	66	-	-	-	66
2	9	14	3	-	1	18
3	1	3	-	-	-	3
4	3	4	4	2	4	12
5	2	6	2	-	2	10
6	6	18	10	4	4	36
8	3	8	10	6	-	24
9	8	12	27	18	15	72
10	1	10	-	-	-	10
11	4	1	20	10	13	44
12	1	12	-	-	-	12
13	3	1	17	11	10	39
14	2	1	12	6	9	28
15	4	1	32	14	13	60
16	2	1	13	7	11	32
18	5	19	40	17	14	90
20	2	2	13	15	10	40
21	1	-	12	4	5	21
24	2	-	29	10	9	48
25	5	2	59	39	25	125
26	1	-	21	-	5	26
29	2	-	30	12	16	58
30	1	-	-	30	-	30
31	1	-	22	4	5	31
36	1	1	25	-	10	36
41	1	-	22	7	12	41
48	2	-	49	26	21	96
64	1	64	-	-	-	64
81	2	-	80	49	33	162
85	1	-	51	15	19	85
97	1	-	56	19	22	97
98	1	-	60	13	25	98
117	1	-	64	12	41	117
TOTAL	148	246	783	350	354	1733
Percentage		14.20%	45.18%	20.20%	20.42%	100
Percentage of adults		23.91%	76.09%			
Average herd size		11.71				
Percentage females with young			45.21%			

(iii) Grant's gazelle

This gazelle was easier to classify than even the preceding species. Males have well developed horns while females have poorly developed and usually deformed ones, or the horns are completely absent. Also adult males are much larger than females.

A total of 720 animals were classified and the results are given on table 27. The group structure of this species had similarities with that of wildebeest. The groupings varied from individuals to 42 animals. The most frequent ones contained 3 to 11 animals and groups containing 16 animals were common. The average group was 9.

Family herds containing adult females, sub-adult females and young usually in the company of an adult male were the most common. The next frequent groups consisted of bachelors both adults and sub-adults. Groups consisting exclussively of adult and sub-adult females were not common. Individual adult males were common while individual females were rarely seen except on a few occasions when intensive searches showed a newly born gazelle in the vicinity.

Table 27

Group composition of Grants' gazelle in Simanjiro Plains

Group size	Frequency	Total males	Total females	Total sub-adults	Total young	Total overall
1	6	6	–	–	–	6
2	4	4	2	–	2	8
3	9	9	13	3	2	27
4	7	6	11	6	5	28
5	4	4	9	4	3	20
6	8	9	21	8	10	48
7	3	6	7	5	3	21
8	1	8	–	–	–	8
9	7	13	29	12	9	63
10	4	9	18	5	8	40
11	7	13	36	16	12	77
12	2	13	11	–	–	24
13	1	13	–	–	–	13
14	2	2	15	7	4	28
15	1	1	6	4	4	15
16	6	16	37	21	22	96
17	1	–	17	–	–	17
18	1	1	9	4	4	18
19	1	1	9	4	5	19
21	2	8	17	11	6	42
26	1	1	13	6	5	26
34	1	1	10	10	13	34
42	1	2	22	10	8	42
TOTAL	80	146	312	137	125	720
Percentage		20.27%	43.33%	19.03%	17.37%	100%
Percentage of adults		31.87%	68.13%			
Average herd size		9.00				
Percentage females with young			40.06%			

The adult solitary males were territorial. They defended their territories mostly by threats including neck display. Actual overt actions were rarely seen. When they happened, they consisted of horn wrestling. Territorial displays increased in the presence of family herds. However on two occasions, 2 adult males and on one occasion, 3 adult males were seen with family groups without any aggressive displays being shown.

Females constituted 68.13% of the adults. Sub-adults and young comprised 36% of the total number observed. Adults females with young constituted 40.06% of the females.

(iv) <u>Thomsons's gazelle</u>

This species shows sexual dimorphism similar to that of the preceding species and was likewise easy to classify. Its group structure was very similar to that of the preceding gazelle.

A total of 533 gazelles contained in 96 groups were analysed and the results are presented on table 28. They were distributed singly or in groups varying from 2 to an aggregation of 56 animals. The most frequent distribution was between 1 and 14 animals. The average was 5.52. This was the smallest mean group size of any species in Simanjiro.

Table 28

Group composition of Thomson's gazelle in the Simanjiro Plains

Group size	Frequency	Total males	Total females	Total sub-adults	Total young	Total overall
1	21	19	2	-	-	21
2	19	5	16	9	8	38
3	10	13	12	2	3	30
4	6	5	11	6	2	24
5	9	12	17	5	11	45
6	8	7	20	12	9	48
7	8	5	18	10	9	42
8	3	9	15	-	-	24
10	1	1	4	3	2	10
13	2	2	9	10	5	26
14	3	14	16	7	5	42
19	1	1	8	6	4	19
21	1	1	11	5	4	21
24	1	-	13	6	5	24
29	1	1	14	9	5	29
34	1	-	19	10	5	34
56	1	1	23	20	12	56
TOTAL	96	96	228	120	89	533
Percentage		18.01%	42.77%	22.52%	16.70%	100%
Percentage of adults		29.62%	70.38%			
Average herd size		5.52				
Percentage females with young			39.03%			

Similar to the preceding two species, groups containing adult females, sub-adult females and young were the most frequently met. Most of the time they were in the company of an adult male. The next frequent groups consisted of adult and sub-adult males. There were also numerous solitary adult males. Only two solitary females were seen.

All individual males were territorial and intrusion into territories by other males resulted in vigorous chases and fights. The intensity of territoriality among Thomson's gazelles was more than that displayed by Grant's gazelles. One territorial male with a distinctive neck mark was seen in the same area for 4 months.

There was a preponderance of females. Among the adult females 39.03% of them were accompanied by young. Adult males constituted 18.01% of the entire sample. Sub-adults and young were next to females in abundance.

(v) Giraffe

Giraffes were classified mainly by observation on external genitalia and size. Adult males had clearly visible testicles and penis. The number classified was only 100 and because of this, they were only classified into males, females and young. There were 20 groups, ranging from individuals to 13.

The most frequent group consisted of females, young and usually more than 1 adult male. There was no territoriality observed in this species. Only the typical neck bouts were observed.

The next most frequent group consisted of adult and young males. Out of 5 individual animals seen, 3 were males thus indicating a probability of more individual males than females. There was a preponderance of females and the percentage of young animals was lower than that observed in the other herbivores (See table 29).

(vi) Impala

This species was very easy to classify because of extreme sexual dimorphism. Males have horns while females have none. Only 208 impala contained in 12 groups were sampled because of their low numbers in the study area. They were distributed singly or in groups up to 38 animals. The average group size was 17.33 this being the highest among all the herbivores sampled.

Table 29

Group composition of giraffe in the Simanjiro Plains

Herd size	Frequency	Total males	Total females	Total young	Total overall
1	5	3	2	-	5
2	3	2	4	-	6
3	3	6	3	-	9
4	1	1	3	-	4
5	1	5	-	-	5
6	1	-	4	2	6
7	1	2	4	1	7
10	2	6	14	-	20
12	1	2	7	3	12
13	2	3	19	4	26
TOTAL	20	30	60	10	100
Percentage		30	60	10	
Adult %		33	67		
Average herd size = 5					

Table 30

Group composition of Impala in the Simanjiro Plains

Herd size	Frequency	Total males	Total females	Total young	Total overall
1	2	1	1	-	2
5	1	5	-	-	5
12	2	24	-	-	24
16	1	16	-	-	16
19	2	20	18	-	38
24	1	1	18	5	24
27	1	1	24	2	27
34	1	-	29	5	34
38	1	1	30	7	38
TOTAL	12	69	120	19	208
Percentage		33%	58%	9%	
Adult %		37%	63%		
Average herd size = 17.33					

Table 31

Group composition of Ostrich in the Simanjiro Plains

Flock size	Frequency	Total cocks	Total hens	Total young	Total overall
1	4	1	3	-	4
2	4	2	6	-	8
3	2	2	4	-	6
4	1	2	2	-	4
5	3	1	14	-	15
7	2	4	10	-	14
8	2	6	10	-	16
9	1	9	-	-	9
10	1	-	10	-	10
11	1	-	11	-	11
13	2	4	22	-	26
14	3	8	28	6	42
17	2	3	31	-	34
20	1	1	4	15	20
25	3	9	66	-	75
28	1	1	1	26	28
29	1	-	1	28	29
30	2	2	58	-	60
38	1	1	-	37	38
41	1	-	41	-	41
62	1	12	40	10	62
TOTAL	39	68	362	122	552
Percentage		12%	66%	22%	
Adult %		16%	84%		
Average flock size = 14.15					

Any bird smaller than the average adult female was classified as young. Nevertheless there may have been errors when immature birds of both sexes almost adult size , were counted as adult females. This , and the pressure from hunting and poaching on the cocks has probably biased the figures in favour of females as an approximately 1:1 sex ratio has been reported elsewhere (Hurxthal, pers. comm.).

[illegible] smaller than the [illegible] classified as young. A total of 552 birds in 39 flocks were sampled.

Nearly all flocks consisted of adult females, young and one or a few cocks. These cocks seemed to tolerate each other more than was the case with the antelopes. However there was pronounced chasing seen between August and October when the adult males turned pink on the necks and thighs. Other flocks consisted of young alone or accompanied by a single male or female or both. Individual birds [illegible] and they were [illegible] (See table [illegible]

(d) Calving

Figures of newly born animals were extracted from observations made on group structure in order to determine the calving period of ungulates and the hatching time for ostriches. This would help in assessing the importance of the Simanjiro in the reproduction of herbivores an obvious but vital phenomenon in the propagation and maintenance of any animal population. The results are given on figure 19. Amongst the migratory species wildebeest dropped their calves entirely in the plains. It was synchronised calving taking place within three weeks between late January and early February. In both 1971 and 1972 no new born calves were seen after February. This was very handy in group structure analysis because all animals born in the same year were of the same size and there were recognizable age groups up to adult-hood. Horn shape and body size was the same for animals born in the same year.

Calving in zebra followed a different pattern. There was no synchrony as in the preceding species. They dropped foals throughout the time they were in the plains. However there was a distinct foaling peak in January which was observed in both years.

No observations could be made on eland for reasons already explained.

Observations on the resident species were year round. Grant's gazelles calved throughout the year. In spite of this there was a distinct peak during the long rains and a minor one during the short rains. The rest of the calving was scantily distributed in the other months with the dry season containing the least. The calving pattern of Thomson's gazelles was very similar to that of Grant's gazelle.

No sufficient number of new-born was observed in either impala or giraffe to be able to ascertain their calving periodicity.

Ostrich hatching occured in October at about the same time and broods were of the same size. They varied in numbers from under 10 to over 30. This synchronised breeding was similar to wildebeest.

Reproduction in domestic stock was not recorded as there was no need to worry about their survival! They were already overstocked. Nevertheless casual observations showed that calving took place mostly during the rains. A lot of new-born calves were seen at this time. The calves were easily seen as the Masai kept them near bomas separate from the adults during the day.

(e) Mortality

(i) Poaching

This was the most common source of mortality in Simanjiro. Carcasses due to poaching were easily determined because there were more than one carcass of the same species in one spot indicating indiscriminate shooting as only practiced by poachers and not licenced hunters. Records of apprehended poachers were also obtained from the Game Division office at Arusha. Also on a few occasions, four-wheel drive vehicles were spotted during aerial censuses and sped off on seeing the plane and this was a fair indication of their intentions. Occasionally during the rains, the Ndorobo tribesmen wandered into the plains in pursuit of their daily bread, game meat. These are not poachers as they are together with the Tindiga, Sandawi and Pahi bushmen traditionally allowed by the Tanzania Government to hunt for their food (Fauna Conservation Ordinance, Cap 302 of the Laws).

Zebras were the most vulnerable species to poaching. It accounted for 88% of the recorded mortality. They were almost entirely poached for their skins. In one instance, 20 freshy skinned carcasses were found within a radius of one mile, a ghastly sight indeed. Stallions suffered more casualties because of their boldness or rather stupid habit of stopping and looking back when a group is fleeing. Also they are preferred because of their big size and hence bigger skins which have pitch black and clear white stripes a pattern the tourists adore. The most favoured spots for poaching were at Mboreti, Osilale, Kiloriti and Terrat. In most instances the zebras were chased by vehicle and shot as they ran. Later in 1972 some poachers taught some Ndorobo how to handle rifles. The latter were then left to collect and accumulate the skins which were later picked up by the master minds at pre-arranged spots and intervals.

Poaching in wildebeests did not constitute an important source of mortality. It accounted for a third of the total. The gnus were only killed for meat. Some meat was sold at Arusha and the settlements around Oljoro. On two occasions wildebeest carcasses were found completely intact except for cut tails. The motive of the killers was only to obtain these parts which make excellent whisks which are especially cherished by Masai elders. What a waste.

Only a few cases of poaching eland were recorded. They were entirely poached for meat and unless the culprit was caught red handed it was difficult to make indirect observations as only the head was left the rest of the carcass being taken for consumption offals and all. Eland meat is a relish among Africans. Even the Masai who otherwise shun game meat will eat "olsirwa" giving the antelopes close resemblance to cattle as the excuse.

Records of poaching on Grant's and Thomson's gazelles were scanty. It was suspected that they were shot after being dazzled with vehicle head lights at night and the whole carcasses taken. In one instance a party of hunters were apprehended at the Lolkisale Game Division check-point having overshot their licences by 3 Thomson's gazelles and 2 Grant's gazelles.

Impalas were poached more than gazelle. Still this accounted for only 13% of the total recorded mortality. They were shot by poachers either in Simanjiro poaching zebra or those who were in transit going to Southern Masailand after that much battered pachyderm, the elephant.

There were no records of poaching on giraffe. It was firmly concluded that since there were sufficient numbers of other game animals for meat, the poachers did not want to bother this rather tough skinned and large artiodactyl. The skin is not yet fashionable and would present a formidable task to remove and carry away.

Ostriches were poached considerably thus being second to zebra in this type of mortality. They were killed both for their skins and plumage. Again, as was the case with zebra, there was selection for males. The males were preferred because of their black and white plumage and their large skins.

(ii) Hunting

Next to poaching hunting constituted another important source of mortality. The largest source of hunting was professionally conducted safaris catering for wealthy overseas clients. It was easy to record animals taken by clients because a record is kept by the licensing office of the Tanzania Wildlife Safaris Limited, Arusha. There was considerable hunting by local people mainly from Arusha but there was no accurate record of their kills except for those who passed through the Game Division check-point at Lolkisale. All the available records are presented on table 32.

Again zebras were the most hunted species. A total of 141 were killed. Their skins are one of the trophies tourist hunters like. They make rugs, hand bags watch straps, wallets, key-ring holders, belts, seat covers, cigarette and lighter cases, and jackets. Feet make table or bedside lamps and ash-trays. The meat is usually given to camp attendants. Residents hunted zebra in Simanjiro on special controlled area permits issued by the Game Division at Arusha. They hunted them primarily for their skins which were sold to curio manufacturers at prices ranging from 200/- to 450/- shillings. Zebra skins were the most prized next to leopard and lion. Meat was of secondary value. The fat was always taken because it is supposed to have medicinal properties and it is also supposed to be a heath tonic. It is yellow in colour and tastes almost like cod liver oil.

Wildebeest were the next most hunted species. The numbers taken amounted to 92. Foreign hunters took them for their skins and heads. The locals mainly went for the meat and sold the skins at 60/- to curio dealers.

The number of Grant's gazelles hunted was the same as that of wildebeests. Tourists hunted them primarily for their head trophies which are usually mounted and hung on walls. The local hunters did not hunt this species much because its meat is not tasty and often has cysts. Some of the meat given to the Game Division staff at Terrat by professional hunters often contained such muscle cysts. The hunting of Thomson's gazelle was prohibited from the end of 1970 because of their scarcity.

Impala was next to Grant's gazelle in numbers hunted which amounted to 83. It was hunted both for its head trophy and its meat. It was equally taken both by foreign clients and local hunters.

A total of 49 eland were taken on licence by tourist hunters. No local hunters took eland in Simanjiro as a more expensive supplementary game licence was required.

Similarly, a supplementary game licence was required to hunt ostriches and a total of 21 were taken by foreign clients.

It is worth-while to note that not only ungulates were hunted. Also 5 leopards, 6 lions and 2 hyenas were killed by tourists.

(iii) <u>Predation</u>

A limited number of instances of predation were noted. The most commonly seen were zebra kills by lions. Eleven such cases were seen in the 2 year period. Most of them were within the short grass plains around bushes. No zebra kills by any other predators were recorded. Lions also preyed on whildebeests and 2 such cases were recorded. Hunting dogs were observed on 3 occasions killing yearling wildebeest. On one such occasion, the kill was observed from beginning to end. A pack of 16 dogs was located in a shallow valley in the grassland. There were 6 adults and 10 puppies. A moment later 5 adults set off after a group of wildebeest leaving one adult with the puppies. On closer observations it was seen that the adult left with puppies was lame. The dogs which were hunting started at a trot and they selected one yearling and ran it down. When the wildebeest had fallen, the puppies with their guardian dashed to the spot and shared in eating. The whole incident took less than half an hour. On another occasion a spotted hyena was found eating a fresh yearling wildebeest. Jackals were seen on five occasions feeding on Thomson's gazelle fawns. Similarly domestic dogs were seen on three occasions feeding on the remains of fawns. An impala killed by a leopard was seen in a drainage line woodland near Ngusero. A cheetah was once seen feeding on an ostrich and on one occasion a pack of hunting dogs ran down and devoured an adult cock.

(iv) Other sources of mortality and the total overall mortality

There were a number of cases in which the cause of mortality could not be determined. Intact zebra carcasses were seen on 4 occasions and disease was suspected. Giraffe carcasses were seen twice. The rest of the mortality which could not be determined consisted of all the skulls and other skeletal remains seen in the plains. All mortality figures are shown on table 32. All the recorded mortality for zebra and wildebeest were recorded while these herbivores were in the plains during the rains. Hence it represents only part of the mortality the other part taking place in the dry season concentration area of Tarangire where they migrate to during that time. The average recorded annual mortality for 1971 and 1972 for zebra was 559. Taking the overall average wet season population of about 6000 zebras, this represents 10 percent of the population. All the observed mortality consisted of adult zebras only. This is because foal carcasses were more easily disposed of by the predators and or scavengers. Also poaching which represented the major portion of mortality selected for adults only with more bias towards male due to reasons already explained. From the group composition data, it shows that the adult zebras represent about 60% of the population or 3600 animals. So in this context adult mortality amounted to 16% a rather high figure. The proportion of males within the adults was only 22.5% or about 800 animals. Since the poaching mortality accounted for 470 and over 80% were males, this means that adult male mortality was close to 50%, an alarming proportion. Such a high mortality is definitely above what can be replaced through recruitment.

Unlike zebra which suffer a high mortality while in the Simanjiro plains, wildebeest mortality was low. The average annual mortality was about 150 animals constituting about 3%. However with wildebeest, calf mortality was relatively higher. It was easier to estimate this because calving was synchronized and the number of calves counted at each count progressively gave the number surviving. The crop of 1971 suffered a mortality of 80% and that of 1972 suffered similarly. On returning the following year the 1971 showed a decrease of 45 representing mortality which took place while the wildebeest were in the dry season concentration area. Those field observations made show that wildebeest calves suffered the most from predation. Nevertheless considering that the overall mortality amounted to 80% of the calf crop and calving amounted to 20% of the population it can be safely assumed that the wildebeest population is able to maintain itself.

Thomson's gazelle is another species whose population is within Simanjiro and any observations of mortality made can be applied at populati n level. The average annual mortality was 25 animals. Taking an average population of about 200 animals, this means 12.5 percent annual mortality. Since new recruitment through calving amounted to 16% or 32 animals it is obvious that reproduction barely sufficient to replace mortality. Although the two figures are about the same, it should be noted that the mortality figure observed is more on the lower side. This is especially

Table 32

Recorded mortality of among large mammals in Simanjiro from 1971 - 1972

Cause of Mortality	Zebra		Wildebeest		Eland		Grants' gazelle		Thomson's gazelle		Impala		Giraffe		Ostrich		Lion		Leopard	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Poaching	420	75.13	35	20.35	5	9.09	3	2.94	14	58.33	8	8.51	-	-	21	42.00	-	-	-	-
Hunting	94	16.82	92	53.49	49	89.09	92	90.20	-	-	83	88.30	-	-	24	48.00	4	100	5	100
Predation	11	1.97	11	6.40	-	-	-	-	2	8.33	1	1.06	-	-	2	4.00	-	-	-	-
Unknown	34	6.08	34	19.76	1	1.82	7	6.86	8	33.31	2	2.13	3	-	3	6.00	-	-	-	-
TOTAL	559	100.00	172	100.00	55	100.00	102	100.00	24	100.00	94	100.00	3	100	50	100.00	4	100	5	100

so because of the small size of Thomson's gazelle thus making its carcass very easily disposed of by predators and scavengers. This is even more so when young animals are involved. Thomson gazelle fawns were observed in Simanjiro to be vulnerable to predation by jackals which were common in the area. It can therefore be concluded that the population of Thomson's gazelle in Simanjiro is suffering from a relatively higher mortality than can be replaced by recruitment and is on the decline.

(f) Utilization of vegetation habitat by the different herbivores

In order to determine the pattern of utilization of the vegetation habitat in Simanjiro, data from both aerial censusing and field observation was used. This mainly involved analysis from the aerial counting maps and feeding observations.

(i) Occupation of different vegetation types by herbivores

In order to determine occupance, that is the presence or absence of a particular herbivore in a given vegetation sub-type, aerial maps with animal distribution plottings for both 1971 and 1972 were used. The transects sampled were examined in detail to determine the lengths of strips of each vegetation sub-type occuring along the transect. For each census only one of the two 12 strip run was used. Then the area of each vegetation strip was obtained by multiplying its length by 0.3 km which was the width of each strip. All these were added up and the area of each vegetation sub-type covered during the aerial censusing determined. The total number of each herbivore occuring in each vegetation type was tallied and divided by the area of the sub-type to obtain density. The subsequent monthly densities in each vegetation sub-type for each year were added up and divided by the total number of aerial censuses done. There were 9 counts in 1971 and 12 counts in 1972 as explained earlier. This then gave the occupance of each species in animal months per hectare. The results are given on tables 33-42.

Furthermore the data for April and October for both 1971 and 1972, the two months representing the heights of the wet season and dry season respectively, was analysed to determine whether the herbivores were distributed randomly in each vegetation type or showed some preference. This was done by applying the Chi-Square (χ^2) test for determining random distribution. The actual number of each herbivore occupying a given vegetation and the expected number were used in calculating χ^2. The actual number of herbivores occuring in a given vegetation was obtained from the raw data as already explained. In order to obtain the number expected, the total number of a herbivore counted during the aerial census was used as follows:-

$$E = \frac{a}{A} y$$

Where E is the expected number

y is the total number of a particular herbivores counted during the census in question

A is the total sampled area

a is the total area of a given vegetation sub-type

In this case A was equal to 137 km^2. It was obtained by calculating the area of each transect which is 19 km long by 0.3 km wide equaling 5.7 km^2 and then multiplying by 24 the total number of transects in each census. Calculation of a, the total area of a given vegetation has already been explained. Finally χ^2 was obtained as follows:-

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where $\sum$ denotates the sum totals

O is the number of observed animals and

E is the number exptected.

The term $(O - E)^2/E$ is calculated for each vegetation type and then all are added up to obtain χ^2 (see table 43) Then the value is compared to the normal χ^2 distribution figure in the table under n-1 degrees of freedom to determine if it is significant.

Zebra

This migratory plains herbivore occupied a wide spectrum of the vegetation types. Occupance figures show that the Pennisetum mezianum - Acacia stuhlmannii seasonally water-logged bushed grassland and the Digitaria macroblephara - Panicum coloratum short grassland had the highest values. In 1971 they were

17.44 and 6.60 animal months/km^2 respectively while they were 9.11 and 8.66 animal months/km^2 respectively in the following year. Third were the woodland sub-types particularly the Commiphora woodland and that of Acacia nilotica ssp. subalata - Commiphora schimperi. The bushland was the least occupied and hence utilized area.

The occupance sequence followed the same pattern in each year. During the first two months of 1971 when the zebra were migrating into the plains, they concentrated more in the Commiphora woodland, short grassland and seasonally water-logged grassland. As the rains increased, more moved into the short grassland. In April a substantial part was seen in the Acacia stuhlmannii bushland around Terrat where this type is more open and interspersed with Acacia drepanolobium. In May towards the end of the rains and when the zebras were about to migrate out, they utilized the seasonally water-logged bushed grassland more. Another substantial portion were in the Acacia nilotica ssp. subalata and Acacia tortilis dominated woodlands. When the zebras started migrating back during the short rains in October to December, 1971 they again mainly occupied the seasonally water-logged bushed grassland with a small portion occuring in the grassland.

The occupance sequence in 1972 was more or less similar to that of the previous year. In January, the major portion of zebras were in the short grassland and the seasonally water-logged grassland. The rains in February increased to about 110 mm compared to 23 mm the previous month and the density of zebra in the short grassland, and Acacia-Commiphora woodland increased while that in the seasonally water-logged grassland decreased. In March there was about half the rainfall recorded in the previous months and the density of zebras in the seasonally water-logged bushed grassland increased very much while that in the grassland decreased. During May and June at the end of the rains the highest density was in the Acacia nilotica ssp. subalata dominated woodland. Ground observations showed the zebras to be in the area where Pennisetum mezianum, Sporobolus sp. and Themeda triandra were common besides Digitaria and Panicum. It was mostly from the woodland and bushland area that the zebras migrated out of the plains.

Analysis of χ^2 conformed to the occupance distribution. April was selected as the middle of the rains and hence the distribution pattern to be typical of the rain season. The majority of zebras were within the short grassland. In 1971 there were 765 zebras in this habitat which was not significantly different from the expected number. In 1972, the number of zebras observed in the grassland was significantly higher than the number expected giving a χ^2 value of 385.35 which indicated the highest preference. The next highest χ^2 was recorded for the Acacia stuhlmannii bushland but the unusual distribution of zebra in this vegetation during the April, 1971 has already been explained. Therefore the next preferred habitat to the grassland was the Acacia nilotica ssp. subalata and the Commiphora dominated woodlands. Both subtypes had more than the expected number of zebras in 1971 and 1972. The seasonally water-logged bushed grassland areas contained zebras but their distribution was close to the expected one thus demonstrating low preference. The Acacia tortilis dominated woodland showed still a higher non-random zebra distribution the number observed being way below the expected one. The least preferred habitat was the bushland sub-types. With the exception of the unusually large group recorded in the Acacia stuhlmanii bushland near Terrat, no zebras were recorded in this type during this time (See table 45 for full details).

October the month chosen to represent the typical dry season conformed to expectation as very few or no zebras altogether were expected to be found in the plains. There were zebras in the plains in October 1971 and only 71 were recorded in the transects in October, 1972. The majority were within the Acacia nilotica ssp. subalata dominated woodland for which they showed high preference while the rest were within the short grassland for which they showed low preference. (See tables 44 and 46).

Table 33

Monthly transect densities and occupance values of zebra within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm – P.c. Grassland	At – C.s. Woodland	Am – C.s. Woodland	Cs – Cm Woodland	Cs – Am Woodland	A.s. Bushland	Am – As Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	9.47	1.25	0	23.33	7.27	0	0	0	8.62
Feb.	4.56	0	0	0	0	0	0	46.30	0
Mar.	18.13	0.37	0	22.11	0	4.52	0	53.20	0
Apr.	14.12	1.94	0	0	0	27.46	0	25.15	0
May	13.17	5.97	8.46	2.66	0	0	0	32.36	46.18
Jun	-	-	-	-	-	-	-	-	-
Jul	0	0	0	0	0	0	0	0	0
Aug	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-
Oct	0	0	0	0	0	0	0	0.15	0
Nov	0	0	0	0	0	0	0	0	0
Dec	0.10	0	0	0	0	0	0	0.91	0.87
TOTAL	59.45	9.53	8.46	48.10	7.27	31.98	0	157.01	55.67
Occupance (Animal Months/KM²)	6.60	1.05	0.94	5.34	0.80	3.55	0	17.44	6.18

1972

Month	Dm – P.c. Grassland	At – C.s. Woodland	Am – C.s. Woodland	Cs – Cm Woodland	Cs – Am Woodland	A.s. Bushland	Am – As Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	19.15	0.37	5.21	0	25.00	0	0	13.71	0
Feb.	25.56	7.54	13.02	0	0	2.11	0	1.82	0
Mar.	36.93	3.77	5.86	0	0	0	4.54	80.18	34.72
Apr.	11.75	0.12	2.93	0	0	0	0	0.30	0
May	4.35	0.31	8.46	0	0	0.50	0	0	4.16
Jun.	0.92	0.32	8.46	0.33	0	8.60	0	0	0
Jul.	0.42	0	0	0	0	0	0	0	0
Aug.	0	0	0	0	0	0	0	0	0
Spt.	0	0	0	0	0	0	0	0	0
Oct.	0.17	0.31	0	0	0	0	0	3.50	0
Nov.	1.84	4.65	18.88	8.00	0	0	0	0	0
Dec.	8.56	10.88	0.97	1.33	0	3.93	0	4.42	5.17
TOTAL	109.35	28.27	63.79	9.66	25.00	15.14	4.54	103.93	44.05
*O(AM/KM²)	9.11	2.35	5.31	0.80	2.08	1.26	0.37	8.66	3.67

* Occupance (Animal Months/KM²)

No censuses were done in June, August and September, 1971

Plant Species

A.d. – Acacia drepanolobium
A.m. – Acacia mellifera
A.S. – Acacia stuhlmannii
A.t. – Acacia tortilis
C.s. – Commiphora Schimperi
C.m. – Commiphora madagariensis
D.m. – Digitaria macroblephara
P.c. Panicum coloratum
P.m. – Pennisetum mezianum

Wildebeest

Occupance of different vegetation types differed to some extent from that of zebra in that wildebeest occupied the grassland habitat more. The occupance values for 1971 and 1972 were 9.90 and 13.27 animal months/Km^2 which were higher than the values for zebra. However like zebra, wildebeest occupied the seasonally water-logged bushed grassland habitat next to the grassland. The Commiphora woodland was third while the other woodland subtypes were the least occupied. Unlike zebras which intermittently ventured into the bushland, no wildebeests were observed at all in this habitat.

The occupance sequence followed that of zebra. At the beginning of the year in 1971 when they were migrating into the plains, most of them occupied the grassland and seasonally water-logged bushed grassland. A few of them were in the Commiphora schimperi-Acacia mellifera woodland and the Acacia tortilis dominated woodland had the lowest density. As the rains continued the highest densities were in the grassland followed by the dominant seasonally water-logged bushed grassland. It should be mentioned that wildebeest favoured very much the edge between this vegetation and the grassland. Although there was no count in June, the count in July showed that most of the wildebeest were still in the grassland, seconded by the Commiphora woodland and a small density was in the seasonally water-logged bushed grassland. This then was the situation at the start of the outward migration. At the onset of the inward migration from October to December, the same occupance sequence started again with the grassland and the seasonally water-logged habitat being occupied first.

This distribution continued into the beginning of the following year, 1972. Also at this time the Acacia nilotica ssp. subalata dominated woodland had a density of 5.85/ha which was one third of that found in the grassland. The Acacia tortilis dominated woodland had a density of only 0.18. During the middle of the rains between February and April, the highest densities were in the grassland. Towards the end of the rains the densities were high in the Pennisetum mezianum-Acacia stuhlmannii bushed grassland and the Commiphora woodland with the grassland ranking third. This was the time during which the wildebeest were migrating out of the plains. The inward migration from October to December followed a similar occupance to that of the previous year (See table 34 for full details).

The χ^2 test made on the April 1971 and 1972 data to determine the randomness of occupance during the peak of the rains, confirmed that the grassland was the most preferred habitat. The observed numbers of wildebeest in this habitat at this time during both years were 862 and 834 respectively which were significantly

Table 34

Monthly transect densities and occupance values of wildebeest within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm - P.s. Grassland	Bt - C.s. Woodland	An - C.s. Woodland	Cs - C[illegible] Woodland	Cs - A.m. Woodland	A.s. Bushland	Am - A.s. Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	6.97	0.30	0	0	0.45	0	0	0.60	0
Feb.	9.80	0	0	0	0	0	0	18.36	0
Mar.	14.48	1.50	0	0.33	0.83	0	0	17.27	0
Apr.	21.63	3.52	0	0	0	0	0	7.01	0
May	18.44	0	0	0	0	0	0	1.82	0
June	-	-	-	-	-	-	-	-	-
July	14.41	0	0	10.66	0	0	0	3.50	0
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	0.63	0	0	0	0	0	0	0.15	0
Nov.	0.67	0	0	0	0	0	0	0	0
Dec.	2.09	0	0	0	0	0	0	1.67	0.87
TOTAL	89.12	5.32	0	10.99	1.28	0	0	50.38	0.87
O(A.M./KM²)	9.90	0.59	0	1.18	0.14	0	0	5.59	0.09

1972

Month	Dm - P.s. Grassland	Bt - C.s. Woodland	An - C.s. Woodland	Cs - C[illegible] Woodland	Cs - A.m. Woodland	A.s. Bushland	Am - A.s. Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	19.65	0.18	5.85	0	0	0	0	23.47	1.38
Feb.	37.71	0.12	0	0	0	0	0	17.53	0
Mar.	32.46	0	0	0	0	0	0	18.40	0
Apr.	20.27	0	0	0	0	0	0	18.23	0
May	18.73	4.08	0	0	0	0	0	28.81	0.81
June	11.65	0	0	14.66	0	0	0	1.37	0
July	1.02	0	0	0	0.83	0	0	0.15	0
Aug.	0	0	0	0	0	0	0	0	0
Sept.	0	0	0	0	0	0	0	0	0
Oct.	3.15	0.56	0	0	0	0	0	1.82	0
Nov.	7.57	1.76	4.14	0	0	0	0	0.91	0
Dec.	7.11	1.38	0	0.66	0	0	0	16.15	2.29
TOTAL	159.32	8.08	9.99	15.32	0.83	0	0	126.84	4.54
O(A.M./KM²)	13.27	0.67	0.83	1.27	0.06	0	0	10.57	0.37

For addition explanation and full names of abreviations see Table 33 higher than the expected numbers which were 462 and 426 respectively. It means that there were about twice as many wildebeest as there were expected to be had they been randomly distributed. This demonstrates conclusively that the grassland was the ideal habitat. Although some were in the seasonally water-logged bushed grassland, the numbers observed were not significantly higher than those expected thus indicating no preference by wildebeest for this habitat at this time.

No wildebeest were in the plains in October 1971 but the few observed in October, 1972 at the beginning of the inward migration still showed preference for the grassland though not as high as was shown during the rains. (see tables 44 and 46).

Eland

In contrast to wildebeest which showed a distinct occupance pattern, eland were rather erratic. Eland recorded in January, 1971 were in the grassland and Acacia tortilis dominated woodland. Even then the densities were very low being 0.21 and 0.06/km^2 respectively. In the next two months, higher densities were recorded in the dominant subtype of the seasonally water-logged bushed grassland.

The densities again dropped in April and by May only 0.28/km^2 was recorded in the grassland. In July the occupance was nearly the same in the grassland and Acacia tortilis dominated woodland. Towards the end of the year there were sporadic presence in the Acacia nilotica ssp. subalata and Acacia mellifera-A. stuhlmannii bushland with the last type having a density of 6.14.

Records for 1972 which had monthly censuses all the year showed that eland utilized all the major vegetation types including the bushland which had the overall highest occupance. The next one was the Acacia tortilis dominated woodland. Although the grassland had a low occupance, it was together with the last mentioned woodland frequented more than any other type between January and July.

Prior to migrating out of the plains, they were recorded to be in the bushland. On returning in the plains between October and December, they occupied the Acacia-Commiphora woodland sub-types and the dominant seasonally water-logged bushed grassland.

It can be concluded that contrary to the preceding two species which showed high occupance for the grassland, eland had higher occupance in the woodland and seasonally water-logged bushed grassland. However they were present in the grassland during most of rain season (See table 35 for full details).

The results of the χ^2 test for April, 1971 and 1972 confirmed the above observation. The seasonally water-logged bushed grassland showed significant preference by eland. (See tables 43 and 45).

Table 35

Monthly transect densities and occupance values of eland within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm - P.c. Grassland	At - C.s. Woodland	An - C.s. Woodland	Cs - Cm Woodland	Cs - A.m. Woodland	A.s. Bushland	An - A.s. Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	0.21	0.06	0	0	0	0	0	0	0
Feb.	2.92	0	0	0	0	0	0	4.56	0
Mar.	2.83	0	0	0	0	0	0	15.24	0
Apr.	0.38	0	0	0	0	0	0	0.60	0
May	0.28	0	0	0	0	0	0	0	0
June	-	-	-	-	-	-	-	-	-
July	1.06	1.00	0	0	0	0	0	0	0
Aug.	-	-	-	-	-	-	-	-	-
Sep.	-	-	-	-	-	-	-	-	-
Oct.	0	0	0.65	0	0	0	0	0	0
Nov.	0	0	0	0	0	0	6.14	0	0
Dec.	2.83	0	0	0	0	0	0	0	0
TOTAL	10.51	1.06	0.65	0	0	0	6.14	20.40	0
α(A.M./KM²)	1.16	0.11	0.07	0	0	0	0.68	2.26	0

1972

Month	Dm - P.c. Grassland	At - C.s. Woodland	An - C.s. Woodland	Cs - Cm Woodland	Cs - A.m. Woodland	A.s. Bushland	An - A.s. Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	2.83	8.53	0	0	0	0	0	0	0
Feb.	0.56	1.38	0	0	0	0	0	0	0
Mar.	0	1.32	0	0	0	19.48	0	1.21	2.77
Apr.	0.07	0	0	0	0	0	0	1.98	0
May	0	0.69	0	0	0	0	0	0	0
June	0.60	0	3.49	0	0	5.68	0	0	0
July	0.35	0.94	0	0	0	0	3.89	0	0
Aug.	0	0	0	0	0	0.81	0	0	0
Sept.	0	0	0	0	0	0	0	0	0
Oct.	0	0	0.32	0	0.78	0	0	0	0
Nov.	0	5.53	0	0	0	0	0	1.37	0
Dec.	0	1.50	0	0	3.40	0	0	4.42	0
TOTAL	4.41	19.89	7.81	0	4.18	25.97	3.89	8.98	2.77
α(A.M./KM²)	0.36	1.65	0.65	0	0.59	2.16	0.32	0.74	0.23

For additional information and full names of abbreviations see Table 33

Grant's gazelle

Unlike the preceding species which utilized the grassland and the seasonally water-logged bushed grassland more and also unlike eland which were erratic in their use of the different vegetation types, Grant's gazelles used all the available vegetation types thus being the most calholic in their choice. But even then the grassland, seasonally water-logged grassland and bushland had the highest occupance values.

During the first two months of 1971 Grant's gazelles concentrated more in the *Pennisetum mezianum* - *Acacia stuhlmannii* seasonally water-logged grassland and the short grassland coming second. In the next two months, utilization extended into the *Acacia mellifera*-*Acacia stuhlmannii* bushland and the major Acacia-Commiphora woodland. By October utilization also included the main bushland and the following month, the *Acacia nilotica* ssp. *subalata* was included in the occupance. This pattern indicated that more and more of the woodland and bushland subtypes were utilized as the dry season intensified. Taking the period from October to December, all the 9 subtypes were being utilized. Even then, the grassland was utilized continuously both through the wet season and dry season and its total occupance was 1.73 animal months/km^2 followed by the *Pennisetum mezianum* - *Acacia stuhlmannii* seasonally water-logged grassland. The bushland subtypes ranked third with 0.57 and 1.21 animal months/km^2 respectively.

The woodland subtypes were the least utilized with occupance values ranging from 0.18 and 0.47 animal months/km^2.

This pattern of utilization repeated itself in 1972 only that the seasonally water-logged grassland had the highest occupance, and was used in every month except February. The Acacia tortilis - Commiphora schimperi woodland was frequented more. During the beginning of the year, the grassland and Acacia-Commiphora woodland were the most utilized parts. Later on during main rains the seasonally water-logged grassland also became widely used. During the dry season this type together with the bushland became the most utilized. Full details are given on table 36.

Even the χ^2 results for both April 1971 and 1972 confirm that while the grassland was utilized, the numbers observed were not significantly different from those expected. On the other hand the numbers observed in some of the bushland and seasonally water-logged bushed grassland were significantly more than those observed. So were the numbers within the Acacia-tortilis - Commiphora schimperi woodland in April, 1972. All this confirms that Grant's gazelle utilize all the vegetation types with the seasonally water-logged bushed grassland and bushland being the most prominently used habitat. (See tables 43 & 45 for full details).

Table 36

Monthly transect densities and occupance values of Grant's gazelle within the different vegetation types of Simanjiro during 1971 and 1972

Month	Dm - P.c. Grassland	At - C.s. Woodland	An - C.s. Woodland	Cs - Cm Woodland	Cs - A.m. Woodland	A.s. Bushland	Am - A.s. Bushland	Pm - A.S. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
1971									
Jan.	1.73	0	0	0	0	0	0	2.11	0
Feb.	2.00	0	0	0	0	0	0	3.04	0
Mar.	3.43	0.25	0	0	0	1.93	0	0	0
Apr.	1.77	0	0	0	0	0	1.94	3.81	0
May	0.84	0.69	0	0	0	0	2.58	0	1.21
June	-	-	-	-	-	-	-	-	-
July	1.73	0	0	0	0	0	0	2.74	1.75
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	1.16	0.62	0	0	0	0.96	2.59	0	0
Nov.	1.73	1.25	2.29	0	1.66	0	3.83	0	0.87
Dec.	1.66	0	1.95	2.00	0	0	0	1.52	1.38
TOTAL	16.05	3.34	4.24	2.00	1.66	2.89	10.94	13.22	5.21
O(A.M./KM^2)	1.78	0.37	0.47	0.22	0.18	0.32	1.21	1.46	0.57
1972									
Jan	1.99	1.19	1.62	0	0	0	0	0.76	0
Feb.	1.59	0.18	0	1.00	0	0.64	0	0	0.87
Mar.	1.80	0.69	0	5.33	0	0	0	1.37	1.38
Apr.	3.00	0.25	0	0	0	2.54	0	2.43	0
May	3.00	0	0	0	0	0	1.29	5.18	5.55
June	1.94	1.44	0	0	0	0.97	0	3.50	2.08
July	0.74	0	0	0	0	0	0	4.72	0
Aug.	1.45	0	0	0	0	4.54	0	1.76	2.01
Sept.	0.14	0.56	0	0	0	0.36	0.64	0.45	0.67
Oct.	3.08	2.07	0	1.50	2.60	0	2.75	3.50	0
Nov.	2.05	0	3.90	0	0	0	0	6.09	2.63
Dec.	2.62	0.81	0	0	0	0	1.94	2.28	0
TOTAL	23.40	7.19	5.52	7.83	2.60	9.05	6.62	32.04	15.19
O(A.M./KM^2)	1.95	0.59	0.46	0.65	0.21	0.75	0.55	2.67	1.26

For additional information and full names of abbreviations see Table 33

Thomson's gazelle

This is the most particular species with regard to utilization of vegetation types. It is primarily confined to the short grassland. The occupance for 1971 and 1972 of this type was 1.26 and 1.22 animal months/km^2 respectively.

The occupance distribution was similar in both years. The whole of the rainy season was spent in the short grassland. Then main part of the dry season was spent in the grassland with excursions into the woodland primarily the Acacia nilotica ssp. subalata dominated subtype and the main Commiphora woodland. Only in July and August 1972 were a few observed in the main seasonally water-logged bushed grassland and these were near the edge of the grassland habitat. Also in October, 1972 a density of 0.50/km^2 was recorded in the grassland. (See table 37 for full details).

The χ^2 data for April, 1971 and 1972 representing the middle of the rain season show that Thomson's gazelles exclusively preferred the short grassland. In both years, there were more than twice the number expected in the grassland with χ^2 values of 50 and 57.97 respectively.

Impala

Unlike most of the preceding species in which the grassland figured prominently in the utilized habitat

Table 37

Monthly transect densities and occupance values of Thomson's gazelle within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – C.m. Woodland	Cs – A.m. Woodland	A.m. Bushland	Am – A.s Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	1.63	0	0	0	0	0	0	0	0
Feb.	0.54	0	0	0	0	0	0	0	0
Mar.	2.51	0	0	0	0	0	0	0	0
Apr.	3.22	0	0	0	0	0	0	0	0
May	0.92	0	0	0	0	0	0	0	0
June	-	-	-	-	-	-	-	-	-
July	0.88	0	0	0	0	0	0	0	0
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	0.65	0	0.33	0.21	0	0	0	0	0
Nov.	1.02	0	0	0	0	0	0	0	0
Dec.	1.16	0	0	0	0	0	0	0	0
TOTAL	11.36	0	0.33	0.21	0	0	0	0	0
O(A.M./KM^2)	1.26	0	0.03	0.02	0	0	0	0	0

1972

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – C.m. Woodland	Cs – A.m. Woodland	A.m. Bushland	Am – A.s Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	1.62	0	0	0	0	0	0	0	0
Feb.	1.37	0	0	0	0	0	0	0	0
Mar.	1.02	0	0	0	0	0	0	0	0
Apr.	1.16	0	0	0	0	0	0	0	0
May	1.41	0	0	0	0	0	0	0	0
June	1.23	0	0	0	0	0	0	0	0
July	1.27	0	0	0	0	0	0	0.76	0
Aug.	1.55	0	0.60	0.71	0	0	0	0.15	0
Sept.	0.87	0	0.32	0.33	0	0	0	0	0
Oct.	1.13	0.50	1.62	0	0	0	0	0	0
Nov.	0.56	0	0	0	0	0	0	0	0
Dec.	1.38	0	0	0	0	0	0	0	0
TOTAL	14.66	0.50	4.54	1.04	0	0	0	0.91	0
O(A.M./KM^2)	1.22	0.04	0.37	0.08	0	0	0	0.08	0

For additional information and full names of abbreviations see Table 33

going to almost being the exclusive habitat used by Thomson's gazelle, impalas mostly utilized the Acacia-Commiphora woodland habitat. The bushland and grassland were utilized much less and the seasonally waterlogged bushed grassland was the least utilized. The habitats mostly used were the Acacia tortilis and Acacia nilotica ssp. subalata woodlands. The former woodland was the most frequented.

In 1971 at the beginning of the rains the impalas were mostly in these woodlands supplemented by the Acacia Commiphora bushland in which Acacia mellifera is the associated species. Although none were recorded within the transects in March, the distribution pattern was the same in April and May but this time they also used the grassland. During the dry season utilization was centred in the woodland, particularly the Acacia tortilis dominated one. Taking the 9 month recorded data for that year this main woodland subtype topped the list with an occupance of 1.26 animal months/km^2 closely followed by the Acacia nilotica ssp. subalata dominated woodland. The pattern was the same in 1972 with slight differences. There was the presence of impala in the grassland at the beginning of the rains and later on in April, and in December. Also the Commiphora schimperi - Acacia mellifera woodland was highly utilized being placed third in occupance to the main woodland subtypes. It should be mentioned that the highest densities of any given type were recorded in the Acacia nilotica ssp. subalata

Table 38

Monthly transect densities and occupance values of Impala within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm - P.c. Grassland	At - C.m. Woodland	An - C.m. Woodland	Cs - Cm Woodland	Cs - A.m. Woodland	A.m. Bushland	Am - As Bushland	Pm - A.m. seasonally water-logged Grassland	Pm - Ad. seasonally water-logged Grassland
Jan.	0	1.89	0	0	1.36	0	0	0	0
Feb.	0	1.08	2.60	0	0	0	5.84	0	0
Mar.	0	0	0	0	0	0	0	0	0
Apr.	0.77	0	0	2.10	0	0	0	0	0
May	0.35	2.62	0	0	0	0.16	0	0	0
June	-	-	-	-	-	-	-	-	-
July	0	0	1.62	1.00	1.66	0	0	0	0
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	0	3.45	0	0	0	0	0	0	0
Nov.	0	2.31	6.51	4.33	0	0	0	0	0
Dec.	0	0	0	0	0	0	0	0	0
TOTAL	1.12	11.35	10.73	7.43	3.02	0.16	5.84	0	0
O(A.M./KM^2)	0.12	1.26	1.19	0.82	0.33	0.01	0.64	0	0

1972

Month	Dm - P.c. Grassland	At - C.m. Woodland	An - C.m. Woodland	Cs - Cm Woodland	Cs - A.m. Woodland	A.m. Bushland	Am - As Bushland	Pm - A.m. seasonally water-logged Grassland	Pm - Ad. seasonally water-logged Grassland
Jan.	1.77	0.44	0	0	0	0	1.29	0.60	0
Feb.	0.14	0.18	1.62	0	2.25	0	0	0	0
Mar.	0	0	1.86	0	0	0	0	0	0
Apr.	0.21	0.42	0	2.40	1.40	0	0	0	2.77
May	0	3.96	0.21	0	0	0	0	0	0
June	0	4.00	2.57	0	0	0	0	0	0
July	0	0	2.90	1.00	0	4.22	0	1.01	0.87
Aug.	0	1.88	0	0	1.90	0	2.86	0	0
Sept.	0	0	0	1.42	2.12	0	0	0	0
Oct.	0	0.37	6.01	5.33	2.67	0	5.46	0	0
Nov.	0	1.88	0	0	2.11	2.32	0	0	0.87
Dec.	0.56	4.15	0	0	2.25	0	0	0	0
TOTAL	2.68	17.28	15.17	10.15	14.70	6.54	9.61	1.61	4.21
O(A.M./KM^2)	0.22	1.44	1.26	0.84	1.22	0.54	0.80	0.13	0.35

For additional information and full names of abbreviations see Table 33

dominated woodland during the dry season. This indicated an intensive utilization of this type during certain times during the dry season. Also during this time the bushland was frequented more (See table 38 for details).

Since observations in April, 1971 were not typical, only the April, 1972 data will be discussed as far as the test for preference is concerned. Data confirm the above observations with the main Acacia-Commiphora woodland subtypes and _Acacia_ _mellifera_ - _A. stuhlmannii_ bushland having significantly more than the expected number of impalas (See table 45 for details).

Giraffe

Giraffes, like Grant's gazelle, utilized all the vegetation types. The most prominently used were the woodland, seasonally water-logged bushed grassland and bushland. The grassland was the least utilized habitat. This utilization pattern is similar to that of impalas except that the latter were not much fond of the seasonally water-logged area.

During the first three months of 1971 the giraffes were concentrated in the _Pennisetum_ _mezianum_ - _Acacia_ _drepanolobium_ seasonally water-logged bushed grassland at a density of 1.45 to 3.34/km^2 followed by the _Commiphora_ _schimperi_ - _Acacia_ _mellifera_ woodland. A lower density was in the other seasonally water-logged subtype while the lowest density was in the grassland. All the woodland subtypes were the main utilized habitat during the main rain season from April to May. The highest recorded density was 7.91 recorded in May in the Commiphora schimperi - Acacia mellifera woodland. A few were still utilizing the grassland at a density of less than $1/km^2$. The situation was much the same in July except that the lesser seasonally water-logged habitat was also occupied. The last part of the year saw higher utilization of this habitat together with the bushland in addition to the Acacia-Commiphora subtypes and minimal use of the grassland.

The situation was the same in 1972 and the complete data gave the true pattern. The highly utilized part between January and February was the Pennisetum mezianum-Acacia drepanolobium seasonally water-logged bushed grassland followed by the Acacia tortilis-Commiphora schimperi woodland. This situation continued throughout the rains and practically all other vegetation subtypes were used at one time or another. At the beginning of the dry season utilization was centred in the woodland with a density of $5.21/km^2$ recorded in June within the Acacia nilotica ssp. subalata - Commiphora schimperi woodland. During the main dry season period from August to October, the giraffes utilized the Acacia mellifera - A. stuhlmannii bushland the most together with the second woodland subtype. By the end of the year, they had shifted more into the Pennisetum mezianum - Acacia drepanolobium

Table 39

Monthly transect densities and occupance values of giraffe within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm - P.c. Grassland	At - C.s. Woodland	An - C.s. Woodland	Cs - Cgm Woodland	Cs - Am Woodland	A.s. Bushland	Am - As Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	0.03	0	0	0	1.36	0	0	1.21	0
Feb.	0.14	0	0	0	0	0	0	0	3.34
Mar.	0	0	0	0	0	0	0	0.91	1.45
Apr.	0.17	0	1.67	0	0	0	0	0	0
May	0.12	0.48	0.16	0.50	7.91	0.60	0	0	0
June	-	-	-	-	-	-	-	-	-
July	0.21	0.06	0	0.66	0	0	0	0	0.87
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	0.07	0	0.32	0	0	1.93	0	0	0
Nov.	0	0.18	0.32	0	0	0.32	0	0	2.24
Dec.	0	0	0	0	0	0	0	0	0
TOTAL	0.74	0.78	2.47	1.16	9.27	2.85	0	2.20	7.90
O(A.M./KM^2)	0.08	0.08	0.27	0.12	1.03	0.31	0	0.24	0.87

1972

Month	Dm - P.c. Grassland	At - C.s. Woodland	An - C.s. Woodland	Cs - Cgm Woodland	Cs - Am Woodland	A.s. Bushland	Am - As Bushland	Pm - A.s. seasonally water-logged Grassland	Pm - A.d. seasonally water-logged Grassland
Jan.	0.28	2.07	0.65	0	0	0	1.94	1.37	11.08
Feb.	0	0	0	0	0	0.64	0	0	0
Mar.	0.03	1.44	0	1.00	0	3.40	0	0	5.55
Apr.	0	1.00	0	0.45	0	0	1.29	1.67	2.77
May	0.03	0.06	0	0	2.50	0.81	0	0	0
June	0.10	0	5.21	1.33	0	1.13	0	0	0
July	0.24	0.06	0.91	0.25	0.46	0	1.04	0.76	1.38
Aug.	0	0	0	0	1.66	2.11	0	0.45	1.38
Sept.	0.14	0.18	0	0	0.83	0	0.48	0	0
Oct.	0	0.31	0	0	0	0	0.64	0.60	0
Nov.	0	0.31	0.32	0	0	0	0.81	1.06	6.42
Dec.	0	0.37	0	0	3.18	0.78	0.32	0	2.29
TOTAL	0.82	5.29	7.09	3.58	8.63	8.87	6.52	5.91	30.87
O(A.M./KM^2)	0.06	0.44	0.59	0.29	0.71	0.73	0.54	0.49	2.57

For additional information and full names of abbreviations see Table 33

seasonally water-logged bushed grassland. This subtype had the highest occupance of 2.57 animal months/km^2. (See table 30 for details).

In view of the absence of giraffes in the April, 1971 transects, it was decided to use only the 1972 data for the vegetation preference test. The χ^2 data matches completely with occupance. The <u>Acacia tortilis</u> dominated woodland, the seasonally water-logged bushed grassland, with <u>Acacia drepanolobium</u> and the Commiphora woodland had significantly more giraffes than expected if they were randomly distributed (See table 43 for details).

<u>Ostrich</u>

The occupance of the different vegetation types by ostrich, though a bird, very much resembled that of Grant's gazelle. The highest occupances for both 1971 and 1972 were within the <u>Pennisetum mezianum</u> - <u>Acacia stuhlmannii</u> seasonally water-logged bushed grassland followed by the short grassland. The values were between 0.5 and 1.96 animal months/km^2. The habitats utilized next were the <u>Acacia tortilis</u> - <u>Commiphora schimperi</u> woodland and the bushland. The least utilized parts were the remaining woodland sub-types.

From January to April, 1971 the most utilized part was the already mentioned seasonally water-logged bushed grassland and the short grassland. The densities in the former habitat varied from $3.04/km^2$ to $4.57/km^2$ while densities in the grassland varied from $0.14/km^2$ to $2.16/km^2$. The Acacia tortilis dominated woodland was utilized in April and May while the Acacia nilotica ssp. subalata dominated woodland was only used in April. During the dry season the ostriches were recorded mainly within the Commiphora woodland, grassland and the dominant bushland sub-type. The distribution at the end of the year reverted to what it was at the beginning of the year.

The pattern of occupance in 1972 was identical to that of the previous year. The frequency of occupance in the seasonally water-logged bushed grassland, bushland and the dominant woodland subtypes increased over that recorded in the previous year. Ostriches were recorded in the first mentioned habitat in all the months. Next in frequency was the grassland. Only in October were ostriches not recorded in this habitat. (See table 40 for full details).

The preference test made with the April data in order to assess the situation during the middle of the rains conformed to expectation. In both 1971 and 1972 the numbers recorded in the seasonally water-logged bushed grassland and bushland were significantly more than the expected ones. Those recorded in the grassland and the Acacia tortilis dominated woodland were significantly less than the expected numbers. The

Table 40

Monthly transect densities and occupance values of Ostrich within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – Cm Woodland	Cs – A.m. Woodland	A.s. Bushland	Am – A.s Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	0.49	0	0	0	0	0	0	3.04	0
Feb.	0.16	0	0	0	0	0.80	0	3.04	0
Mar	2.16	0	0	0	0	0	0	3.35	0
Apr.	0.14	0.37	1.30	0	0	0	1.29	4.87	0
May	1.98	2.26	0	0	0	0	0	0.76	0
June	–	–	–	–	–	–	–	–	–
July	0.70	0	0	0	0	0	0	0	1.75
Aug.	–	–	–	–	–	–	–	–	–
Sept.	–	–	–	–	–	–	–	–	–
Oct.	1.09	0.06	0	4.33	0	0	0	0	0
Nov.	0.74	0	0	0	0	0.16	0	0	0
Dec.	0.84	0.06	0	0	0	0.97	0	2.59	0
TOTAL	8.30	2.75	1.30	4.33	0	1.93	1.29	17.65	1.75
O(A.M./KM^2)	0.92	0.30	0.10	0.36	0	0.21	0.14	1.96	0.14

1972

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – Cm Woodland	Cs – A.m. Woodland	A.s. Bushland	Am – A.s Bushland	Pm – A.s. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	0.21	1.19	0	0	0	0	0	4.11	0
Feb.	0.70	0.37	0	0	0	0	0.64	0.21	0.17
Mar.	0.07	1.19	0	0	0	0	0	2.21	1.28
Apr.	0.46	0.37	0	0	0	0	3.14	2.13	1.38
May	0.33	0.06	0	0	0	0	0	1.37	0
June	0.81	0	0	0	0	0.32	0	0.15	0
July	0.17	0.75	0	0	0	0	0	0.45	0
Aug.	0.95	0	0	0	0	0	0	0.76	0
Sept.	1.06	0	0	0	3.33	0	0.16	0.45	0.87
Oct.	0	0.44	1.30	0	0	0	0.32	1.98	0
Nov.	0.31	0	0	0	0	0	0	1.37	0
Dec.	0.42	0	0	1.66	0	0	0	0.30	0
TOTAL	5.49	4.37	1.30	1.66	3.33	0.32	4.26	15.49	3.70
O(A.M./KM^2)	0.45	0.36	0.10	0.13	0.27	0.02	0.35	1.29	0.30

For additional information and full names of abbreviations see Table 33

situation was much the same in October during the peak of the dry season (See tables 43 & 45 for details).

Cattle

In contrast to wildebeest the main wild bovine in Simanjiro which mainly concentrated in the grassland, cattle utilized all vegetation subtypes. Its occupance pattern was nearer to that of zebra. Cattle being the most numerous species in the plains obviously showed the highest densities. The most utilized habitats in terms of occupance were the Acacia nilotica ssp. subalata dominated woodland and the Commiphora woodland. They had values of 71.92 and 55.36 animal months/km^2 respectively in 1971 and 81.60 and 42.73 animal months/km^2 respectively in 1972. The highest densities in the woodland were mainly during the rains while those in the grassland were mainly during the dry season. Inspite of being third in occupance, the grassland was the most frequented habitat. Cattle were recorded there during all the censuses. The bushland and Commiphora schimperi - Acacia mellifera woodland were the least used habitats.

The results of the χ^2 analysis for April both in 1971 and 1972 corresponded with occupance. The largest number of cattle were within the grassland but they were not significantly more than the expected number in 1971 and they were actually significantly less than the expected number in the following year. The Acacia niloti ssp. subalata dominated woodland had significantly more

Table 41

Monthly transect densities and occupance values of cattle within the different vegetation types of Simanjiro during 1971 and 1972

1971

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – Cmq Woodland	Cs – A.m. Woodland	A.s. Bushland	Am – A.s. Bushland	Am – A.s. seasonally water-logged Grassland	PH – A.d. seasonally water-logged Grassland
Jan.	14.12	12.76	13.02	53.33	72.72	0	13.77	0	0
Feb.	17.48	4.70	7.14	25.00	155.80	0	0	6.46	0
Mar.	45.30	6.45	62.04	92.00	0	0	0	0	0
Apr.	47.49	2.20	29.34	20.00	0	0	0	38.10	0
May	65.72	0	254.07	133.33	0	7.26	19.48	63.71	0
June	–	–	–	–	–	–	–	–	–
July	25.37	14.46	81.43	9.00	0	48.46	0	118.90	52.63
Aug.	–	–	–	–	–	–	–	–	–
Sept.	–	–	–	–	–	–	–	–	–
Oct.	65.65	10.34	146.57	150.00	0	16.15	0	0	65.78
Nov.	98.05	34.59	53.74	15.66	0	1.77	0	28.96	25.48
Dec.	55.99	15.40	0	0	0	69.80	0	0.45	113.61
TOTAL	433.17	120.87	647.32	498.32	228.52	143.44	33.25	256.58	257.50
O(A.M./KM²)	48.13	13.43	71.92	55.36	25.39	15.93	3.69	28.50	28.61

1972

Month	Dm – P.c. Grassland	At – C.s. Woodland	An – C.s. Woodland	Cs – Cmq Woodland	Cs – A.m. Woodland	A.s. Bushland	Am – A.s. Bushland	Am – A.s. seasonally water-logged Grassland	PH – A.d. seasonally water-logged Grassland
Jan.	3.43	41.82	232.14	3.66	0	34.09	0	274.00	0
Feb.	9.70	67.61	144.95	153.33	71.66	17.85	107.78	0	62.50
Mar.	20.89	73.53	43.97	12.50	17.26	53.57	0	107.62	76.38
April	36.81	72.32	87.94	0	0	9.56	0	15.24	17.36
May	62.88	24.33	107.49	43.33	0	3.40	0	135.94	138.88
June	64.68	27.04	0	35.00	0	26.46	0	0	0
July	74.43	19.49	100.97	106.66	0	49.67	0	50.30	0
Aug.	63.05	15.72	14.65	0	0	4.54	0	8.84	0
Sept.	32.40	7.67	113.02	78.33	15.38	0	34.09	9.14	0
Oct.	68.00	13.83	48.85	46.66	82.72	0	0	69.78	0
Nov.	38.49	35.84	46.25	33.32	0	0	0	39.63	0
Dec.	2.76	8.30	39.08	0	0	0	0	C	0
TOTAL	468.50	409.50	979.31	512.79	187.02	199.14	141.87	456.49	295.12
O(A.M./KM²)	39.04	34.12	81.60	42.73	15.58	16.59	11.82	38.04	24.59

For additional information and full names of abbreviations see Table 33

than the expected numbers in both years and so was the Commiphora woodland. The main seasonally water-logged bushed grassland had the highest χ^2 value there being very significantly more cattle than were expected. In October which represented the dry season, the grassland had significantly more than the expected number of cattle in 1971. The Commiphora woodland had high preference during both years (See tables 43-46 for details).

Goats and sheep

The occupance pattern of goats and sheep was not similar to that of cattle. Although the highest recorded occupance during both years was in the Pennisetum mezianum - Acacia drepanolobium seasonally water-logged bushed grassland, this was caused by high densities varying from 76.38 to 263.15/km^2 in some months, otherwise this habitat had no goats recorded in it during most of time. Consequently the most utilized habitat was the Acacia-nilotica ssp. subalata dominated woodland. The main seasonally water-logged bushed grassland was also highly utilized and particularly so in 1972. The bushland sub-types also had sporadic intensive utilization during the dry season reflected in high occupance values. The grassland and the Acacia tortilis dominated woodland had similar occupances. They were 5.12 and 5.07 animal months/km^2 respectively in 1971 and 6.61 and 7.44 animal months/km^2 respectively in 1972. Similarly, these habitats were the most frequented. In 1972 only in one month out of the whole year were there no goats in each of them. The Acacia nilotica ssp. subalata which had the next frequency missed out on three months. The Commiphora woodland was the least utilized habitat. (See table 42 for details).

The χ^2 data show that the Acacia nilotica ssp. subalata dominated woodland was the most preferred habitat in April. In 1971 it contained 125 goats compared to 13 expected ones which gave a high χ^2 value of 964.92. Similarly in April 1972 it had 274 as opposed to 53 expected ones giving a χ^2 of 921.53. The bushland in 1971 had the next highest preference but in 1972 it was the Acacia tortilis dominated woodland. The grassland always had significantly less than the expected number, thus reflecting low preference by goats. During October, both in 1971 and 1972, the Acacia stuhlmannii bushland showed the highest preferences. Although the Acacia-Commiphora woodland subtypes and the grassland had goats, the numbers contained were significantly less than those expected due to random distribution (See tables 43-46 for details).

Table 42

Monthly transect densities and occupance values of goats and sheep within the different vegetation types of Sinanjiro during 1971 and 1972

1971

Month	Dm – P.e. Grassland	Ab – C.m. Woodland	Am – C.m. Woodland	Cm – Cgm Woodland	Cm – A.m. Woodland	A.m. Bushland	Am – A.m. Bushland	Pm – A.m. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	7.08	10.69	26.05	10.00	16.16	2.92	0	0	5.74
Feb.	3.82	10.68	30.88	0	0	0	0	0	0
Mar	7.78	12.40	32.52	6.66	0	0	0	0	0
April	2.83	0	40.71	0	0	4.84	0	0	0
May	8.79	0	33.33	33.33	0	0	0	28.96	0
June	-	-	-	-	-	-	-	-	-
July	1.59	5.66	0	0	0	0	0	5.33	263.15
Aug.	-	-	-	-	-	-	-	-	-
Sept.	-	-	-	-	-	-	-	-	-
Oct.	5.31	6.28	17.08	0	0	0	90.90	0	0
Nov.	8.85	0	26.05	0	0	25.84	0	12.19	0
Dec.	2.83	0	13.02	0	0	0	0	0.91	1.38
TOTAL	46.10	45.71	219.56	49.49	16.16	33.60	90.90	47.39	270.27
O(A.U./KM²)	5.12	5.07	24.39	5.55	1.79	3.73	10.10	5.26	30.03

1972

Month	Dm – P.e. Grassland	Ab – C.m. Woodland	Am – C.m. Woodland	Cm – Cgm Woodland	Cm – A.m. Woodland	A.m. Bushland	Am – A.m. Bushland	Pm – A.m. seasonally water-logged Grassland	Pm – A.d. seasonally water-logged Grassland
Jan.	4.38	5.03	26.05	0	0	28.40	0	22.86	0
Feb.	5.31	6.28	0	0	0	0	0	0	65.97
Mar.	7.79	5.03	32.57	0	0	0	0	107.62	76.38
Apr.	2.12	25.17	43.64	0	0	0	9.09	3.04	6.94
May	10.25	16.66	0	0	0	0	0	45.73	0
June	20.33	7.54	9.77	0	0	12.98	0	3.81	0
July	22.66	0	13.02	0	48.33	0	0	13.71	0
Aug.	0	8.80	14.65	0	0	0	0	9.14	0
Sept.	3.18	1.57	0	0	0	0	0	27.43	0
Oct.	21.06	0.37	11.40	26.66	5.00	94.15	11.36	45.82	0
Nov.	2.12	3.14	9.77	0	0	0	0	18.29	12.19
Dec.	2.12	9.43	28.99	0	0	0	0	6.85	37.35
TOTAL	79.37	89.32	189.86	26.66	53.33	135.53	20.45	304.30	530.26
O(A.U./KM²)	6.61	7.44	15.82	2.22	4.44	11.29	1.70	25.35	44.18

For additional information and full names of abbreviations see Table 37

Chi-Square (χ^2) values for testing the degree of random distribution of large herbivores among the different vegetation types of Simanjiro during the April, 1971 census

Species	Dm – Pc Short Grass-land	At – Cs Woodland	An – Cs Woodland	Cs – Ca Woodland	Pm – Ad seasonally water-logged bushed Grassland	As Bushland	An – As Bushland	Cs – An Woodland	Pm – As seasonally water-logged bushed Grassland	
	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	$\sum \chi^2$
Cattle	0.27	374.63	108.70	111.00	2475.94	194.88	172.00	2617.31	17.72	3783.45
Goats and Sheep	57.19	45.00	964.92	6.00	6.00	83.33	8.00	5.00	16.00	1191.44
Zebra	11.13	1.38	84.55	21.33	7.27	359.67	70.00	39.20	9.02	1603.73
Wildebeest	346.32	106.85	58.00	26.00	3.45	76.50	37.00	0.04	22.54	676.70
Grant's gazelle	1.28	22.00	6.00	3.00	27.00	9.60	4.90	3.00	3.13	79.91
Thomson's gazelle	50.00	14.00	4.00	2.00	2.00	9.00	3.00	2.00	5.00	91.00
Eland	2.67	2.00	1.00	0	0	2.00	0	0	9.00	16.67
Impala	32.05	15.00	4.00	2.00	2.00	0.10	348.33	420.50	5.00	821.96
Ostrich	9.00	4.00	1.00	0	1.00	33.33	9.00	0	4.00	56.33

Dm – Digitaria macroblephara
Pc – Panicum coloratum
Pm – Pennisetum mezianum
At – Acacia tortilis
Cs – Commiphora schimperi
An – Acacia nilotica ssp. Subalata
Ca – Commiphora africana
Ad – Acacia drepanolobium

Chi-Square (χ^2) values for testing the degree of random distribution of large herbivores among the different vegetation types of Simanjiro during the October 1971 Census

Species	Dm - Pc Short Grassland	At - Cs Woodland	An - Cs Woodland	Cs - Ca Woodland	Pm - Ad seasonally water-logged bushed Grassland	As Bushland	Am - As Woodland	Cs - Am Woodland	Pm - As seasonally water-logged bushed Grassland	
	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	$\sum \chi^2$
Cattle	268.88	419.76	2.27	2092.80	28.00	597.83	187.00	3046.23	230.53	6873.30
Goats & Sheep	11.50	80.00	18.00	13.00	2.00	905.56	12.00	3.00	30.00	1075.06
Zebra	-	-	-	-	-	-	-	-	-	-
Wildebeest	-	-	-	-	-	-	-	-	-	-
Grant's gazelle	0.78	14.00	1.33	50.00	0	1.00	1.00	1.00	5.00	61.25
Thomson's gazelle	21.24	7.00	8.00	1.00	0	5.00	1.00	0	3.00	46.24
Eland	-	-	-	-	0	-	-	-	-	-
Impala	-	-	-	-	-	-	-	-	-	-
Giraffe	8.10	2.25	0	1.00	0	1.33	0	0	2.00	14.68
Ostrich	13.47		2.00	1.00		3.20	2.00	0	3.00	27.80

For full names of abbreviations of vegetation sub types see table 43

Chi-Square (X^2) values for testing the degree of random distribution of large herbivores among the different vegetation types of Simanjiro during the April, 1972 Census

	Pn - Pe Short Grassland	Ab - Cs Woodland	Am - Cs Woodland	Cs - Ca Woodland	Pn - Ad seasonally Water-logged bushed grassland	A.s Bushland	Am - As Bushland	Cs - Am Woodland	PM - As seasonally Water-logged bushed grassland	
	X^2	X^2	X^2	X^2	X^2	X^2	X^2	X^2		$\sum X^2$
Cattle	244.92	177.57	22.22	10.38	103.04	749.42	25.38	28.67	325.24	1681.24
Goats & Sheep	164.15	309.01	921.53	25.00	30.00	10.14	7.47	38.00	134.00	1639.30
Zebra	385.35	111.00	19.00	2.78	11.00	40.00	20.00	13.00	47.00	649.13
Wildebeest	390.76	253.00	43.00	20.00	25.00	6.72	46.02	31.00	1.55	817.05
Grant's gazelle	0.87	7.31	6.00	3.00	3.00	1.92	11.57	4.00	1.67	39.34
Thomson's gazelle	57.97	17.00	3.00	1.00	2.00	6.00	3.00	2.00	7.00	98.97
Eland	15.00	1.29	1.00	1.00	1.00	3.00	1.00	196.00	33.33	250.62
Impala	17.00	10.00	2.00	1.00	10.89	4.00	2.00	64.00	4.00	1191.00
Giraffe	9.09	28.00	1.00	4.00	1.00	2.00	1.00	1.00	3.00	50.09
Ostrich	0.03	13.47	3.00	2.00	2.00	51.57	4.00	2.00	12.50	90.57

For full names of abbreviations of vegetation sub types see table 43

Chi-Square (χ^2) values for testing the degree of random distribution of large herbivores among the different vegetation types of Simanjiro during the October, 1972, Census

[illegible]	Bm – Pe Short Grassland	Ab – Cs Woodland	Am – Cs Woodland	Cs – Cn Woodland	Pm – Ad seasonally water-logged bushed grassland	As Bushland	Am – As Bushland	Cs – Am Woodland	Pm – As seasonally water-logged bushed grassland	
	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	χ^2	$\sum \chi^2$
Cattle	0.21	266.53	135.84	587.00	62.67	21.31	188.00	32715.78	310.09	34067.63
Goats & Sheep	102.74	301.12	11.20	111.20	22.00	204.62	30.00	24.00	36.91	843.67
Zebra	13.33	3.00	113.88	3.00	1.00	7.00	2.00	1.00	7.00	151.21
Wildebeest	38.67	9.00	4.00	9.00	3.00	1.32	5.00	2.25	18.05	90.00
Grant's gazelle	4.42	1.82	18.00	0.89	31.57	10.63	9.00	7.00	0.03	102.76
Thomson's gazelle	10.32	11.00	18.00	4.50	1.00	4.00	1.00	1.00	4.00	54.82
Eland	–	–	–	–	–	–	–	–	–	–
Impala	38.72	14.29	217.80	28.80	2.00	111.36	3.00	0.50	10.08	426.55
Giraffe	7.00	1.00	1.00	1.00	0	16.00	0	0	4.50	30.50
Ostrich	0	0.31	3.00	3.00	1.00	16.20	1.00	1.00	0.67	26.18

For full names of abbreviations of vegetation sub types see table 43

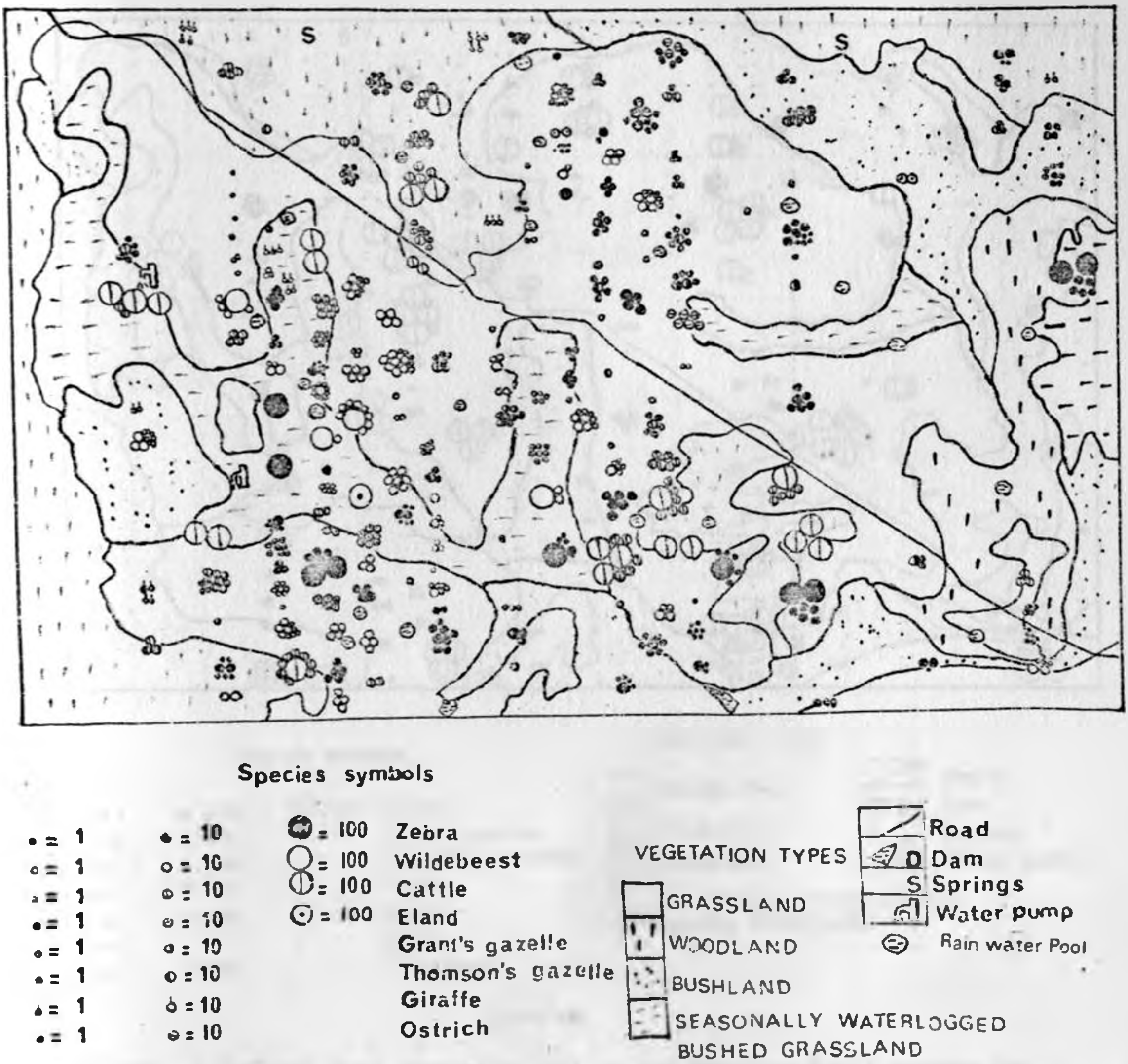


Figure 15

Results of the 1971 aerial transect counts of the Simanjiro Plains showing the general distribution of large herbivores in the middle of the rains. Goats and sheep are not shown.

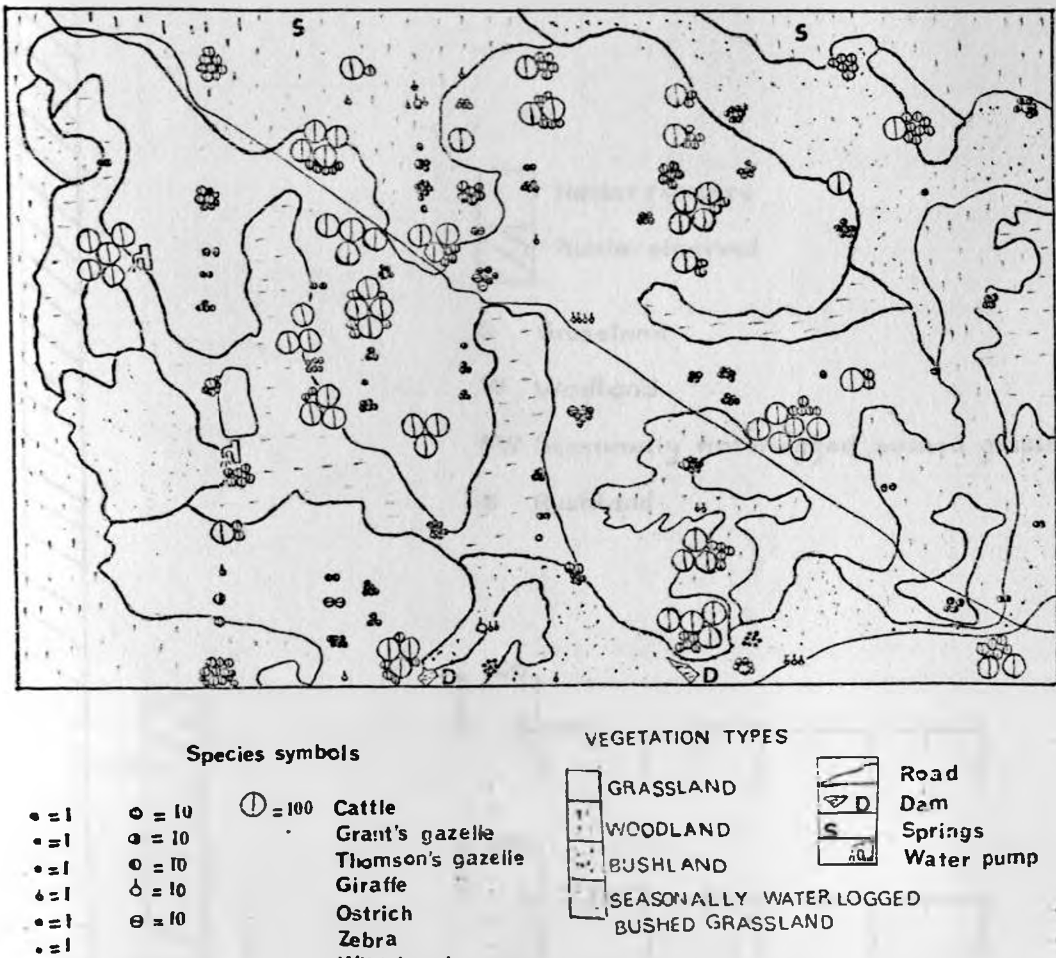


Figure 16

Results of the 1971 aerial transect counts of the Simanjiro Plains showing the general distribution of large herbivores in the middle of the dry season. Goats and sheep are not shown.

Figure 17

The distribution of large herbivores in the vegetation communities of Simanjiro during the April 1971 wet season count

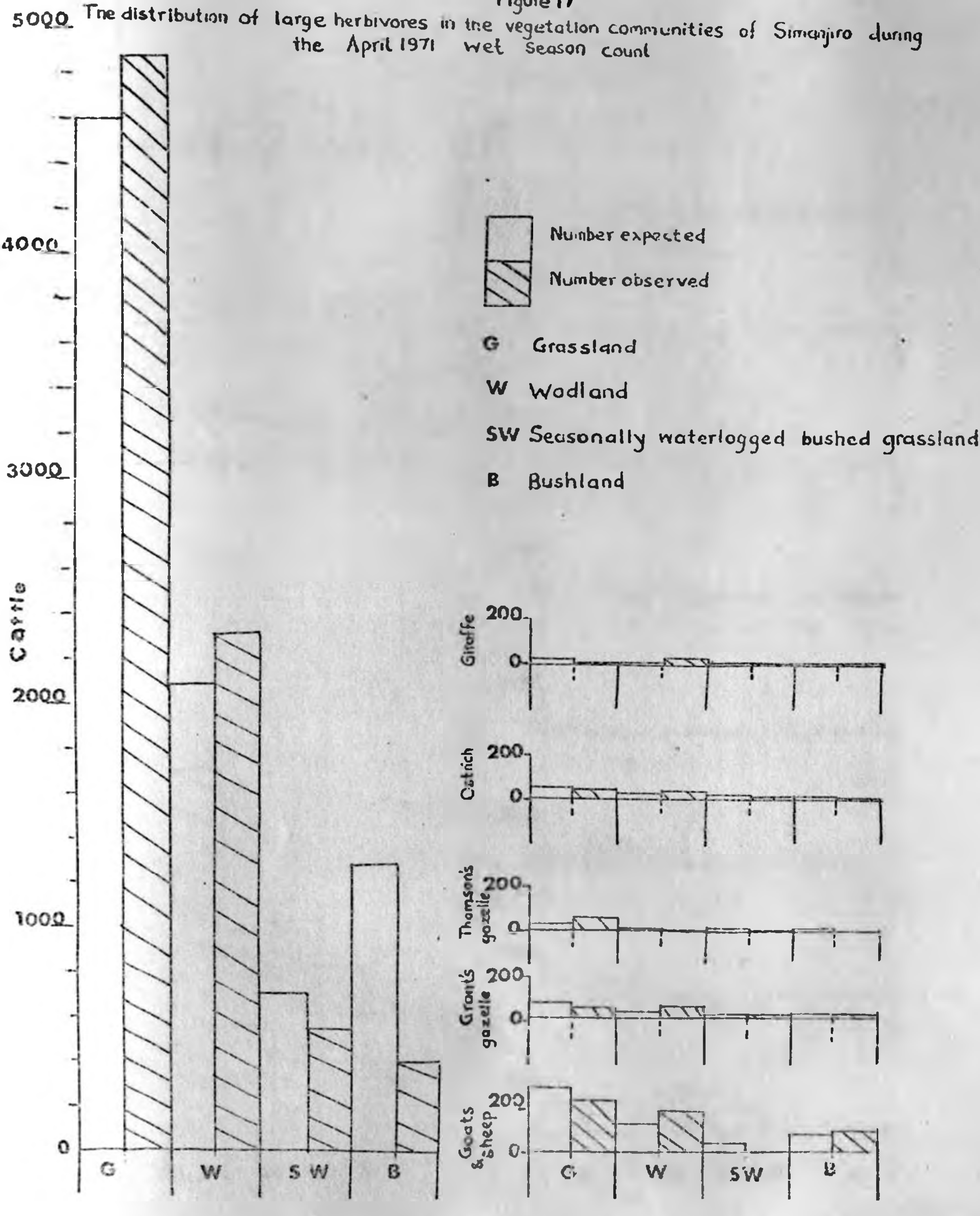
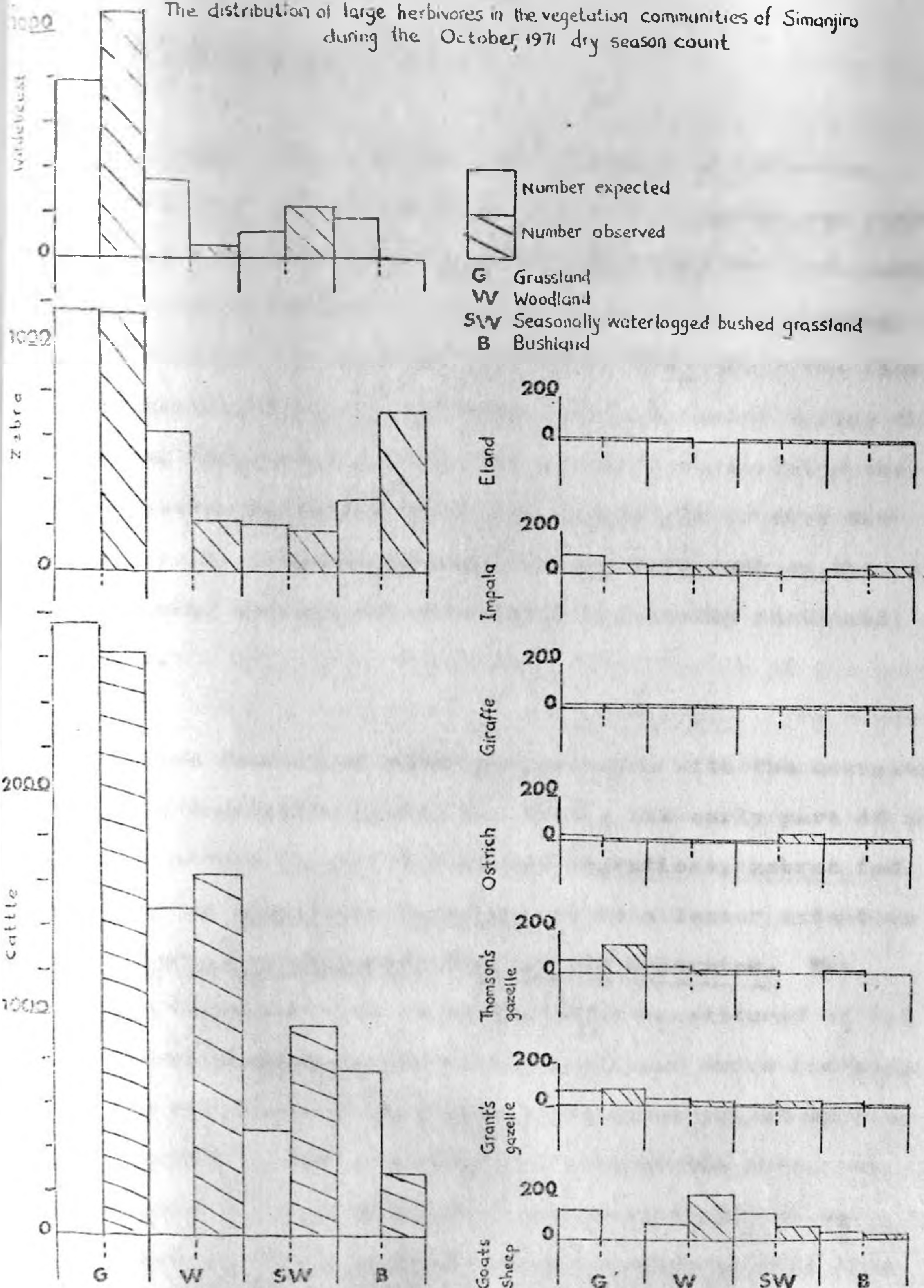


Figure 18

The distribution of large herbivores in the vegetation communities of Simanjiro during the October, 1971 dry season count



(ii) Feeding by herbivores

Feeding observations were carried out on zebra, wildebeest, Grant's gazelle, Thomson's gazelle and cattle as these represent the main wild and domestic herbivores using the Simanjiro plains. Results of these feeding observations are presented on table 47. Since the first two mentioned species migrate into the plains during the rains, their feeding observations only represented the wet season while for the other species it covered the full year. Occasional observations were made on the remaining species and these will be briefly mentioned later.

The feeding of zebra corresponded with the occupance of the vegetation habitats. During the early part of the rains at the time of the inward migrations, zebras fed mostly on Pennisetum mezianum and to a lesser extent on Digitaria macroblephara and Panicum coloratum. The first mentioned species is the major constituent of the seasonally water-logged bushed grassland which had high zebra occupance at this time. The other grazed species are mainly in the grassland and some of the more open woodland subtypes which also had considerable zebra occupance. Other species fed on by zebra at this time were Themeda triandra, Sporobolus fimbriatus and Cenchrus ciliaris all of which are mainly woodland species. The average grazing height of zebra was 20 cm with a range of 4.1 - 40 cm which generally corresponded with the medium height grasses which constituted rough herbage. Later on as the rains increased, zebras fed mainly on Digitaria macroblephara and Panicum coloratum. Other plants commonly eaten included Eustachys paspaloides, Cynodon dactylon and Eragrostis superba. The feeding level was about 15 cm and corresponded with the short grass species, the major constituent of the grassland in which zebras were concentrated at this time. Also these species constitute a large portion of the ground layer of the Acacia nilotica and Commiphora dominated woodland in which some zebras were found at this time. As the rains receded, the zebras reverted back to the taller rough herbage on which they first fed on at the beginning of the rains mainly Pennisetum mezianum. The importance of this species is reflected in the fact that it constituted about the quarter of the bites. Other species fed on included Lintonia nutans and Setaria incrassata all of which are found in the seasonally water-logged grassland which had high zebra occupance.

Wildebeests followed a similar trend to that of zebra except that they grazed in places already shortened by the former species. At the beginning of the rains they grazed on Pennisetum mezianum for a shorter period than zebras did as reflected by the former's shift of occupance from the seasonally water-logged bushed grassland to the grassland earlier than zebras. Their main diet during the rains was Digitaria macroblephara and Panicum coloratum and hence the high occupance of the short grassland by wildebeest at this time. The two species constituted almost half of the observed number of bites. At the onset of the dry season just before the outward migration, they took in more Pennisetum mezianum, Setaria incrassata and Lintonia nutans. These species especially flourished on the edge between the grassland and seasonally water-logged bushed grassland and hence the frequenting of this habitat by wildebeest at this time. The grazing height of wildebeest was lower than that of zebra. The range was from 3.5 to 36 cm with an average of 16.57 cm.

Contrary to the former two species whose diet was mainly composed of grasses, Grant's gazelle had a wide array of plants both grasses and shrubs to feed on. While zebras were seen feeding on 15 species, Grant's gazelles fed on 23 species. During the rains their diet consisted of those species taken by the former two species plus Cyathula cylindrica, Sericocomopsis hildebrandtii, Euphorbia systyloides Crotalaria spinosa and Indigofera sp. During the dry season the proportion of shrubs taken increased substantially constituting more than half of the observations. The main species browsed were Sericocomopsis hildebrandtii. Acacia tortilis regeneration and some legumes. As the dry season intensified they even took dry twigs of Ipomoea hildebrandtii and the spiny Barleria ramulosa. They were also seen feeding on Acacia tortilis pods. Their average grazing height was 25.4 cm but their maximum feeding height exceeded that of zebra or wildebeest ranging from 5.3 to over 50 cm.

Unlike its related preceding species, Thomson's gazelles ate more grasses than shrubs. The grasses constituted 87% of the total bites observed during the rains. The composition of species taken was similar to that of Grant's gazelle but contained higher proportions of Digitaria macroblephara, Panicum coloratum, Cynodon dactylon Themeda triandra, Pennisetum mezianum and Eustachys paspaloides. Shrubs taken were only a portion of those taken by Grant's gazelle. During the dry season, they took in more shrubs particularly legumes. The average grazing height was 7 cm with a range of 2 to 18 cm.

Observations on cattle during the rains showed very similar grazing to that of wildebeest. They also took in some shrubs such as Cyathula orthocantha, Rynchosia minima and Crotalaria sp. During the dry season they still mostly fed on grasses but they included more shrubs including Sericocomopsis hildebrandtii, Achyranthes aspera, Indigofera sp. and Crotalaria sp. They were also seen feeding on Acacia tortilis pods. The average grazing height was 9 cm with a range of 4.5 to 28.5 cm.

No systematic records were made on the rest of the species but casual observations were made. Giraffes were mostly seen feeding on Acacia drepanolobium and A. tortilis. The former species is abundant in the lesser subtype of the seasonally water-logged bushed grassland in the west at Lekitejo. This habitat had a high giraffe occupance. The second mentioned tree formed the main diet in the woodland and grassland localities with tree regeneration. In fact most of the sparse Acacia tortilis regenerating in the grassland had a hedged appearance because of heavy browsing by giraffe. Other trees on which giraffes were seen feeding on were Acacia nilotica ssp. subalata, A. mellifera Commiphora schimperi and Balanites aegyptiaca. They were seen on a number of times feeding on Solanum incanum within the grassland. Also they were seen on a few occasions during the dry season feeding on the succulent creeper Cyphostemma orondo in the grassland.

There were even fewer observations of feeding by impala as they were most often within the woodland or bush areas. They were however seen on a few occasions browsing on Acacia tortilis regeneration and Dicrostachys cinerea. They were also seen feeding on the pods of Acacia tortilis and those of A. nilotica ssp. subalata. During the rains, they were seen on a number of occasions grazing in the grassland. Ostriches were the most difficult to observe while feeding because of their habit of almost burrying the head in the ground while feeding and moving forward at the same time. On one occasion

Table 47

Percentage composition of plants fed on by 5 large herbivores in Simanjiro

Plant species eaten	Ze	Wi	Gr	Th	Ca
	% in total	% in total	% in total	% in total	% in total
Digitaria macroblephara	17.41	25.20	10.07	19.22	18.34
Panicum massaiense	14.25	20.44	6.79	17.42	15.94
Cynodon dactylon	5.77	8.46	5.78	16.22	13.11
Eustachys paspaloides	2.78	2.77	-	6.31	7.28
Harpachne schimperi	1.96	1.66	3.53	2.70	3.08
Setaria incrassata	8.26	9.75	-	1.80	-
Sporobolus festivus	0.41	0.46	0.76	1.30	1.20
Cenchrus ciliaris	2.37	4.28	0.76	-	6.68
Pennisetum mezianum	24.54	14.74	3.02	7.81	14.40
Bothriochloa radicans	9.90	7.05	4.53	-	-
Themeda triandra	7.04	4.60	3.78	10.82	9.25
Eragrostis superba	4.01	1.49	3.53	-	2.57
Sericocomopsis hildebrandtii	-	-	6.55	-	4.46
Acacia tortilis	-	-	2.76	-	0.26
Acacia nilotica ssp. subalata	-	-	2.02	-	0.26
Barleria ramulosa	-	-	4.28	1.50	-
Astripomoea hyoscyamoides	-	-	2.02	3.00	-
Macrotyloma maranguense	-	-	3.02	1.80	-
Vigna fragrans*	-	-	0.76	1.80	0.47
Indigofera spp.	0.31	-	4.78	0.90	0.52
Crotalaria spinosa	-	-	2.02	1.20	-
Rhynchosia minima	0.21	-	0.76	1.80	-
Cyathula orthacantha	-	-	5.54	-	-
Rhus natalensis	-	-	1.01	-	-
Euphorbia systyloides	-	-	4.53	-	-
Solanum incanum	-	-	0.76	-	0.86
Pavonia patens	-	-	1.26	-	-
Ocimum sp.	-	-	1.26	-	-
Ipomoea hildebrandtii	-	-	1.01	-	-
Ormocarpum kirkii	-	-	1.51	-	-
Ampelis mossambicensis	-	-	2.27	-	0.34
Grewia bicolor	-	-	2.27	-	-
Sida ovata	-	-	3.54	2.70	0.77
Glinus lotoides	-	-	-	-	0.47
Other dicots	-	-	3.02	1.50	0.34
Total grasses	99.49	100.00	42.55	83.80	91.85
Total dicots	0.51	-	57.45	16.20	8.15
Total for all plants	100.00	100.00	100.00	100.00	100.00

Ze - Zebra
Wi - Wildebeest
Gr - Grant's gazelle
Th - Thomson's gazelle
Ca - Cattle

a male ostrich was killed by hunting dogs and its stomach contents had a large portion of <u>Eragrostis superba</u> seeds and green dicotyledinous material. Goats were seen browsing nearly on all shrubs and low growing trees.

(g) <u>Migration between Simanjiro and Tarangire National Park and other areas</u>

(i) <u>Migration patterns</u>

The location of animals counted during the reconnaissance flights between Simanjiro and Tarangire National Park was determined by subtracting the time at the start from the time the animals were seen from the western boundary of the study area and this was converted into distance from the starting point by multiplying by the speed of the aeroplane. These were then plotted on a map.

The first reconnaissance flight was flown in March, 1972 in addition to a complete census of the Simanjiro Plains. This was during the middle of the rains. The results are shown on figure 22. None of the migratory species was seen in the corridor or in Tarangire National Park. They were all in Simanjiro. Ground observations in the Ardai Plains near Monduli showed that there were a few zebra and wildebeest in the area. Only 23 wildebeests and 98 zebras were seen in one day. There were Grant's and Thomson's gazelles numbering over 100. All animals were extremely wary. Part of the area was military training ground (see figure 23). A portion north of the Arusha-Dodoma road was under cultivation. Observations in the Sanya Plains between Arusha and Moshi showed a similar grim situation. Only 215 Thomson's gazelles were seen. Also only a handful of zebra and wildebeest were seen in the southern part. A large proportion of the plains near the Arusha-Moshi road was under bean cultivation and 5 kilometres south of the district boundary was the new International Airport. This made the Sanya Plains virtually inaccessible to wildlife.

The second reconnaissance flight was done in September during the height of the dry season. This also included a complete sample census of Tarangire National Park. The results are given on figure 20. All the wildebeests and zebras were in the Tarangire National Park while there were none in Simanjiro. Aerial reconnaissance done northwards to Komolo Springs, a former dry season area for a portion of the migratory plains ungulates (Lamprey, 1964) proved fruitless. No migratory ungulates were seen. Another flight southwards to Loiboiserrit springs proved likewise. Intensive ground observations showed that there were still a few zebras whose number could not exceed 100 still using the Komolo area. Also oryx were seen in this area but they were estimated not to exceed 50. There were elands estimated to be about 300. Also on one occasion a group of 13 zebras were seen near Naberera. Another group of 8 was seen near Naibormurot springs about 50 kilometres south of Simanjiro.

Another reconnaissance was done in November when the short rains were on. The results are shown on figure 20. The major proportion of zebra amounting to 51% were still in the Tarangire National Park. The corridor in between contained 14% and the rest were in the plains. Unlike zebra the large portion of wildebeest were already in the plains. They amounted to 43% of all wildebeests counted during the whole exercise. The corridor contained 38% and the park 19%.

It is interesting to note that the migratory animals in the corridor were orientated towards Simanjiro (see plate 20). The area they were in was open woodland interspersed with bushland and seasonally water-logged bushed grassland.

The last reconnaissance flight was done in December, 1972 and it coincided with the last aerial census of the plains. The results are shown on figure 21. The majority of zebra constituting 54% were now in the corridor between Tarangire and Simanjiro but concentrating more near Simanjiro. The next portion was in the plains while only a small number were still in Tarangire. About three quarters of the wildebeest were in Simanjiro. The corridor contained 24% while only 1%

were still in Tarangire.

(ii) Timing of migrations

Zebra and wildebeest were the main herbivores migrating into the Simanjiro Plains during the rain season. A limited number of eland also migrated into the plains at the same time. Oryx only migrated into the area once in 1970 and they were never seen again. In all the three years of observations, zebras exceeded wildebeest in numbers and constituted 56%. Wildebeest constituted 40% and eland only 4%.

Zebra

The migration of this species into the plains always started after the onset of the rains. When the first aerial count was done in April, 1970 the migration had been completed. Ground observations carried out in early January showed that zebra had started migrating into the plains. Ground observations in May did not indicate any further increases. The outward migration started in June. By July, the majority of zebras had already left the plains. Only 5 zebras were seen in August, 1970 near Sukuro dam. The same number was seen again in November. It seemed probable that this group did not migrate out of the plains for some unknown reasons.

The migrations in 1971 followed a similar pattern.

The inward migration started in late December and by 20th January had reached 30%. Nearly 90% of the migration was reached by the end of February. It was completed in April when the maximum population size was reached. Outward migration started in May and was completed by the middle of June. Only 7 zebra were seen during the census on 16th July, 1971. This same number was seen again during ground observations in the subsequent months showing that it did not move out of the area. The first zebras to migrate back into the plains were seen in December.

The migration pattern in 1972 was similar to that of the previous years. Only that there was a larger portion of the migration in January. Also the outward movements started in April but were as usual completed in June.

During the migrations zebras moved in groups. They did not migrate in one large formation. The incoming groups contained both males and females. They were of the same group composition as when they were in the plains.

<u>Wildebeest</u>

Wildebeest migrations into Simanjiro though coinciding with those of the previous species, always started a bit earlier. Observations in January, 1970 indicated that a larger proportion than that of zebra had already moved into Simanjiro. The outward movement started in June and there were none seen in late August. The next inward migration started in November when 4% of the maximum population size for that year were estimated to be in the plains. This increased to 46% by January, 1970 and by the end of March the migration had been completed. The outward migrations started in June and continued throughout July ending in August. This was later than the cessation of the outward zebra movements. The first wildebeest into the plains were seen in October, 1971. They continued to increase and were completed in February, 1972 a month earlier than was the case in the previous year. The outward migrations started in April and were completed in July.

The wildebeests like zebra moved in separate groups during the migrations. There were no large aggregations. The vanguard of the migrations was mainly formed by adult territorial bulls which were the first to arrive into the plains and then dispersed into their territories. Ground observations at the onset of the migrations showed that 90% of the wildebeest present in the plains were such bulls. The nursery and bachelor groups followed later. They were the first to move out during the outward migrations. The territorial bulls were the last to leave.

Eland

The migration of eland followed those of the preceding species. Ground observations in January, 1970 showed a few of them to be in the plains. They kept on moving in and reached their peak in April. They migrated out of the area in June. The inward migration in 1970 started in October and kept on continuing into the following year. It was completed in March. The outward migration started the following month and was completed in June. The following inward movement lagged behind that of the other migratory species by 2 months starting in December. The build up was faster than for any of the other two species and they were completed in January, 1972. A proportion of elands then kept on moving in and out of the plains in the following months and they completely moved out in August. The next inward movement started in October quickly building up and reaching a peak in December.

During the migrations eland tended to migrate in large groups. One such group contained about 300 animals. Also their movements were faster than those of either zebras or wildebeests.

(ii) Local animal movements

Although Grant's gazelles, Thomson's gazelles, impalas, giraffes and ostriches did not migrate out of the plains, they kept on moving between the plains and the surrounding areas continually. These movements intensified during the dry season. Giraffes and Impala showed the greatest movements sometimes leaving the plains area altogether. Grant's gazelles were next in the intensity of excursions followed by giraffes and ostriches. Thomson's gazelles showed the least movements. They only ventured into the more open woodland within close proximity of the plains and only during the dry season.

(iii) Livestock movements

Although there were livestock in the plains throughout the year, there were definite movements into the plains during dry season and outward movements during the rains. This was exactly the opposite of game movements. The cattle came from Oljoro, and Komolo in the north and from Narakau, Kitiangare, Naibormuruti and Kimotorok in the south and other neighbouring parts of southern Masailand. The inward movements reached a peak in October, 1970. The outward movements followed the next month and numbers stayed low during the rains. The inward movements started in May and intensified in the following month. They reached a peak in November, 1971. The outward movements again started in December, 1971 and continued to be low up to April, 1972. There was an influx between May and June which receded again in August. Another influx occurred in October and November but over half moved out in December, 1972.

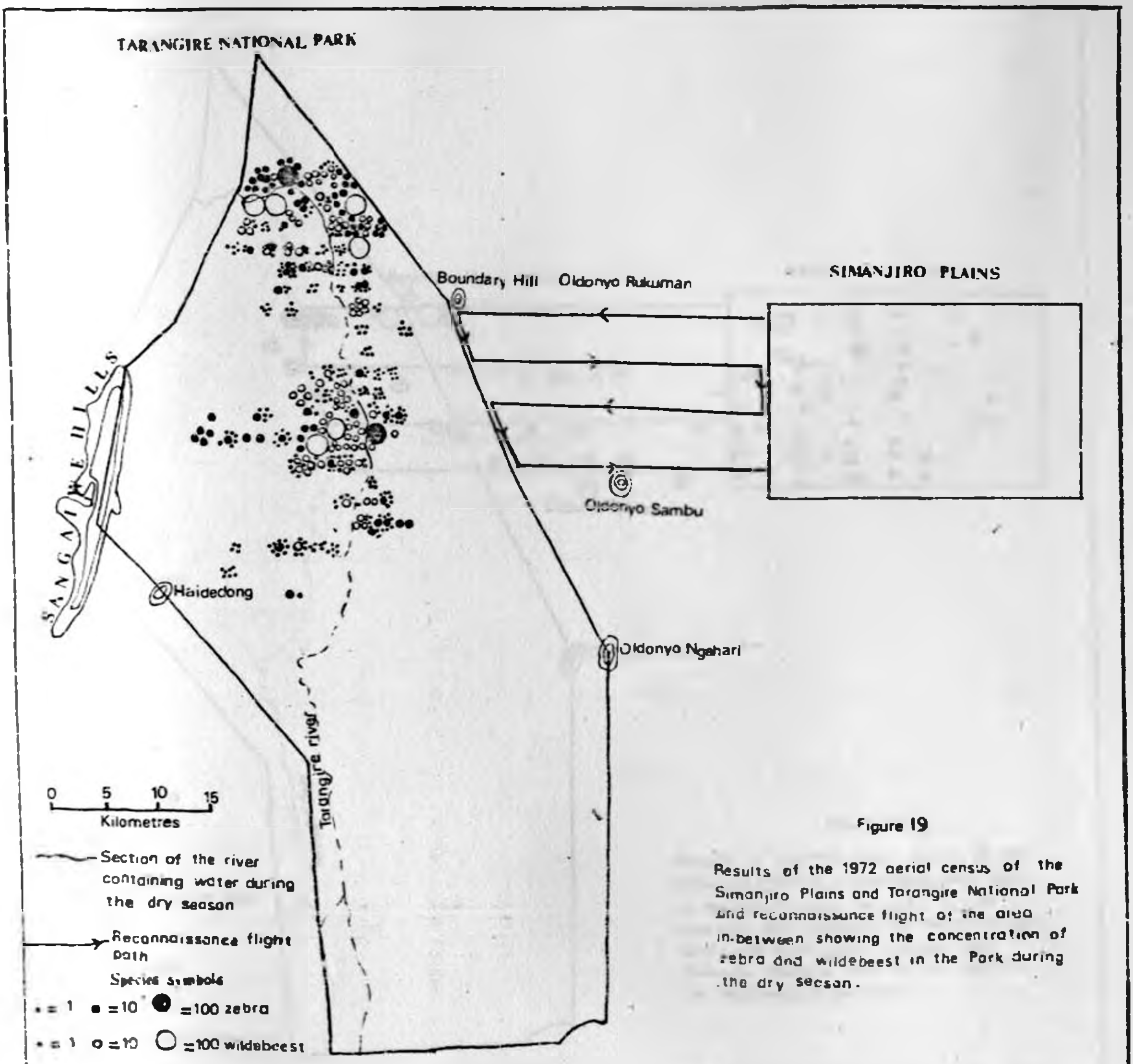


Figure 19

Results of the 1972 aerial census of the Simanjiro Plains and Tarangire National Park and reconnaissance flight of the area in-between showing the concentration of zebra and wildebeest in the Park during the dry season.

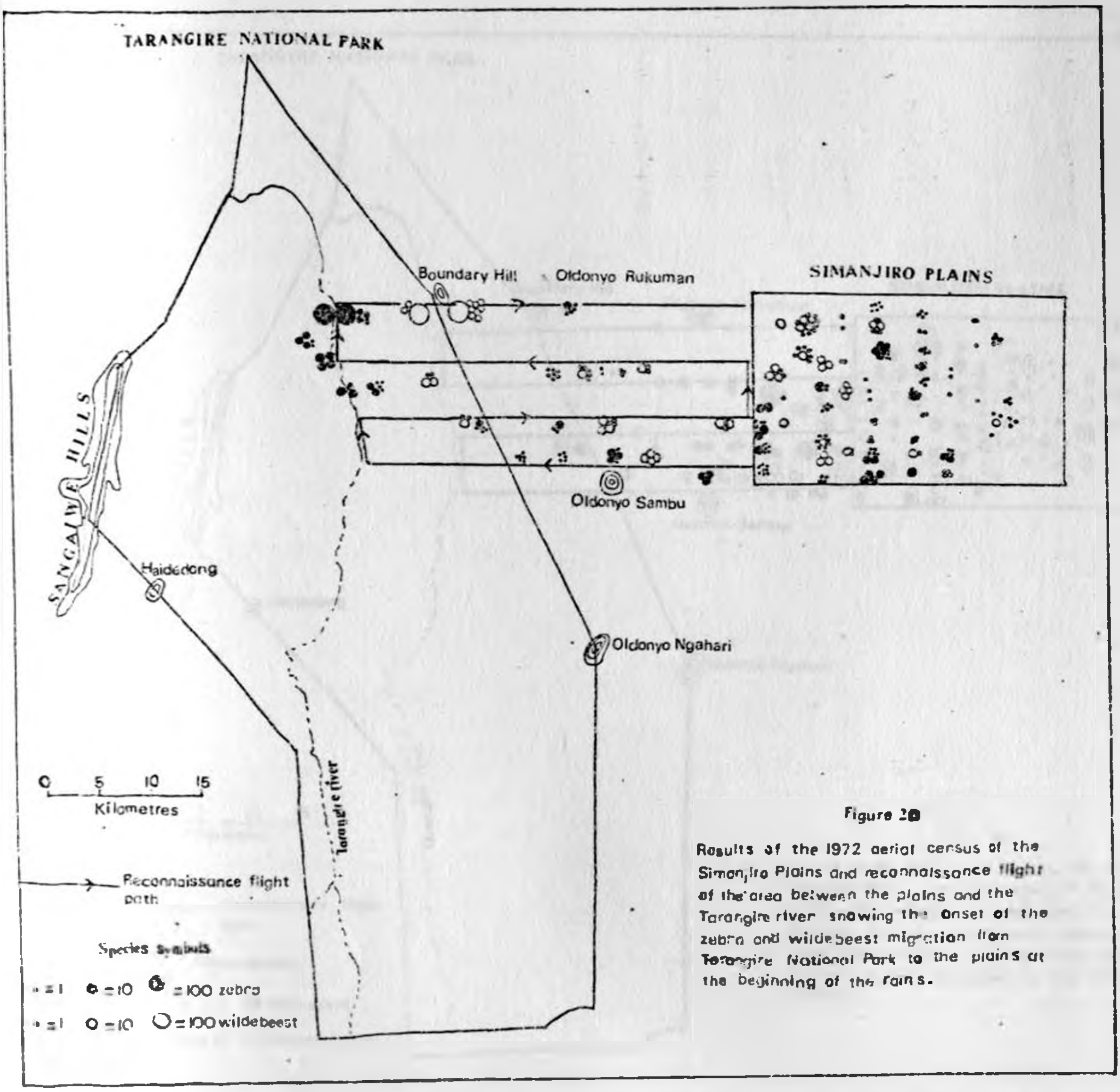


Figure 20

Results of the 1972 aerial census of the Simanjiro Plains and reconnaissance flight of the area between the plains and the Tarangire river showing the onset of the zebra and wildebeest migration from Tarangire National Park to the plains at the beginning of the rains.

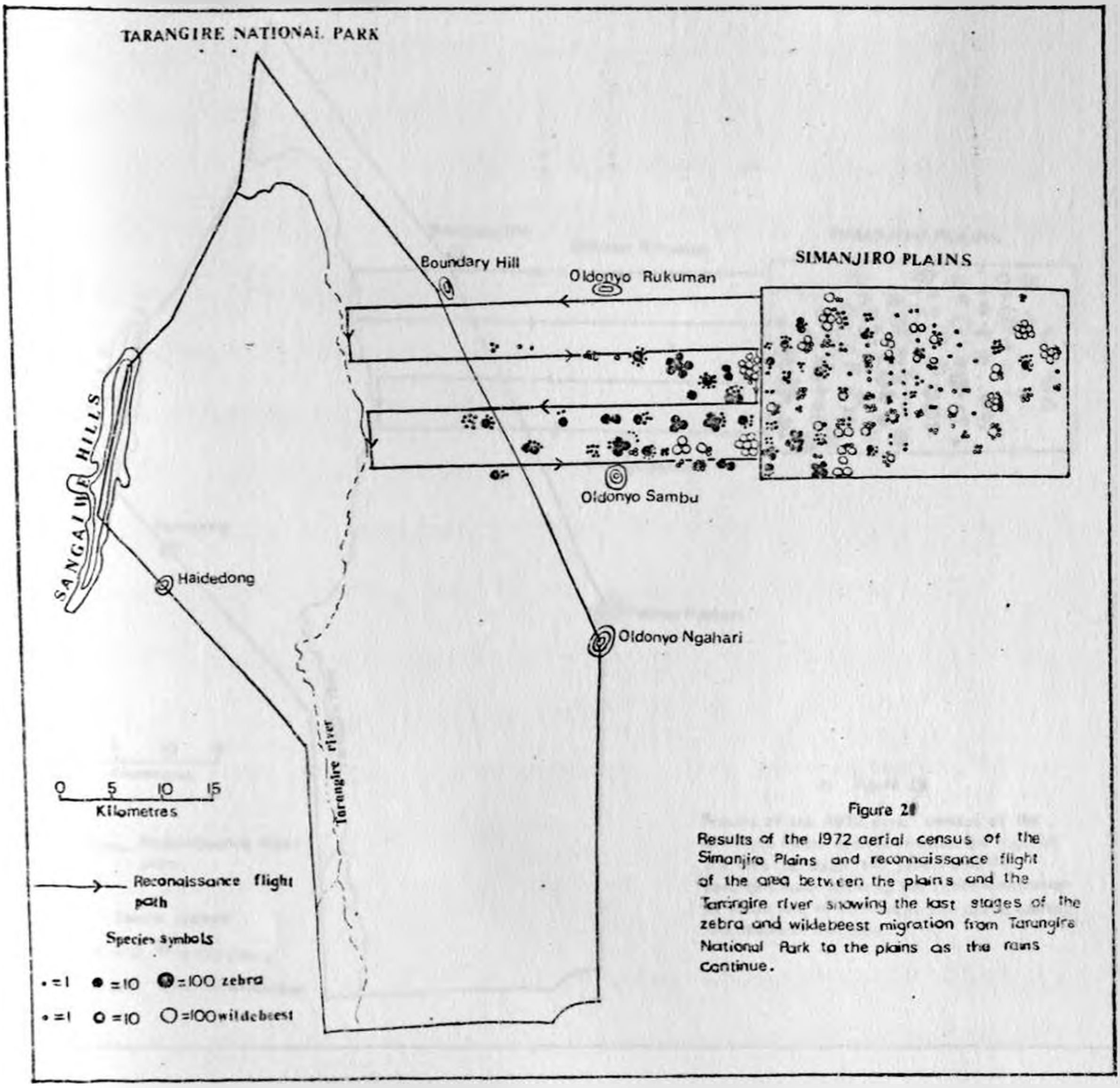


Figure 21

Results of the 1972 aerial census of the Simanjiro Plains and reconnaissance flight of the area between the plains and the Tarangire river showing the last stages of the zebra and wildebeest migration from Tarangire National Park to the plains as the rains continue.

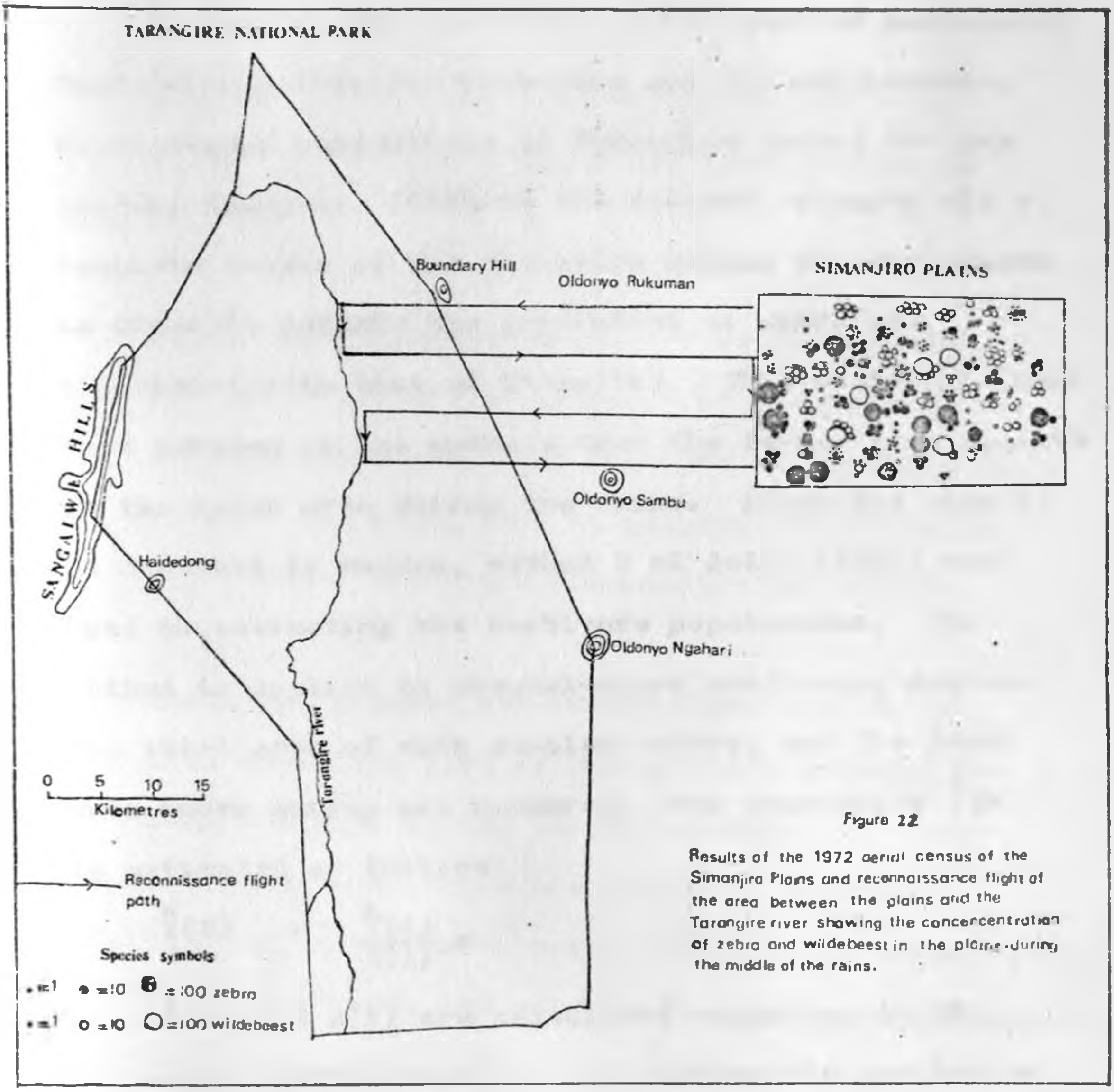


Figure 22

Results of the 1972 aerial census of the Simanjiro Plains and reconnaissance flight of the area between the plains and the Tarangire river showing the concencentration of zebra and wildebeest in the plains during the middle of the rains.

(v) Tarangire National Park census

In view of the fact that it was earlier postulated that animals from the Simanjiro and the neighbouring Masai steppe concentrate in Tarangire during the dry season, (Lamprey, 1964), it was decided to carry out a complete census of the Tarangire during the dry season in order to compare the population of zebra and wildebeest with that of Simanjiro. This would determine what portion of the animals from the former area migrate to the later area during the rains. Since the area to be censused is uneven, Method 2 of Jolly (1969) was used in estimating the herbivore populations. The method is applied to unequal-sized units using ratios. The total area of each sampled unit z, and the total area under survey are measured. The population $\hat{Y}(2)$ is estimated as follows

$$\hat{Y}(2) = \frac{\hat{Y}(1)}{z(1)} z$$

$\hat{Y}(1)$ and $z(1)$ are calculated according to the previous method used for calculating the population estimates in Simanjiro.

$\hat{Y}(1)$ is the number of animals in the sampled area

$z(1)$ is the area being sampled

z is the total area whose population is to be estimated. The variance of the population estimate is obtained as follows:-

$$S\hat{Y}(2) = \sum \frac{N(N-n)}{n} (sy^2 - 2\hat{R}Szy + \hat{R}^2 Sz^2)$$

Where $\hat{R} = \frac{\hat{Y}(1)}{z(1)}$ and $Szy = \frac{1}{n-1} \left(\sum zy - \frac{(\sum z)(\sum y)}{n}\right)$

$$\text{and } Sy^2 = \frac{1}{n-1}\left(y^2 - \frac{(y)^2}{n}\right)$$

$$\text{and } Sz = \frac{1}{n-1}\left(z^2 - \frac{(z)^2}{n}\right)$$

N as in the previous method is the total number of units in the stratum while n is the total number of units sampled.

Results show that the animals were distributed along the river bed in the sample area and thinned out with increasing distance away from the river bed. There were distinct concentrations at Lamprey's Camp and at Matete Camp where there are permanent water pools.

Zebras and wildebeests though important in Tarangire, form only part of the ungulate populations inhabiting the area during the dry season. The other important large herbivores are elephant, buffalo, eland, impala, oryx, hartebeest, black rhino, giraffe, ostrich, lesser kudu, and water-buck Kobus ellipsiprymnus Kuru Heller (Lamprey, 1963). In this census, it was decided to leave out impala, lesser kudu and water-buck as they lived in either woodland, bushland or riverine habitat where it was difficult to see through from the air.

The estimated zebra and wildebeest populations were 4946 and 6244 respectively. Zebras had a biomass density of 3.69 kg/km^2 while that of wildebeest was

Table [illegible]

Northern Tarangire National Park large herbivore
Population estimate - 27th September, 1973

	BLOCK A		BLOCK B		BLOCK C		BLOCK D		TOTAL	
	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE	$\hat{Y}$	SE
Elephant	1289	114	1805	354	121	22	292	48	3538	538
Buffalo	1916	979	2683	301	0	0	14	2	4613	979
Zebra	3720	671	1038	475	199	65	0	0	4957	909
Wildebeest	4916	640	1082	395	124	18	133	26	6255	1077
Eland	12	11	46	25	0	0	9	6	67	42
Hartebeest	6	8	90	58	3	5	143	86	242	157
Rhino	50	15	22	6	0	0	18	7	90	28
Ostrich	56	34	50	38	5	7	18	11	129	90
Giraffe	50	11	3	4	0	0	18	6	71	21

$\hat{Y}$ Population estimate

SE Standard error

4.65 kg/km^2 respectively. The biomass of both species constituted 17.70% of the total. The largest biomass was constituted by elephants which amounted to 7,532,356 kg or 58.04%. Their population was 3533. Buffalo had a population of 4607 and constituted 21.62% of the total biomass. The rhino population was estimated to be 90 and constituted only 0.69% of the total biomass. The data for the rest of the species and the full details are given on table 48.

(vi) <u>Zebra and wildebeest migrations in other controlled areas of northern Tanzania east of the rift:</u>

In addition to observations in areas adjacent to Simanjiro and Tarangire a few visits were made to other controlled areas of northern Tanzania east of the rift to observe migrations of zebras and wildebeests. The results are shown on figure 23.

<u>Engaruka-Lake Manyara-Oldonyo Lengai migrations</u>

Observations showed that the permanent stream flowing from the rift into the Engaruka basin to the north of Lake Manyara forms another important dry season habitat for zebra and wildebeest. It was estimated that their numbers were each between 2000 and 3000. Other species commonly seen in this area during the dry season were oryx. Also Thomson's gazelles and Grant's gazelles were seen in limited numbers. There were no zebra or wildebeest seen in this area during the dry season. These species were seen in the plains between Oldonyo Lengai and Lake Natron and around the north-eastern shores of Lake Manyara during the rains which indicated that they migrated to these areas at this time.

Ngaserai-Longido migrations

The Ngaserai water furrow which flows from the northern part of Mt. Meru (see figure 24) terminates in the middle of the Longido Game Controlled Area within the Ngaserai Plains. Where it ends, it contains permanent water and some zebra, wildebeest, oryx and eland spend the dry season there. Also Thomson's and Grant's gazelle and ostriches are resident in the plains. The surrounding woodland contains Lesser Kudu, giraffe and gerenuk Litocranius walleri walleri (Brooke). Occasionally, elephant and rhino wander through the area. Casual observations put the zebra and wildebeest numbers to be between 500 and 1000. During the rains the migratory species disperse into the surrounding areas within Longido and Lake Natron game controlled areas.

Southern Masailand migrations

During the study period a number of excursions were made through southern Masailand between Naberera and Loiborserrit down to Kibaya and Kijungu. Small herds of zebra varying between 3 and 8 were seen intermittently within the woodland habitat in the vicinity of permanent water holes during the dry season. Areas where they were seen included Lendanai, Naberera, Ngasumet, Londergess and Naibormurut (see figure 23). Observations during the rains showed minor aggregations of zebra and wildebeest at Makame, Kitwai and Ambusel. In each area there were estimated to number between 100 and 500 with the first two areas containing more.

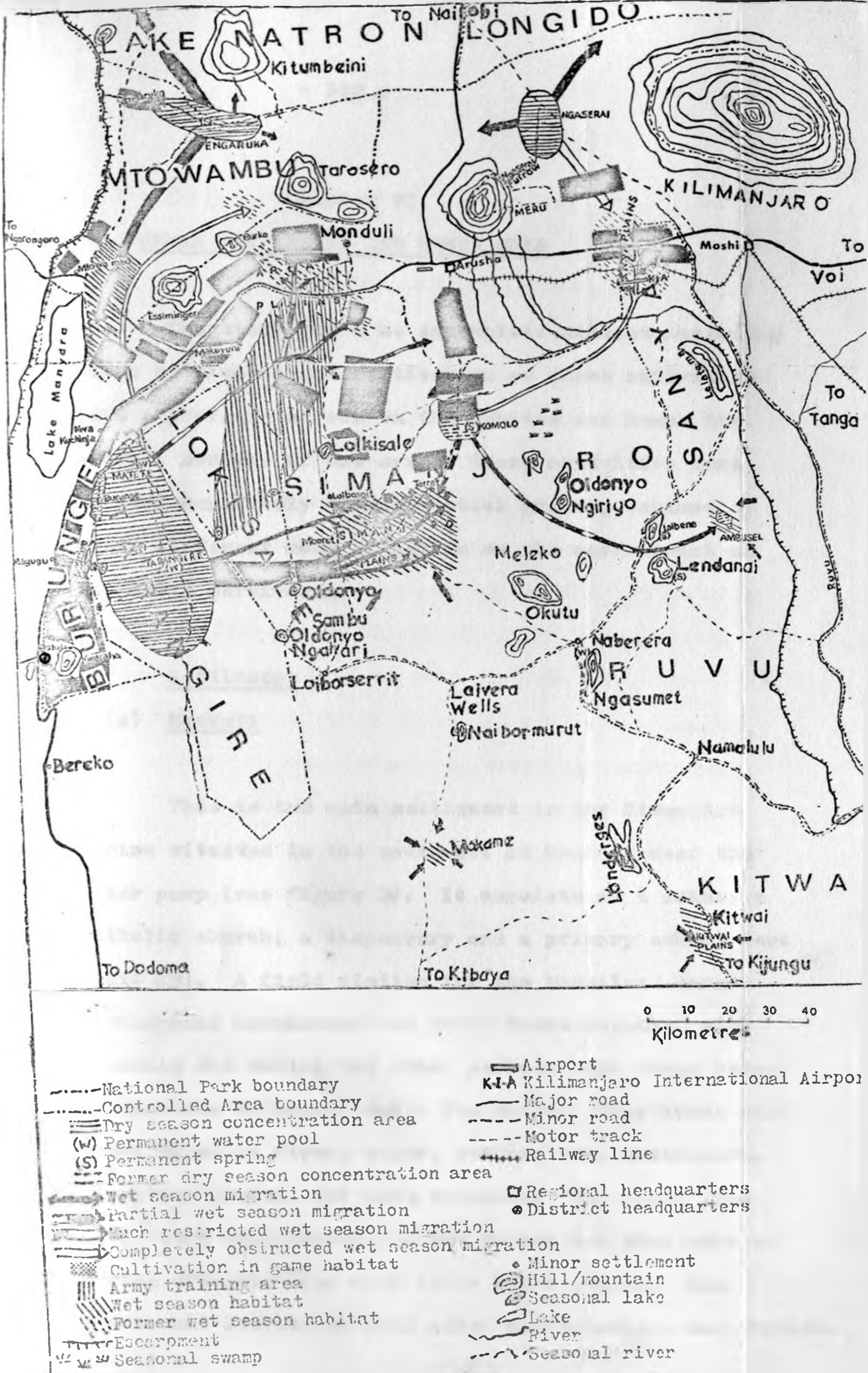


Figure 3

Zebra and wildebeest dry season concentration areas and migrations to wet season habitats in the Tarangire ecosystem of southern Masailand, Tanzania. Notice the central location of the Simanjiro Plains and its importance as wet season habitat.

Chapter VI

HUMAN SETTLEMENT AND OTHER USES

The study would be incomplete without including human settlement and cultivation as these activities have a profound effect on the habitat and hence the overall ecology of the area. These activities were treated separately from livestock grazing because of their different mode of action on the environment of the large herbivores.

1. Settlement

(a) Mboreti

This is the main settlement in the Simanjiro Plains situated in the southwest at Mboreti near the water pump (see figure 10). It consists of 4 dukas, a Catholic church, a dispensary and a primary school (see plate 23). A field station for the Masailand Range Development Commission was built there together with a cattle dip during the study period. The dukas belong to Waarusha tribesmen and a few Masai. They trade with Masai in maize flour, sugar, cooking fat, containers, blankets, sheets, and wire trinkets. The first item sells very much during the dry season and even more so during droughts when milk is in short supply. This settlement started in 1952 after the bore-hole was drilled.

(b) Terrat

This is a smaller settlement than the one at Mboreti. It is situated in the northwest corner of the study area. It consists of 4 dukas, a Lutheran church, a cattle market and the Game Division camp from which this research was conducted (see plate 1). A cattle dip was also recently built near the water. The dukas are owned by Waarusha a few Masai and Somali. Items of trade are the same as those at Mboreti except that a considerable amount of beer is sold during cattle auctions which take place once a month. Terrat is the administrative centre of Simanjiro where the T.A.N.U. Party Jumbe resides. This settlement is older than the preceding one as it was built to cater for the Masai who water their livestock at the natural springs.

(c) Loiborsoit

This is a much smaller settlement than the preceding two. It is situated in the northwest corner of the study area. It consists of 2 dukas and a dispensary. The home of the late Laibon for Simanjiro is near this settlement and it used to be the administrative centre for the area in the past. The two shops are owned by an Abyssinian and Waarusha. The former runs a maize mill, the only one in the whole area. This is the oldest settlement in Simanjiro.

(d) Sukuro

This is the smallest and most recent settlement in Simanjiro. It is situated just east of the middle of the southern boundary of the study area at Sukuro dam. It consists of 2 dukas only, owned by Waarusha. Its existence depends on the availability of water in Sukuro dam as it supplies the Masai who come to water their cattle. When the dam dried up in October, 1972 the shops had to be closed due to lack of customers.

2. Masai bomas

There are only 5 permanent bomas in the area. These are situated at Mboreti, Loiborsoit, Osilale, Terrat and Loldnelement. These belong to Masai who are either partly engaged in cultivation or traders. The rest of the bomas are temporary. They increase during the dry season and decrease during the rains. In March 1972 during the middle of the rains there were estimated to be about 42 bomas while in September during the middle of the dry season there were about twice as much.

3. Cultivation

During the aerial censuses in 1972, all cultivation was ploted on a map and later, ground observations were made to estimate areas of the cultivated plots.

Cultivation has been introduced in Simanjiro by Waarusha tribesmen from Arusha to the north. So far there is only one large cultivated area at Loiborsoit. This consists of two farms one on each side of the road. The area cultivated in 1972 north of the road to Lolkisale was 4 hectares and it was planted with wheat which became overgrown with weeds and could not be harvested. This belonged to the Abyssinian shop owner. The farm south of the road covered 65 hectares and belonged to some Waarusha in partnership with the Laibon's sons. It was all under maize. However the crop never matured. This was because of insufficient rains and heavy weed infestation. The other cultivation was at Terrat, Loldnelement and at Simanjiro adjacent to the permanent bomas. The rest of the cultivation consisted of small hand cultivated plots on abandoned boma sites for growing maize. This was done by Masais in order to supplement their milk diet. In all the total land cultivated in Simanjiro in 1972 amounted to 77 hectares or less than 1% of the study area.

4. <u>Charcoal burning</u>

In July, 1971, one charcoal burner settled at Terrat and started chopping down mature *Acacia tortilis* trees for burning charcoal (see plate 2[illegible]). He abandoned this venture near the end of the year due to lack of business. Masais do not need charcoal and the charcoal traders from Arusha find Simanjiro too far. They prefer to buy the charcoal from Oljoro which is nearer to Arusha.

5. Prospecting for Gemstones

Masailand is well known for its gemstones. It was within this district that the sensational Tanzanite was found. There are many Africans who have taken up the pick and spade and are trying their luck. Simanjiro is no exception. During the study period there were prospector's excavations at Terrat and Loiborsoit. The major gemstones taken were red garnet, green garnet, green tourmaline, and amethyst. Most of the prospectors were staying in ramshackle structures and looked rather haggard.

Chapter VII

DISCUSSION

1. Vegetation

(a) The importance of the present vegetation study

It has already been mentioned that it was necessary to study the vegetation of the Simanjiro Plains as it is the major component of the herbivore habitat. Prior to this study there was no detailed vegetation data for this area. As already mentioned in the introduction, most of the studies were on a broader basis and more descriptive in nature. They were vegetation surveys covering a broader area in which Simanjiro happened to be.

Even most of the other vegetation studies in East Africa have been on general classification (Brenan and Greenway, 1949; Edwards and Bogdan; Dale, 1952; Hedberg, 1957; Harker and Napper, 1960; Napper 1965; Agnew 1974). Others have been phytosociological (Vesey-Fitzgerald, 1955, 1963; Abraham, 1958; Jeffers and Boaler 1966; Boaler, 1966; Greenway and Fitzgerald, 1969). Also general descriptions have been included in wildlife or other ecological studies (Grzimek and Grzimek, 1961; Talbot and Talbot, 1961; Lamprey, 1962; Hedberg, 1964; Watson, 1967; Sinclair, 1969; Harris, 1972; Western, 1973; Lind and Morrison, 1974). On the other hand, quantitative studies have been rather few (Kerfoot, 1965; Agnew, 1968; Herlocker and Dirschl, 1972). So the quantitative study of the Simanjiro vegetation contributed towards filling in the existing gap besides the ecological value.

(b) Simanjiro vegetation as a discrete plant community

The concept of plant community originated in Europe and the United States of America when pioneer studies of vegetation and subsequent classification into communities were made. The pioneers of the study of plant communities and hence plant ecology included Warming (1909), Braun-Blanquet (1932), Raunkiaer (1934) and Weaver and Clements (1938). Oosting (1956) broadly defines community as "an aggregate of living organisms having mutual relationships among themselves and to their environment." This definition embraces both animals and plants. More recently, Cain and Castro (1959) have discussed the various enteracting environmental factors including time and space in a plant community and have summed up the definition of plant community as, "a sociological unit of any rank, occupying a territory and having a characteristic composition and structure." This is a more specific and consise definition and could be applied to this study.

Pratt et al (1966) lists the main vegetation types of East Africa as forest, woodland, grassland, bushland

and seasonally water-logged bushed grassland. So in order for any given piece of vegetation to be considered as a community, it must include one or more combination of these types. In this study a plant community can be defined as "a single vegetation type or combination of types the latter occupying a defined area of similar climatic, topographical and edaphic conditions and having a species composition which is specific to it." In the case of Simanjiro, the most obvious and characteristic vegetation type is the short grassland. The boundaries of this type are all confined to Simanjiro and the species composition is specific to it. Even the patches of grassland found in the surrounding areas of Masailand are different. This grassland is therefore the dominant feature of the Simanjiro plant community. On the other hand the composition of the woodland is not fully specific to Simanjiro. This is especially so with the Acacia tortilis - Commiphora-schimperi woodland which extends far outside the study area. On the other hand there are patches of this subtype which are definitely confined to Simanjiro as far as age is concerned. Also the Acacia nilotica ssp. subalata forms a distinct plant formation. The seasonally water-logged bushed grassland though found outside the confines of the study area is so centrally located within the grassland that the combination forms a distinct feature. On the other hand the bushland extends far outside the study area so that it is not discrete enough. The Simanjiro vegetation is mainly formed by the grassland in a definite combination with the seasonally water-logged grassland and combining at the periphery with various sub types of the woodland and bushland. This vegetation formation is specific enough to constitute a plant community. In this case general classifications such as that given by Odum (1959) in which he places most of northern Tanzania and most of Kenya within the "tropical savannah savannah" are rather too broad to be of any practical value. On the other hand the classification of Phillips (1930) which is based on Clementian (1916) system agrees well with that adopted for this study.

(c) The Simanjiro vegetation types as compared with others in East Africa

(i) Grassland

The Simanjiro grassland is unique in that its species composition varies from the other grasslands in East Africa. In his survey of grassland and potential grassland types in East Africa, Heady (1960) recognized this difference and classified it as a variant of the broad Themeda-Hyparrhenia grassland which covers a wide area in northern Tanzania east of Lake Victoria and is also found in Ankole Uganda and the Athi-Kapiti plains in Kenya. The Simanjiro grassland is the southmost distribution of these grassland types and occurs as an isolated island within the broad Acacia woodland/ bushland area of Tazania Masailand (Langdale-Brown and Trapnell, 1972). It is only in this grassland that Digitaria macroblephara and Panicum coloratum form the major subtype with the later species growing as a short form though it is a polymorphic species growing in heights ranging from 8-100 cm (Napper, 1965). The former species is locally dominant in some localities of the short grass area of the northern portions of the Eastern Serengeti plains (Herlocker and Dirschl, 1972). The other common species found in Simanjiro namely Pennisetum mezianum, Themeda triandra Eustachys paspaloides, Bothriochloa radicans,Cynodon dactylon, Harpachne schimperi also occur in the other grasslands of East Africa namely the Serengeti (Herlocker and Dirschl, 1972), Athi-Kapiti (Stewart, 1970; Casebeer and Koss, 1970), Mara (Talbot and Talbot, 1961; Taiti (1973), Ankole (Heady, 1960) and Karamoja (Bredon and Wilson, 1963). Within these grasslands, it is only in Simanjiro that Barleria ramulosa grows as a dominant shrub. Also the leguminous Macrotyloma maranguense is very widespread in this area during the rains. A specimen was collected which had underground pods. Although such geocarpic fruits are known to exist (Gillett, Polhill and Verdcourt, 1971) there are very few such specimens which have been collected in the East African Herbarium.

(ii) Woodland

This vegetation type, as already mentioned, is typical of the vegetation of semi-arid zone of East Africa. It is a constituent of the Acacia-Themeda vegetation association which extends from northern Kenya and northeastern Uganda to central Tanzania (Edwards, 1951; Langdale-Brown and Trapnell, 1967). Various other parts of this type have been described from Kenya (Edwards and Bogdan, 1951), northern Uganda (Bredon and Wilson, 1963), and northern Tanzania (Lamprey, 1963; Greenway and Vesey-Fitzgerald, 1969; Watson, 1969; Herlocker and Dirschl, 1972). In all these areas Acacia tortilis is the most widespread species commonly associated with Commiphora species and other acacias. The occurence of a discrete Acacia nilotica ssp. subalata dominated sub-type adds to the complexity of the Simanjiro woodland. Areas composed of this species have been described from northern Uganda (Kerfoot, 1965) central Kenya (Edwards, 1951) and Ngorongoro (Herlocker and Dirschl, 1972). Similar to Acacia tortilis, the most dominant and widespread associated species in the Acacia-Themeda zone are C. schimperi, C. africana and C. madagascariensis all of which dominate in Simanjiro.

The woodland in Simanjiro is of a more open nature. The crown cover is generally less than 20% and compares well with values obtained in northern Uganda (Kerfoot, 1965) parts of Tsavo (Agnew, 1968) and Ngorongoro (Herlocker and Dirschl, 1972).

(iii) Bushland

Acacia/Commiphora bushland type in East Africa covers a similar range as the Acacia-Themeda type. In some areas it covers large expanses and is usually known as the thornbush or Nyika (Brown, 1965). This type usually consists of low growing thorny bushes in dense formations. The cover is usually over 20% (Pratt et al, 1966). The bushland in Simanjiro is a distinct subtype and is almost exclussively dominated by Acacia stuhlmannii. In this area it forms a dense impenetrable stand with canopy cover exceeding 60%. It forms quite an expanse and extends well outside the study area. Excursions to other areas during the study period showed that such tracts of this species are mainly confined to southern Masailand. However it has been recorded from elsewhere in Kenya and Tanzania. The associated species in Simanjiro is A. mellifera which is the most widespread species within the thorn bush community throughout East Africa. It is found in northern and eastern Kenya (Edwards, 1951) northwestern Uganda (Kerfoot, 1965) and northern and northeastern Tanzania (Lamprey, 1963; Greenway and Vesey-Fitz Gerald, 1969; Harris, 1972; Herlocker and Dirschl, 1972).

Casual observations in the Engaruka area towards Oldonyo Lengai showed that A. nubica was the dominant species there. Different species of low growing Commiphoras are associated with the Acacia species in the bushland and in Tsavo, they constitute 32% of the percentage cover of woody vegetation (Agnew, 1968). Other important bush species found in this type in East Africa include Salvadora persica, Boscia sp. Balanites spp. and Terminalia sp. Sansevieria is also a common constituent of the bushland (Edwards, 1951; Brown, 1965). The large baobab Adansonia digitata is a common tree in most parts of the bushland community particularly in the eastern range. It is very common in Tsavo (Bax and Sheldrick, 1963). This species is not in Simanjiro. This may be because of the altitude of Simanjiro which is generally higher than that of the range of the baobab. Dale and Greenway (1961) describe it as growing from sea level to 1080 m. The altitude of Simanjiro is over 1080 m.

(iv) Seasonally water-logged bushed grassland

Like with the preceding vegetation type, this vegetation is also found in other parts of East Africa. It occurs on low lying sites with impeded drainage within the Acacia-Commiphora woodland and bushland. Lamprey (1964) referred to it in Tarangire as "grassland and flood plain." Verdcourt (1962) refers to it in Nairobi

Park as "black cotton soil associations." This vegetation is also referred to as "cotton soil mbugas" (Michelmore, 1939). The formation has also been referred to in Serengeti as "sump" (Bell, 1970). Species growing in these areas are those which can withstand water-logging and high alkalinity. In Simanjiro the dominant species are Pennisetum mezianum and Acacia stuhlmannii while A. drepanolobium is less extensive. It is interesting to note that although the Acacia species growing in these sumps all withstand seasonal flooding and high alkalinity, usually only one species dominates in any particular area. It appears that the degree of water-logging, salinity and temperature determine the type of species occuring in a given area. The dominant species in Simanjiro is Acacia stuhlmannii. Where there is more water-logging A. drepanolobium dominates. The differences are clearly illustrated in Simanjiro where A. stuhlmannii forms a fringe around a stand of A. drepanolobium. The later grows on a more water-logged area in the west at Lekitejo and the former species grows on the edges of the area where the ground starts rising towards the grassland. In other parts of East Africa, it is Acacia drepanolobium which predominates (Lamprey, 1963; Bredon and Wilson, 1963; Greenway and Vesey Fitz Gerald, 1969).

(v) Interspersion of vegetation types

It is not only the availability of habitat types, in this case vegetation, which affects the distribution of large herbivores but also the way they are distributed within a given range. This phenomenon is pointed out by Leopold (1933), who states that, "the maximum population of any given piece of land depends, therefore, not only on its environmental types or composition, but also on the interspersion of these types.........," interspersion being described as, "the degree to which environmental types are intermingled or interspersed on a game range." Whenever two vegetation types meet they create an edge which is favoured by herbivores and thus accomodates a higher density. Dasmann (1966) states that "whenever two habitats come together, the edge between the two types will be more favourable to wildlife than either of the two types considered alone." This is known as the edge effect. Odum (1959) describes it as "the tendency for increased variety and density at community junctions." Lamprey (1963) working in Tarangire noted this effect among large mammals and it was especially pronounced with impala.

In Simanjiro there are 8 main vegetation subtypes. These are the Digitaria macroblephara - Panicum coloratum grassland, Acacia tortilis Commiphora pilosa woodland, Acacia stuhlmannii and A. mellifera bushland and the Pennisetum mezianum - Acacia stuhlmannii and P. mezianum - Acacia drepanolobium seasonally water-logged bushed grassland. The number of edges which can be created by the meeting of each pair of types can be mathematically obtained by the following formula:-

$$C(N,r) = \frac{N!}{r!(N-r)!}$$

In this case it becomes

$$C(N,r) = \frac{8!}{2!(8-2)!}$$

$$= 28$$

Therefore, there are 28 possible edges which can be created out of the 8 different vegetation subtypes present in Simanjiro. Out of these, the actual interspersion has 20 such edges (see figure 6). The grassland being the major and centrally located portion has the edge which has the most contact with the other subtypes. Its most extensive contact is with the seasonally water-logged bushed grassland. This is caused by the elongated irregular shape of the latter thus creating a long line of contact. The advantage of such an arrangement in creating a longer ecotone is described by Leopold (1933) who states that "the linear mileage of type edges available in any block of range is, as a matter of geometry, proportional to the degree of interspersion." The next longest ecotone is between the grassland and *Acacia stuhlmannii* bushland followed by those between the grassland and the different woodland subtypes. It should also be noted that the isolated piece of grassland at Loldnelemet in the northeast corner of the study areas has 3 edges while the one at Tukusi in the southeast has 1 major edge. The different edges created in Simanjiro can be seen on figure 6.

2. Topography-soil-vegetation catena

The distribution of soils and hence vegetation in Simanjiro is strongly correlated with topography. Each topography is associated with a particular soil and vegetation and these associations repeat themselves in a series forming a catena (see figure 24). On the gently undulating surface with good drainage there occurs the red brown soil on which is found the short grassland.

In the eastern and western end of the study area and some parts in the northwest and northeast there are ridges which are completely drained. These ridges contain the same dark red sandy loam or reddish brown soil found in the grassland. This is where the *Acacia tortilis* - *Commiphora schimperi* is found.

On the low lying and shallow depressions within the grassland there is the dark grey soil where there is slight seasonally impeded drainage. This soil contains more clay than the preceding one. The average pH in Simanjiro was 7.3. This soil is also known as the dark grey soil. Within these depressions, the most characteristic shrub is *Becium capitatum*. The grasses growing there consist of Bothriochloa radicans, Digitaria macroblephara and Pennisetum mezianum. Within the grassland at Osilale and Sukuro there are larger areas of flat surface with slightly more seasonally impeded drainage. The soil occuring here is the same as the preceding one only that it is darker and contains still more clay. On this type there grows the Commiphora woodland. The main species growing on this soil at Simanjiro are Commiphora schimperi and Commiphora pilosa and Acacia mellifera. A sample described from Kongwa supported a Commiphora thicket with occassional baobabs and sparse ground flora (Muir, Anderson and Stephen, 1957). The ground flora at Simanjiro was also rather sparse. The first and third species have also been described elsewhere as occuring on "hard-pan" soils (Brenan and Greenway, 1949; Burtt, 1953).

Further up the slope from the Commiphora woodland at Osilale the soil though the same pale grey type has slightly more drainage. The major vegetation on this soil is the Acacia nilotica subsp. subalata with Commiphora schimperi. The former species grows on the latosolic sandy loams on the upper slopes and level ground of the catchments of Karamoja (Kerfoot, 1965).

Within the grassland and in the extreme western and eastern parts, there are the low lying depressions where drainage is impeded. The soil within these depressions is black clay. The major vegetation is the *Pennisetum mezianum* - *Acacia stuhlmannii* or *Acacia drepanolobium* seasonally water-logged bushed grassland. The latter Acacia is a dominant feature of this formation throughout East Africa (Brenan and Greenway, 1949; Eggeling and Dale, 1951; Dale and Greenway, 1961). Similarly *Pennisetum mezianum* together with *Lintonia nutans* and *Setaria incrassata* all of which occur in Simanjiro are typical grasses of the seasonally water-logged soils (Edwards and Bogdan, 1951; Bredon and Wilson, 1963; Napper, 1965; Trapnell and Langdale Brown, 1972; Verdcourt, 1962).

On the flats surrounding the grassland, in Simanjiro where the black clay occurs which has slightly less clay and dries faster, the predominant vegetation is *Acacia stuhlmannii* bushland with *Acacia mellifera* bushland occuring in same localities. The former species is well known for withstanding alkaline conditions (Brenan and Greenway, 1949). It is also reported as often growing on heavy alluvial soils and an indicator of saline soil (Brenan, 1959).

This repetition of such vegetation soil associations in a catena is a very common feature in Masailand. This is caused by the undulating nature of the topography. Scott (1972) describes a typical catena which is similar

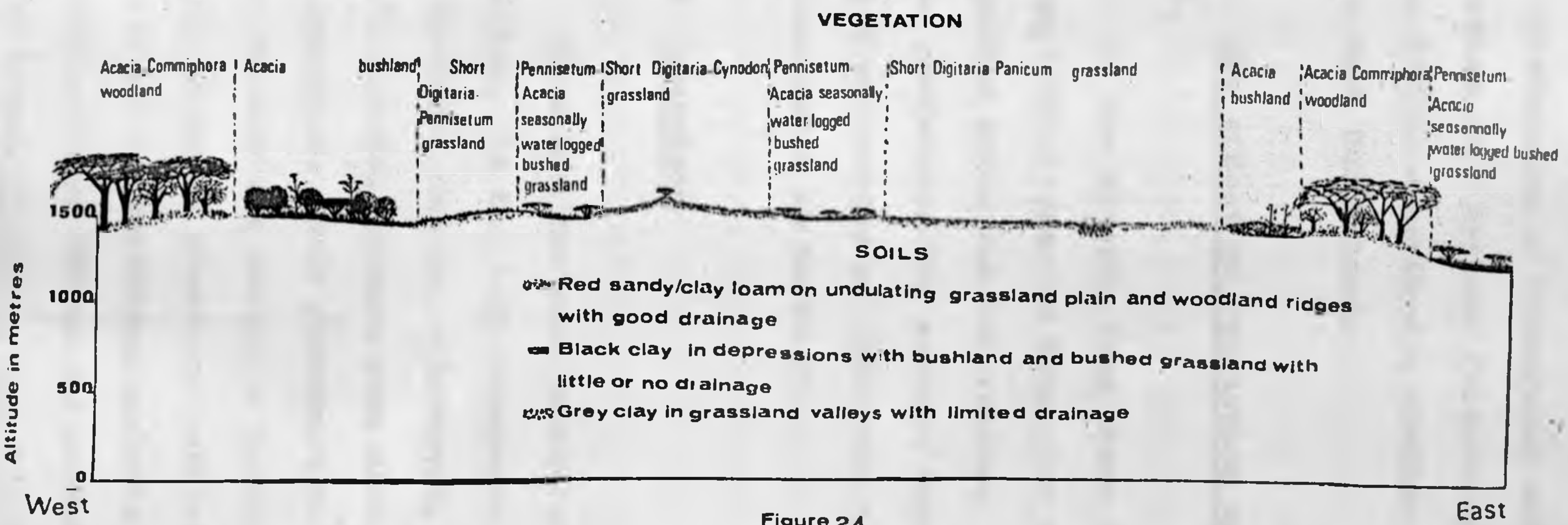


Figure 24

A west to east vegetation/soil catena through the middle of the Simanjiro Plains to the one in Simanjiro. Also Gillman (1949) noted this alternation of topography and the accompanying vegetation as a typical feature of Masailand. Also Calton (1963) described a similar soil - topographic catena from Sukumaland.

3. <u>The effect of vegetation on herbivore distribution</u>

It has already been shown that the distribution of large herbivores in Simanjiro within the different vegetation types was not random. Animals showed marked preference for certain types. The vegetation habitat preference by different herbivores in Simanjiro is illustrated on table 49.

(a) <u>Grassland</u>

This was the most preferred habitat type in Simanjiro. It had high occupance and Chi-square ratings for Thomsons gazelle, wildebeest, zebra, cattle and Grant's gazelle. Elands were also mostly observed in the grassland. This conformed to expectation because these species are mostly or partly grazers and they are usually found in grassland habitat (Brown, 1965). Results of the grassland analysis show that grasses constituted over 80% of the percentage composition. Out of these, <u>Digitaria macroblephara</u>, <u>Panicum coloratum</u>, <u>Pennisetum mezianum</u>, <u>Themeda triandra</u>, <u>Bothriochloa</u>

radicans and Cynodon dactylon constituted over 75%. Examination of the feeding observations show that these species formed the major diet of these ungulates and particularly wildebeest, zebra, Thomson's gazelle and cattle and constituted a sizeable portion of Grant's gazelle's food. The preference of some of these plains herbivores for the above grasses has been reported in Kapiti area. The most preferred species there were Themeda triandra and Cynodon dactylon. Panicum massaience and Eustachys paspaloides and Pennisetum mezianum though common were largely ignored (Stewart and Stewart, 1970). Even in Simanjiro P. mezianum was grazed at the early stages of growth which confirms with observations elsewhere (Edwards and Bogdan, 1951). Observations in the Narok, Loita, Mara, Kajiado Athi Plains by Talbot and Talbot (1962) between February and December, 1960 showed that both wildebeest and Thomson's gazelle grazed considerably on P. mezianum but Themeda triandra had a low rating with the latter gazelle species. More recent observations in the Athi-Kapiti Plains on the food habits of wildebeest, zebra, hartebeest and cattle show that the preferred species were Themeda triandra, Digitaria macroblephara and Pennisetum mezianum in that order. The difference between observations in Simanjiro and the Athi-Kapiti area is due to the fact that while Themeda triandra, Digitaria macroblephara and P. mezianum and Cynodon dactylon formed 11%, 18%, 27% and 9% respectively of the percentage grass composition at Athi River, in one of the transects at Simanjiro they constituted 5%, 29%, 4% and there was no Cynodon. So the differences are partly due to the availability of the grasses. In one area where Cynodon was available in Simanjiro, it had a high preference and the spot was the most favoured in the whole plains by wildebeest and Thomson's gazelles. In this study, Themeda triandra was grazed while it was growing, the animals did not prefer it during later growth.

With regard to the intake of dicotyledonous materials by these herbivores, observations in Simanjiro conformed to earlier observations elsewhere. Like in Simanjiro, Grant's gazelle and Thomson's gazelle in the Narok, Mara, Athi plains and Serengeti Plains took in more dicotyledonous material which constituted over 50% of the diet of the former gazelle and about 20% of the latter (Talbot and Talbot, 1962; Gwynne and Bell, 1968; Stewart and Stewart, 1970; Casebeer and Koss, 1970). The intake of these plants in the resident gazelles of Simanjiro increased during the dry season a factor which has also been reported in Serengeti (Gwynne and Bell, 1968). Observations on wildebeest and zebra in their dry season habitat by Lamprey (1963) showed that 7.43% and 5.52% respectively of their diet was constituted by herbs and shrubs.

Although no formal observations were done on the feeding habits of ostrich, casual observations showed that the grassland habitat provided a sizeable portion of their diet and hence the frequenting to this habitat by this herbivore. Ostrich was included in the study because its diet consists of fresh grass leaves, shrubs and herbs and their fruits in addition to insects and animal matter (Mackworth-Praed and Grant, 1957). Similar feeding habits have been observed in Nairobi National Park by Huxthal (pers. comm.). In Simanjiro, the wide variety of plants made the grassland an ideal habitat. Observations by Lamprey (1963) in Tarangire showed similar habits by ostrich. As the season advanced and grasses, shrubs and herbs dropped their seeds, the latter constituted an important source of ostrich diet. The stomach contents of a male ostrich killed by wild dogs in October 1972 contained a large portion of *Erogrostis superba* seeds.

The grassland also formed an important part of the giraffe habitat because it provided a large portion of the diet. The *Acacia tortilis* regeneration on ridges within the grassland were seen to be intensively browsed by giraffe until they showed a hedged appearance. The rather short size of these Acacias is due more to browsing by giraffe than it is to age. Studies in Serengeti have shown that *Acacia senegal* and *A. hockii* in exclosures made a height growth of between 3 and 6 metres in 5 years while those subject to browsing by giraffe only grew 1 metre (Lamprey, 1972). Also such hedging effect has been reported in Nairobi National Park (Foster, 1966). Besides the Acacias, the Simanjiro grassland provided other diet for giraffe. They were seen on a number of occasions feeding on *Solanum incanum* and once on the creepy *Cyphostemma orondo*. They also have been observed in Tarangire and Tsavo feeding on shrubs and climbers (Lamprey, 1963; Leuthold and Leuthold, 1972).

The Simanjiro short grassland is also used by impala primarily during the rains. They particularly favour the ecotone between the short grassland and the woodland. Such preference has also been reported in Tarangire (Lamprey, 1963). Although no feeding observations were carried out on impalas, they were seen grazing on short grasses on a number of times. Talbot and Talbot (1962) reported 56% of the stomach contents of impala from Narok and Kajiado to be grasses. Also Dorst and Dandelot (1970) includes short grass as one of impala diet.

Besides being an important habitat through provision of diet to wild herbivores, the Simanjiro grassland habitat is the most preferred habitat for cattle because of similar reasons. Although cattle movements are dictated by the Masai herdsmen, the latter have over a period of time evolved an ecologically sound system of herding which coincides with the cattle's requirements (Peberdy, 1972). The short grasslands of East Africa are the main rangelands (Heady, 1960). Just as with the preceding wild ungulates, cattle in Simanjiro grazed mainly on similar grasses which constituted over 90% of their diet. Cattle on the Athi-Kapiti plains were similarly observed to show high preference for short grass species and a few dicotyledonous plants (Stewart and Stewart, 1970; Casebeer and Koss, 1970). Shrubs and herbs are widely known as additional cattle feed besides grasses among the Masai and Kipsigis (Glover et al, 1966). In Simanjiro, cattle took in more browse during the dry season although the difference between the dry season and the wet season were minimal. Similar observations were made by Payne and Macfarlane (1963) who observed Masai cattle to eat considerable browse during the dry season. A minimal variation between cattle diet during the two seasons has also been reported in the Athi-Kapiti Plains (Casebeer and Koss, 1970).

The grassland though less important as habitat for goats and sheep in Simanjiro still contributes considerably towards their nutritional requirements. Although goats are primarily browsers, they spent considerable time in the grassland where casual observations showed them to be grazing. This is in agreement with observations in South Baringo where grass constituted 38.4% of the diet, (Knight, 1965). However it differs from earlier reports which showed goats to be almost exclusively browsers (Edwards, 1948; Staples et al, 1962). It is interesting to note that goats and sheep in Simanjiro spent more time in the grassland during the height of the dry season than during the wet season. This means that they took in comparatively more grasses and shrubs which were growing there than in any other vegetation type.

Besides supplying the normal nutritional requirements for the plains ungulates the short grassland provides additional nutritional requirements needed for reproduction. The short grasses form what is referred to in South Africa as "sweet veldt" (Brown, 1965). During the rains, the grasses grow new leaves and have a high leaf: stem ratio. At this stage, the protein content of these short grasses is high. As the growth advances, the crude protein level drops until it is at its lowest during the dry season (Edwards and Bogdan, 1951; Chippindall and Scott et al, 1955; Rodgers, 1969). The increase in protein during the wet season coincides with the migration of zebra and wildebeest in the plains. The gravid females find a ready source of high protein which they require. Calving takes place especially in wildebeest at this time. In cattle the lactating mother and the calf need a higher protein diet than is otherwise required by non-lactating individuals (Maynard and Loosli, 1962). This is provided for in the wildebeest in Simanjiro by the high protein level of the short grasses. Wildebeest calves start feeding on grass when they are 10 days old and by the time they are 3 months, it forms the bulk of the diet (Talbot and Talbot, 1961). High protein level is also needed by males in cattle to be able to produce sufficient viable sperm and by the females to undergo proper physiolocial changes leading to fertile implantation (Maynard and Loosli, 1962). Copulation in zebra and wildebeest takes place in Simanjiro and the high protein short grass still meets their nutritional requirements. Zebra have a gestation period of 361 to 390 days (Klingel, 1969) and since they foal in Simanjiro mainly between January and April, most of the copulation takes place in the plains. The interval between mating and calving in wildebeest is 8 to 8.5 months (Estes, 1966). So since they calve between January and February, mating must have taken place between April and May, when the grass is actively growing and has a higher protein content.

Furthermore plains ungulates favour the short grassland habitat because of good visibility. This enables them to detect predators and hence affords them a better chance of escape. As Walther (1968) puts it, "in optical perception (in general, and in special case of perception of enemies) gazelles recognize movements and silhouettes prodominantly. This is probably true in many horned ungulates." The main predators in Simanjiro are lions, hyenas, jackals and cheetah. Lions which seem to be the most important predators in the area usually hunt by stalking and using all available cover (Guggisberg, 1962; Kruuk and Turner, 1967). So more open short grassland in this case favours the prey. In Serengeti the hunting success of lions, in open country was less than that in areas with cover (Schaller, 1972).

(b) Woodland

The woodland habitat in Simanjiro affects the distribution of the large herbivores through the interspersion of the vegetation sub-type namely *Acacia tortilis*-*Commiphora schimperi*, *Acacia nilotica* subsp. *subalata*, and *Commiphora* spp. In the northwest all the three are in close proximity to each other thus creating an even better habitat through ecotones. Individually, the second mentioned sub-type is the most important for large herbivores. Its percentage crown cover is low and it contains short grasses which are considerably grazed by the large ungulates. During the wet season when the migratory herbivores are in Simanjiro the species which most frequently grazes in this woodland is zebra. Also there was a number of zebra skulls in this habitat which was an indication of utilization. Wildebeests use this habitat to a limited extent. Elands on the other hand use this habitat more than wildebeest. This preference for open woodland by this herbivore has also been reported in Tarangire where they were observed to feed on both grasses and browse (Lamprey, 1963). They have also been reported as being mostly browsers (Dorst and Dandelot, 1970). This makes this woodland habitat in Simanjiro ideal for them. This habitat contains a considerable number of browse species and this together with the available grasses make the subtype an ideal habitat especially for mixed feeders namely Grant's gazelle and impala.

In addition to the grasses, shrubs and herbs which are available in this habitat, the dominant tree Acacia nilotica subsp. subalata, is eaten by ruminants. Observations in different parts of Kenya have shown the branches, twigs, pods and seeds of this Acacia to be eaten by ruminants and particularly impala (Dougall and Drysdale, 1964). The abundance of the large and fleshy pods attracts the ruminants. These trees flower twice in a year both during and before the short rains and long rains (Brenan and Greenway, 1949). This means that pods are available for a considerable length of time. Impala increase their use of the area during the dry season. This means they increase their consumption of the Acacia twigs, pods and seeds which are high in protein. Observations in Serengeti have shown that impalas take more browse during the dry season (Jarman and Jarman, 1969).

Unlike the preceding species, Thomson's gazelle were observed in this habitat only during the dry season. It was at this time that they were also seen feeding more on browse. This confirms with observations in Serengeti where this species has been observed to feed more on dicotyledinous material during the dry season (Gwynne and Bell, 1968). Also observations elsewhere show that open woodland is part of this species habitat (Brooks, 1961).

Not only is this woodland habitat used by wildlife, it is also used by livestock. Cattle use it more during the rains. This coincides with the new grass growth and an abundance of herbs particularly *Justicia exigua*. Cattle were observed feeding on this species. It is reported to be frequently eaten by cattle elsewhere (Glover, Stewart and Gwynne, 1966). The preference of cattle, and for that matter all plains ungulates, for the short grasses during the rains has already been discussed. During the dry season, cattle browsed more than they did during the rains. This is similar to observations reported from elsewhere in northern Tanzania (Payne and MacFarlane, 1963). However, the abundance of *Acacia nilotica* subsp. ~~subalata~~ fruits at the beginning of the dry season did not result in an increase of cattle which did not seem to like this Acacia species. Masais interviewed during the study indicated that this Acacia is not good for cattle. This conforms with observations from South Baringo where though readily eaten by cattle, the pods are regarded to be poisonous by the Tugen pastoralists (Dougall and Bogdan, 1958). On the other hand, the fruits are reported to be readily eaten by cattle in the Karamoja area (Wilson and Bredon, 1963).

Similarly, goats and sheep use this habitat during both seasons. However, unlike cattle which showed less use during the dry season, goats and sheep used it as much during this season. They fed considerably on leaves, twigs and pods of _Acacia_ _nilotica_ subsp. _subalata_. Reports from south Baringo likewise show increased feeding by goats on this species during the dry season (Knight, 1965).

The Commiphora woodland is also extensively used by herbivores. Its grass composition is similar to that of the previously discussed area. The difference between the two woodlands is in the tree density, the latter being more dense. During the rains, zebra use it more than any of the other wild herbivores though to a lesser extent than the preceding subtype. The advantages of the short grasses growing in this habitat which are similar to those growing in the previous habitat have already been discussed. Wildebeest tended to use this habitat more particularly at Sukuro where the Commiphora woodland is more open. They especially like the ecotone between this woodland and the grassland. Such edge effect has also been reported in Tarangire (Lamprey, 1963). Grant's and Thomson's gazelles and eland use it in the same manner and for almost the same reasons they use the previous woodland sub-type. Giraffes also use it considerably particularly during the rains. Commiphora schimperi the major constituent of this vegetation is reported to constitute the main food of giraffes in Shinyanga during the wet season (Spinage, 1968). During the dry season, they favour the Sukuro area where Acacia mellifera is associated with the dominant tree. The latter species is known to constitute important browse for giraffe (Lamprey, 1963; Dougall and Drysdale, 1964). Impalas prefer the Commiphora woodland where it is associated with Acacia mellifera which is found in the Sukuro area to the north of the dam. This is because impalas browse to a considerable extent on the latter plant as observations in other areas show (Talbot and Talbot, 1961; Lamprey, 1961; Dougall and Drysdale, 1964; Jarman, 1972).

Among the livestock, cattle use it more than goats and sheep. They do not seem to show preference for the habitat which contains Acacia mellifera. There they follow the available grasses which are similar to those found in the preceding vegetation subtype. On the other hand goats prefer the latter area more. This is because of the availability of Acacia mellifera on which goats are known to browse considerably (Knight, 1965).

The Acacia tortilis - Commiphora schimperi woodland sub-type is not as much used as the preceding subtypes by the migratory ungulates. Even zebras which are more catholic in their use of vegetation types use this area sparingly. The woodland contains tall grasses and these are usually low in protein during the rains as analysis in various areas show (Bredon and Wilson, 1963; Dougall and Drysdale, 1964). This makes the area unattractive to the migratory herbivores which prefer areas with high protein value grasses as already explained. They mainly use this woodland during the migrations. On the other hand, the majority of resident species use this habitat considerably. Grant's gazelle use it during both seasons but more so during the dry season. This is because this habitat contains a variety of browse species. Observations in the Mara, Tarangire and Athi-Kapiti area confirm this (Talbot and Talbot, 1961; Lamprey, 1963; Stewart and Stewart, 1970). Acacia tortilis, the dominant species was browsed on considerably by Grant's gazelle in Simanjiro. This is similar to observations made in the above mentioned areas which also show that the pods and seeds are taken considerably during the dry season. No Thomson's gazelles were observed in this habitat. This is mainly because of the long grass cover found. Observations by Brooks (1961) show that this species will avoid areas with long grass "at all costs". However what repels one species attracts another and this is the ideal habitat for impala. The wide array of browse species make it especially attractive. This is in fact the most characteristic habitat of impala within the Acacia savannah (Dorst and Dandelot, 1970). Acacia tortilis is a major food species of impala. The latter browses on twigs and leaves and feeds on pods and seeds. A large number of feeding observations made on Acacia tortilis in Tarangire were contributed by impala (Lamprey, 1963). Besides impala, giraffes also use this habitat to a considerable extent. This is because this habitat has a variety of Acacia species and other trees upon which giraffes feed. The major ones besides the dominant ones are A. mellifera and Acacia seyal, Balanites aegyptiaca, and Commiphora schimperi. Reports from various areas indicate these species to be browsed by giraffe (Lamprey, 1963; Dougall and Drysdale, 1964; Forster, 1966; Spinage, 1968; Guggisberg, 1969). Ostriches also use this habitat particularly where it is more open. They follow the herbs which are numerous during the rains. Herbs found in Simanjiro are similar to those found in Tarangire and ostriches fed on some (Lamprey, 1963).

Like the majority of the resident game species livestock use this woodland habitat. Cattle were observed in this habitat during both seasons but there were more during the dry season. There were a number of bomas built by Masais in this habitat during the rains because it was more drained and therefore less wet. Also cattle fed on some of the herbs, and Cenchrus ciliaris and Themeda triandra. Both species are reported by Edwards and Bogdan (1951) to be valued in natural pasture. In a vegetation zone in Karamoja similar to this habitat, it was found that these species had their highest level of digestible proteins during the rains and Cenchrus ciliaris had a higher level than that of Themeda triandra during the dry season (Bredon and Wilson, 1963). During the dry season in Simanjiro cattle fed more in this habitat. They were seen browsing on Grewia bicolor, Achyranthes aspera, Sericocomopsis hildebrandtii, Maerua triphylla, Capparis sp. Leucas pododiskos and also on Acacia tortilis pods. This is identical with cattle browsing observations made in northern Tanzania in the past (Payne and Macfarlane, 1963). Goats also used this habitat in a similar way to cattle, being especially attracted by the numerous browse species in the area. The above mentioned browse species and others available in this habitat such as Rhus natalensis, Aspilia sp. Ocimum sp. and Solanum incanum have been recorded as being browsed on by goats in South Baringo (Knight, 1965).

(c) Seasonally water-logged bushed grassland

This vegetation type is also important as herbivore habitat. All the migratory species use it intermittently when they are in the area. Both zebra and wildebeest use it at the beginning of the rains. This is at the time when Pennisetum mezianum the dominant species in this vegetation type is producing new growth. Samples of this species analysed from Karamoja contained the highest crude protein content at this time (Bredon and Wilson, 1963). This would make it more acceptable to the ruminants. Also Lintonia nutans is grazed by these ruminants during the rains. Setaria incrassata which grows on the edges of this vegetation type was also grazed by these ruminants. This species has also been recorded elsewhere as being grazed by zebra (Dougall and Drysdale, 1964). When the rains cease, zebras move into this vegetation type to graze the rough and plentiful Pennisetum mezianum before migrating out. They are followed by the wildebeest. So this vegetation serves both as a supplement to the grassland but more so as a transition zone during the outward migration. A similar function of the so called sumps has been described in Serengeti (Bell, 1970). P. mezianum is also fed on by zebra and wildebeest when it is mature in the Athi-Kapiti plains (Stewart and Stewart, 1970).

Resident species use this vegetation subtype in varying intensities. Grant's gazelles use it more than the other species. They were seen grazing on Pennisetum during both seasons. This is similar to observations made from the Athi-Kapiti plains (Stewart and Stewart, 1970). They also fed on Ecbolium revolutum which grows in this habitat. This has also been reported to occur in Tarangire (Lamprey, 1963). They also fed on Balanites aegyptiaca and Capparis sp. which grow on termite mounds within this habitat. The former species has been recorded to be eaten by Grant's gazelle from the Serengeti/Mara area (Talbot and Talbot, 1962). Contrary to the utilization of this habitat by Grant's gazelles, Thomson's gazelles never used this habitat. This is similar to observations which have been made in Serengeti where they avoid black cotton soil areas with poor drainage (Brooks, 1961). Similarly, this habitat is not particularly attractive to impala. They were only seen on the edges where Acacia mellifera grew together with A. stuhlmannii. These edges are the only parts of this vegetation type where giraffes were seen usually browsing on A. mellifera. However the most favoured part of this habitat by giraffe is that which is dominated by Acacia drepanolobium. They were seen on numerous occasions browsing on this species. This whistling thorn bush has been reported from many areas as being favourite giraffe browse (Lamprey, 1963; Brown, 1965; Forster, 1966; Spinage, 1968). Ostriches on the other hand utilized this habitat regularly. They were attracted by the herbs such as *Oxygonum sinuatum* which were abundant there during the rains. This species has been observed being fed on by ostrich in Tarangire (Lamprey, 1963). During the dry season, the ostriches were attracted to this habitat by the numerous seeds of the annual shrubs and herbs found there.

Cattle, like the migratory herbivores used this seasonally water-logged habitat more during the rains because of the new grass growth. *P. mezianum* is reported elsewhere to be grazed by cattle when it is still young (Edwards and Bogdan, 1951). It is also fed on in the Athi-Kapiti Plains by cattle when it is mature and brown (Stewart and Stewart, 1970). Cattle use this habitat sparingly during the dry season as there are fewer browse species in this habitat compared to the woodland area. Goats use it in a limited way for the same reasons.

(d) *Bushland*

This is the least used of all the habitat types in Simanjiro. This is because most of it is impenetrable thickets. However, the open spaces have grasses, shrubs and herbs which grow mainly during the rains. In more open spaces, *Pennisetum mezianum* grows. Zebra venture into these areas to graze on it occasionally. Wildebeest on the other hand rarely wander into this habitat type. Dense thicket is not generally regarded as ideal habitat for either zebra or wildebeest (Dorst and Dandelot, 1970). Besides lack of good grazing, this bush habitat make these species vulnerable to predation by lions (Schaller, 1972).

Resident species use this habitat only to a limited extent. Grant's gazelles use it more than the other species. Even then they are confined to the open spaces particularly where other shrubs grow besides the dominant <u>Acacia stuhlmannii</u>. They especially favour where <u>Dicrostachys</u> sp., <u>Ormocarpum kirkii</u> and <u>Acacia mellifera</u> grow. Some of these species have been reported to be fed on by Grant's gazelles elsewhere (Dougall and Drysdale, 1963). Bushland has also been reported as part of this species habitat (Dorst and Dandelot, 1970). Thomson's gazelles on the other hand do not use the bushland. It is for the same reasons as those given for the sumps. Brooks (1961) in his study of this species did not rank bushland among its habitat. Giraffes use this habitat in the same pattern as Grant's gazelles do. So do impalas. Ostriches use this area less often.

Even livestock use this habitat only to a limited extent. Cattle use the open patches to graze on

Table 49

The general habitat preference of the large herbivores in Simanjiro

Species	Grassland	Woodland	Seasonally water-logged bushed grassland	Bushland
Cattle	A	B	C	C
Goats & Sheep	B	A	C	C
Zebra	A	B	B	C
Wildebeest	A	C	B	D
Eland	A	B	C	C
Grant's gazelle	A	B	C	C
Thomson's gazelle	A	C	B	D
Ostrich	A	B	C	C
Giraffe	C	A	C	B
Impala	C	A	B	C

A = Preferred habitat

B = Secondary but important habitat

C = Little used habitat

D = Unused habitat

young *Pennisetum mezianum* during the rains. Goats use it in the same manner as Grant's gazelles do. This is because *Acacia stuhlmannii*, the dominant bush is not favoured by them. They feed in the open areas where other shrubs grow. Some of the shrubs growing in these open areas are also reported to be fed on by goats in other areas (French, 1944; Knight, 1965).

4. Ecological separation

In the natural Acacia-Themeda community of East Africa, there is usually a large number of herbivores which exploit the same vegetation community for their food supply. In Tanzania alone, there are 45 large herbivores (Cloudsley-Thomson, 1969). One would therefore expect that when a number of different species are dependent on the same food supply, competition would ensue. This however, is not the case. Each herbivore occupies a separate niche in the community resulting in ecological separation. Niche is defined as, "the position or status of an organism within its community and ecosystem resulting from the organisms structural adaptations, physiological responses and specific behaviour," (Odum, 1959). Lamprey (1963) in Tarangire found six factors which facilitated ecological separation. These were occupation of different vegetation types, different types of food, occupation of the same area at different seasons, occupation of different areas at the same season, the use of different feeding level in the vegetation and the occupation of different dry season refuges.

All these mechanisms operate in Simanjiro. The most obvious factor already discussed in detail is the occupation of different vegetation types and broad habitats by the different herbivores. This automatically separates the browsers from the grazers. The primary grazers mainly wildebeests, cattle, ostriches, Thomson's gazelles and zebra are separated from the primary browsers mainly giraffe, Grant's gazelles, impalas and goats. It has already been seen that no species is exclusively confined to one habitat and there are some overlaps. These overlaps have also been noted in Tarangire (Lamprey, 1963). It is a well known fact that the habitat of the majority of East African herbivores involves more than one vegetation type (Dorst and Dandelot, 1970). It is also an accepted game management fact that the abundance of wildlife in any given range depends upon the diversity of habitat types (Leopold, 1933). However the fact that each species has different anatomical and behavioral adaptations, makes the niches separate when time and space are considered.

In addition to the separation between grazers and browsers, it has already been noted that the species composition of the diets of these herbivores differ. This again is another mechanism of ecological separation.

The most important mechanism of ecological separation in Simanjiro is the use of different feeding levels in time and space. The latter results in a feeding sequence which particularly operates in the grassland. It is usually referred to as grazing succession (Vesey-Fitzgerald, 1960). The differences in feeding level are facilitated by the broad morphological differences of the herbivores. The giraffes with their long necks browse on tops of the bushes and trees which are not available to the other browsers such as impalas, Grant's gazelles and goats. Among these three browsers separation is brought by food preference. Impalas feed more on Acacias including pods and seeds, Grant's gazelles take more grass and a variety of low growing shrubs and goats take in a wide range of species. This has already been discussed.

Since the short-grassland is the most important habitat because of being utilized by zebra, wildebeest, Grant's gazelles, Thomson's gazelles, eland, giraffes, ostriches, cattle and goats, mechanisms operating here to facilitate separation are the most important. This is where grazing succession comes in. Zebra, wildebeest, cattle and Thomson's gazelles are the major grazers and only these will be considered. Ecological separation starts to operate right at the beginning of the inward migration during the short rains usually in December. Wildebeest move in first and zebras come later. This means that food which is still scanty is only shared by wildebeest and even then the territorial bulls come in first. The other wildebeest and zebra come later as the rains increase and more grass is available. When all the species are in the plains, during the long rains, there is plenty of grass available for all species. Also zebras supplemented their diet from grasses in woodland. As the grasses became mature and vigorous growth ceased, the zebras tended to go to spots with coarse growth. After grazing these spots down they moved to others while the low grazed areas were then grazed by wildebeest and Thomson's gazelles in that order. Measurements taken during the feeding observations showed that each species fed at a particular level. The average feeding level of zebra was 19.57 cm while that of wildebeest was 12 cm, Thomson's gazelle 7 cm and cattle 11 cm. This means that the zebras fed on rougher herbage containing more stem as height is achieved by the stem length. Observations made in Serengeti have shown that zebra take the largest proportion of stem (Gwynne and Bell, 1968). The action of the zebras in removing stems is trantamount to clipping. It is a well known fact that when the terminal bud of a stem is removed by grazing, buds at the base of the stem are stimulated and new shoots grow provided there is sufficient soil moisture (Stoddart and Smith, 1955). This then means that the action of zebras results in new leaf growth which is eaten by the other species. Wildebeest which fed on the next level would then take in mostly the remaining grass portions. The usual grass leaf height is lower than stem height. Then Thomson's gazelles feeding on the shortest leavel would take in mainly the remaining grass portions. The Thomson's gazelles preferred the upper parts of ridges with short grass. Such preference has already been reported in Serengeti (Brooks, 1961). Quantitative analysis of stomach contents of these three species in Serengeti show that wildebeest take in more leaf while Thomson's gazelle take in more sheath (Gwynne and Bell, 1968). In grasses stems are highest followed by leaves and lastly sheaths. This explains the differences in feeding heights of these three herbivores. When the dry season starts, the zebras move into the low lying depressions where there is abundant and rough herbage. They graze it down before migrating out. The remaining herbage is then grazed by wildebeest before migrating out. Thomson's gazelles do not migrate out. The whole pattern therefore shows a definite grazing sequence. Such grazing succession is a common ecological phenomenon amongst East African herbivores (Vesey-FitzGerald, 1960; Brown, 1965).

On the other hand, the presence of cattle introduces a new dimension in the grazing pattern within the Simanjiro Plains. They graze at a level which is very similar to that of wildebeest. This means that there is an overlap since they feed on the same species. Fortunately the two species feed on the same grounds during the rains. This is the time when food is abundant and cattle supplement their diet with resources from the woodland. Also cattle numbers are at their lowest at this time. Wildebeest migrate out during the dry season when competition would be high. Even then it would appear that there is some competition between these two species towards the end of the rains and at the beginning of the dry season before the migration starts. Both species are ruminants and feed on identical grass parts that is the tender leaves which the rumen can easily digest. The zebra on the other hand is monogastric like a horse with an enlarged caecum and this aids in fermentation of the crude fibre diet it takes (Dukes, 1955). Competition between wildebeest and cattle has been postulated to occur in the Loliondo part of the Serengeti Plains. Observations done on two similar adjacent habitats one of which was used by wildebeest only and the other by both wildebeest and cattle had very similar biomass densities. It was suggested that "there is a large degree of overlap between the requirements of wildebeest and cattle" (Watson et al, 1969). Censuses in the Nairobi National Park show that the population of wildebeest has been increasing since cattle were excluded from the park (McLaughlin, 1970). There are also indications that the population of wildebeest in the Serengeti National

Park has been increasing (Sinclair, 1973). This could be partly due to the exclusion of cattle from the area in the early fifties.

5. The distribution of water and its effect on herbivores

Water is a vital part of the habitat in addition to vegetation (Leopord, 1933). This is especially so in the East African grasslands. The major plains game namely zebra and wildebeest drink regularly. Both species must drink everyday although it has been suggested that wildebeest can go for 5 days without water (Lamprey, 1963; Dorst and Dandelot, 1970).

The available permanent water in Simanjiro is in the form of dams, bore holes and natural springs as described earlier. These are all placed on the peripheries of the grassland and as such are not well placed. They are also constantly utilized by cattle such that the wild herbivores are more or less completely displaced. Luckily enough, the migratory herbivores come to Simanjiro during the rains when water is abundant. So besides stimulating grass growth, rainfall provides direct drinking water and the migration and duration of utilisation of Simanjiro by herbivores was geared to rainfall.

The rainfall recorded in 1971 and 1972 was 538.36mm and 443.90mm respectively. This was below normal as the average rainfall from past records kept by the Roman Catholic Mission at Loiborsoit is 600mm (Kametz, 1962). This delayed the inward migration and accelarated the outward migration from Simanjiro. The scarcity of rainfall in these two years was also reported in Tarangire National Park when 566.50mm and 359.86mm fell. The annual rainfall distribution pattern in Simanjiro is typical of the general pattern of the whole of Masailand both in Tanzania and Kenya (Griffiths and Gwynne, 1961) and hence has similar ecological effects.

During the rains in Simanjiro, there are 12 major water pools which form and are scattered throughout the grassland. These pools are heavily utilized by zebra, wildebeest and cattle. Thomson's and Grant's gazelles, impalas and giraffes have been seen drinking but not regularly. Goats and sheep also drink regularly but not at the same frequency as cattle do. The heavy utilization of the rain pools is clearly indicated by the numerous trails which criss-cross the plains ultimately converging on the pools. The larger pools are utilized more than the smaller pools and they have consequently more trails converging on them. These pools are very well dispersed throughout the plains and this in return results in a fair dispersion of the animals without over-concentration in particular areas. Also the close proximity of water conserves the energy of these animals which would otherwise be expended in walking to a more distant source of water. The saved energy is thus available for other important activities such as reproduction and growth. Cattle are reported to gain more weight when they do not have to walk for water (Stoddart and Smith, 1955).

When the rains stop, most of the pools dry up fast. Simanjiro falls within a zone of high evaporation potential (Woodhead, 1969). There are two water holes where the Terrat drainage line starts which are deeper and hold water longer. Zebras utilize the vicinity of these water holes just before migrating out. The territorial wildebeest which remain longer use the dams.

The importance of these water pools to cattle was clearly demonstrated in 1972 when Sukuro dam dried out by early October. Heavy showers fell in late October within the vicinity of Sukuro and several water-pools formed. There was an immediate influx of cattle until the water-pools dried when they moved out again.

During the dry season, the only water available in the plains is from the dams, boreholes and springs mentioned earlier. Even the rest of Masailand, except for a few spots, becomes a water-less wilderness. It is then that a large influx of cattle into Simanjiro occurs. Since the permanent water is on the periphery of the grassland there is an unusually heavy concentration around the permanent water resulting in overgrazing and denudation of grass. A grass cover appraisal done in October, 1972 near Sukuro dam showed a percentage ground cover of less than 10%. Such grazing pressure around permanent water is a common feature in Masailand (Voorthuizen, 1971). Data from aerial observations collected in 1972 show that cattle were concentrated around the permanent water including Sukuro dam. When the Sukuro dam dried, aerial data showed no cattle there. They all moved farther north and there was an unusually heavy concentration around the Terrat springs. Other cattle were moved farther north into the Oljoro springs. This caused clashes between the Masai herders and the Waarusha settlers. Tribal warfare was only averted through direct intervention by the government. This is a clear demonstration of the importance of water in Masailand.

In order to avoid such undue concentration and over-grazing by livestock in Masailand, the siting of permanent water will have to be carefully planned.

6. The populations, densities biomasses and migration of the large herbivores

(a) Populations

Before going on to discuss the different population parameters it is important to define what the term means. According to the definition adopted by the wildlife Society of the United States, it means, "a social aggregation of animals in defined time and space" (Mosby et al, 1963). This definition will be adopted for this study with certain local modifications. In this study a population constitutes all animals of any given species whose centre of distribution at a given time is within the Simanjiro Plains, intebreeds and has the same migratory or ranging pattern. If more than half of a given species are distributed within the plains, that constitutes a population.

Both aerial and ground observations in and around Simanjiro confirmed the earlier hypothesis that zebra and wildebeest found there constituted complete populations. This could not be said of eland as there were some which were seen outside the study area frequently. Among the resident game species only Thomson's gazelle were confined to the study area. The population of Grant's gazelle also had its locus within the plains as fewer animals were observed outside the plains. The same can be said of ostrich. However the impala and giraffe numbers did not constitute populations as their distribution extended well outside the study area.

The zebra and wildebeest populations in Simanjiro during the rains are the largest in Tanzania east of the rift. The average zebra population is 5500 and wildebeest 4200. The estimated populations of these species in Mto-wa-Mbu is 1109 and 1066 (Mmari, 1965). The figures for Longido are 659 and 996 respectively (College of African Wildlife Management, 1968). The largest zebra populations in East Africa are in Serengeti and Mara where they reach over 200,000 (Talbot and Stewart, 1962; Skoog, 1970). The Loliondo area contains a large number of zebras but they are considered to be a sub-population of the Serengeti population (Skoog, 1970). The Athi-Kapiti population estimated to be 14,536 by Casebeer (1970) is also higher than the Simanjiro one. On the other hand, the population of this species in Simanjiro is about the same size as that recorded in Ngorongoro Crater estimated to be 5038 (Turner and Watson, 1964).

Generally the total wildebeest populations in East Africa are larger than those of zebra. The highest concentration of the former is found in the Serengeti Plains where it attains spectacular proportions and has recently been estimated to be 840,000 (Norton-Griffiths, 1973). The next highest population is 16,000 in Mara (Stewart and Talbot, 1962). Even the Ngorongoro Crater population at 14,222 is much higher than that of Simanjiro (Turner and Watson, 1964). The Loliondo one which is 5863 is also higher than the Simanjiro one (Watson et al, 1969). The average number of eland estimated to be 300 in Simanjiro during the rains, compares well with those recorded elsewhere. The average numbers are about the same as 342 recorded in Ngorongoro during the rains (Turner and Watson, 1964).

The average number of Grant's gazelles in Simanjiro which is 500 compares well with most of the other areas in East Africa. It is about the same as that recorded in Nairobi (Forster and McLaughlin, 1968). It is exceeded by that of Longido (College of African Wildlife Management, 1968) where it is estimated to be 2090. The highest number of 1200 recorded in Simanjiro is about the same as that recorded around Lake Rudolf (Stewart, 1963). It appears that the areas with mixed scattered tree grassland and bushland, the ideal habitat for this species carry larger populations. On the other hand, the population of Thomson's gazelle in Simanjiro, estimated to be about 200 is one of the lowest recorded in East Africa. The largest population of this species is in the Serengeti where there are estimated to be about 600,000 animals (Bradley, 1972). The Loliondo population is the next largest with all gazelles totalling 37,729 (Watson et al, 1969). Even the Longido population numbering about 900 animals is higher than that of Simanjiro (College of African Wildlife Management, 1968). The population of the study area is comparable to that of Nairobi National Park of (Foster and Kearney, 1967) and is low compared to the other areas of E. Africa as already mentioned.

Similarly the numbers of impala recorded in Simanjiro are the lowest in East Africa. The highest population of this species recorded in East Africa is from Loliondo where there are estimated to be 14,776 (Watson et al, 1969). Even the Tarangire population numbering about 1,200 animals, exceeds that of the study area. Also the Longido population at 611 exceeds the Simanjiro one (College of African Wildlife Management, 1968). The Nairobi Park population estimated in 1967 to be about 300 (Foster and Kearney, 1967) also exceeds the Simanjiro one. The giraffe number in Simanjiro estimated to be about 80 in 1971 is close to that of Nairobi. It is however exceeded by the populations in Tarangire, Loliondo and Mkomazi (Lamprey, 1963; Watson et al, 1969). The ostrich population at an average of 200 is about twice that recorded in the Nairobi park. It far exceeds that of the Ngorongoro Crater (Turner and Watson, 1964) which was estimated to be 37.

Plate 13
Wildebeest in the Short grassland habitat

Plate 14
Giraffes on the edge of the woodland habitat

Plate 15
Ostriches in the short grassland habitat

Plate 16
A family herd of Thomson's gazelles in the short grassland habitat

Plate 17
A territorial male Thomsons gazelle

Plate 18
An aerial view of cattle in the short grassland habitat

The cattle population in the study area at an average of 17,000 is quite high compared to other areas. It far exceeds that of Mto-wa-Mbu estimated to be 5000 (Mmari, 1965). It is about the same as that of Amboseli (Western, 1973) and South Turkana (Watson, 1969). It is only exceeded by Loliondo estimated to be 92,610 and some parts of North eastern Kenya (Watson, 1967 and 1969). The proportion of goats and sheep to cattle in East Africa is usually in favour of cattle as is the case in Simanjiro except in South Turkana and Mandera where it is the reverse (Watson, 1969).

(b) Density and biomass

As mentioned earlier, density and biomass are better criteria for comparing herbivores in different habitats. They reflect the actual carrying capacity, the later meaning the number of animals of each species able to live on a piece of land without deletious effects to the range. While biomass density for all herbivores is used in comparing the standing crop of different ranges, density is used for comparing the carrying capacity of different ranges for different species. It is the figure usually given in most of the population studies and it is easier to calculate than biomass.

(i) Zebra

The density of zebra in Simanjiro during the rains for 1971 and 1972 was 9.96 and 10.10 animals per square kilometre. The density for the Serengeti as a whole is 11.2/km^2 but much higher when only the short grassland is considered. The figure for Ngorongoro is 18.0/km^2 (Kruuk, 1970). The figure for Loliondo and Mkomazi are 5.40 and 1/km^2 (Watson et al, 1969). The later area represents the lowest recorded density in East Africa. This is expected as Mkomazi has no short grassland habitat which provides the required wet season requirements.

The density for the Tarangire recorded during this study for the entire sampled area was 3.43/km^2. Lamprey (1964) recorded close to 30/km^2 within the transects. This figure is only surpassed by that of the Serengeti short grassland area during the rains. The figure for the transect data cannot be taken to be representative as the transects did not cover the total distribution range, they were concentrated near the permanent water where animals congregate in large numbers. During this study, the total area in which zebra were distributed covered about 840 km^2 or 324 square miles. The census done during this study covered 1342 km^2. The actual density within the area containing occupied transects was 5.49/km^2.

This good density of zebra in the study area is achieved through the plentiful availability of food.

The whole amount of the rougher herbage in Simanjiro is primarily used by this species. The only competitor could have been the domestic ass but its population and hence density is very low. The higher densities recorded in Ngorongoro and Serengeti are due to the large area of short grassland. Also the Ngorongoro Crater has high grass cover and abundance of *Cynodon dactylon*, *Sporobolus marginatus* and even *Chloris gayana* in some areas which are all highly nutritious grasses.

(ii) Wildebeest

The density of wildebeest during the rains in 1971 and 1972 was 6.31/km^2 and 8.68/km^2 respectively. This is an average density compared to densities in the major wildebeest ranges of East Africa. The densities for Serengeti and Ngorongoro are 14.4/km^2 and 41.0/km^2 respectively (Kruuk, 1970) and are the highest in East Africa. The density in the Mara is about 11/km^2 (Talbot and Talbot, 1961). That for the study area compares well with some of the densities recorded in the transect area of Tarangire (Lamprey, 1964). The density recorded for Tarangire during this study was 4.65/km^2. The density recorded in the transect area mentioned above for October, 1960 was 4.79/km^2 which compares well with the present study's figure. The Simanjiro density on the other hand exceeds that of Loliondo which is 1.04/km^2 (Watson et al, 1969). It also exceeds that of Nairobi which is about 2.5/km^2 (McLaughlin, 1970). It also exceeds that of Longido (College of African Wildlife Management, Mweka, 1968).

The density of wildebeest is likewise dependent on the food supply. Unlike zebra which has practically no competition, wildebeest competes with cattle. This means that the density of the former is decreased by the high density of the latter. It has been shown for Loliondo that there is a large degree of overlap between the requirements of wildebeest and cattle (Watson et al, 1969). The exclusion of cattle from the Nairobi park resulted in an increase of the wildebeest population and hence density (McLaughlin, 1970). It is therefore almost certain that if cattle were removed from Simanjiro, the wildebeest density would increase. The Ngorongoro Crater density is not much affected by cattle because the numbers of the latter are very much restricted.

(iii) Eland

The eland densities for 1971 and 1972 wet seasons were 0.51 and 0.32/km^2 respectively. This is about the same density as that recorded by Watson et al (1969) for Loliondo which was 0.54/km^2. However, it is on the whole a rather low density. The densities recorded in Tarangire by Lamprey (1964) varied between 0.35/km^2

and 6.15/km^2 with an average of 4.64/km^2. The density calculated from the Ngorongoro population is 1.10/km^2 (Turner and Watson, 1964). That worked from the Nairobi population is 3.15/km^2 (McLaughlin, 1970). The Serengeti density is estimated to be 1.06/km^2 (Sinclair, 1972).

The very high mobility of eland makes it difficult for any conclusions to be drawn about the part played by the study area in regulating density. Extreme fluctuation and large scale migration of this species have been reported in Tarangire and Serengeti (Lamprey, 1964; Sinclair, 1972) thus making this species rather laborious to study.

(iv) Grant's gazelle

The densities of Grant's gazelle in the study area for 1971 and 1972 wet season period were 1.07/km^2 and 1.16/km^2 respectively. Although there are few figures from other areas to compare with, those available indicate that this is about the optimum density for this species. Lamprey (1964) in his studies recorded densities varying from 0.05/km^2 to 3.65/km^2. The one for Longido is 1.89/km^2 (College of African Wildlife Management, Mweka, 1968). The only higher density was recorded in Nairobi National Park where it was 3.68/km^2 (McLaughlin, 1970).

This rather high density of this species in Simanjiro is due to the availability of both good grazing and browse. This species has no major competitor in the plains. Also the higher mobility of this species enables it to utilize a large spectrum of its available food resource even outside the study area. Goats which could have been the major competitors are much more restricted in movement.

(v) Thomson's gazelle

The densities of 0.40 and 0.26/km^2 recorded for 1971 and 1972 respectively for this species within the study area is the lowest ever recorded. The highest density is about 24/km^2 for the Serengeti National Park (Bradley, 1972). The Nairobi National Park density is 2.35/km^2 (McLaughlin, 1970. Even the Longido area which is also considered to contain a low density, it is 0.84/km^2.

Unlike Grant's gazelle which enjoys a wide variety of food, Thomson's gazelle is much more restricted. Its high dependence on the grassland habitat throughout most of the year brings it into direct competition with cattle especially during the dry season. On the other hand, cattle keep down the grass to a level which Thomson's gazelle prefer. So the former are a factor in the grazing succession during the dry season.

(vi) Giraffe

The densities of this species in the two years for the wet seasons were 0.15 and 0.20/km^2. This is below the average density in most of its habitat. The density in Nairobi park in 1968 was 0.74/km^2 (McLaughlin, 1970). Watson et al, (1969) recorded a density of 0.39/km^2 in Loliondo. Sinclair (1972) recorded a density of 0.76/km^2 in Serengeti. The only density lower than that for the study area was recorded in Mkomazi where it was 0.08/km^2 (Watson et al, 1969). The highest density ever recorded was 3.07/km^2 in Tarangire (Lamprey, 1964).

The preferred food species for giraffes are *Acacia drepanolobium* and *A. mellifera* (Lamprey, 1963; Foster, 1966). The two Acacias and particularly the latter have a high protein content (Dougall and Drysdale, 1964). The Tarangire has large areas dominated by the latter species while Nairobi is dominated by the former species. This is not the case with Simanjiro which is primarily grassland. This is the main cause of the low giraffe density in the study area.

(vii) Impala

The density of this species for the two periods considered was 0.26 and 0.30/km^2. This, as was the case with giraffe is a low density when compared to other areas in East Africa. In Loliondo the density is $2.59/km^2$ (Watson et al, 1969). The density for Serengeti is $5.98/km^2$ (Sinclair, 1972). The highest recorded density was $25.58/km^2$ recorded in Tarangire in 1958 (Lamprey, 1964).

Studies in Serengeti have shown that the most preferred species in order of importance are *Acacia kirkii*, *A. tortilis*, *A. senegal*, *A. mellifera* and *A. drepanolobium* (Jarman and Jarman 1969). The Tarangire area which has the highest impala density in East Africa contains all these species. It is therefore the ideal impala habitat. Simanjiro on the other hand is primarily a grassland and contains a limited amount of impala's favourite menu and hence the low density.

(viii) Ostrich

The densities of ostriches during the periods under consideration were 0.53 and $0.36/km^2$ respectively. This is about the average density for this species within its major habitats in East Africa. It is between the lowest recorded density of $0.12/km^2$ for Ngorongoro (Turner and Watson, 1964) and the highest of $0.86/km^2$ worked from the population count for Nairobi (McLaughlin, 1970).

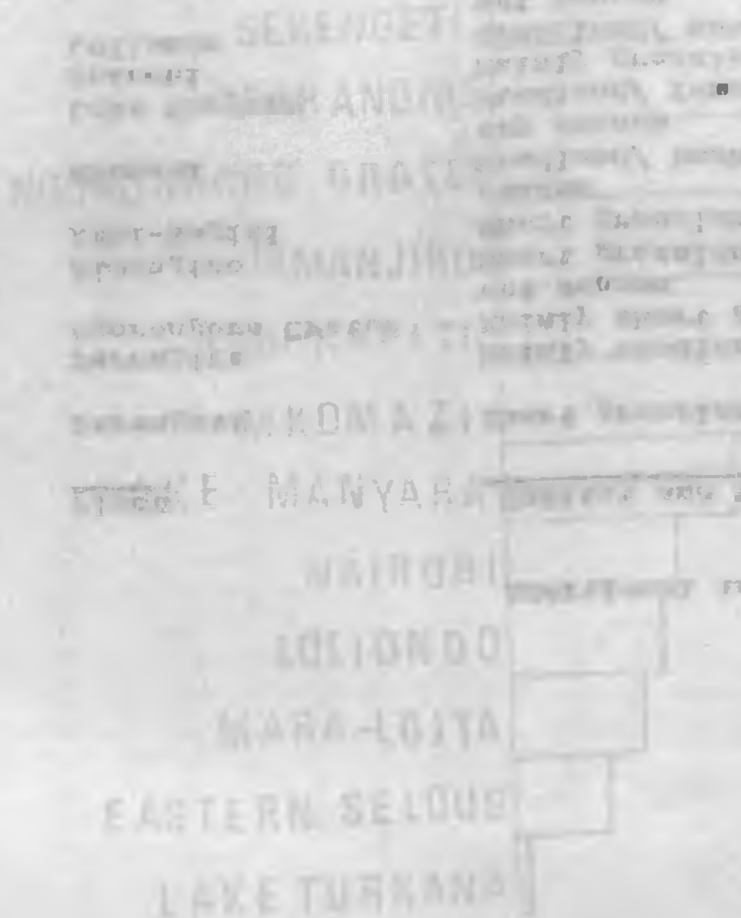
The medium density of ostriches in Simanjiro means that the area is [illegible] habitat for this species. The abundance of vegetable matter particularly grasses, herbs and shrubs means sufficient food to support the ostriches. Also the grassland contains a large variety of insects which also form part of the diet of ostrich.

(ix) Livestock

The densities of cattle during the wet seasons of 1971 and 1972 were 21.69 and 30.08/km^2 respectively. The dry season densities in 1972 averaged 31.55/km^2. This by any standard is a very high density. The density recorded in Loliondo by Watson *et al.* (1969) was 16.21/km^2. The Simanjiro density is only exceeded by that of Kaputei which is 36.2/km^2 (Watson, 1969). The high cattle densities of Simanjiro are an indication of the productivity of the range. It has been assessed that the carrying capacity of the plains is about 25 cattle/km^2. Other areas such as Ngaserai, Longido and Mto-wa-Mbu area have a capacity of 20 cattle/km^2 (Voorthuizen, 1971). The range in Simanjiro is therefore overstocked.

The density of goats and sheep is lower than that of cattle. Their average density was 7.89/km^2. This is a medium density by East African standards. Studies in North-eastern Kenya show a density varying from 1.4/km^2 in Wajir to 46.4/km^2 in South Turkana (Watson, 1969). There seems to be an inverse relationship between cattle and goat and sheep numbers. This is related to the habitat requirements of the two species. Areas with more grassland have more cattle while the semi-arid to arid woodland/bushland have more goats. The medium density of Simanjiro is a reflection on the variety of the vegetation types.

Taking the overall average biomass density of all species for the three months mentioned earlier, the biomass densities for 1971 and 1972 are 8090 kg/km^2 and 10,200 kg/km^2 respectively. The overall average is 8500 kg/km^2. Out of this 2700 kg/km^2 is contributed by game animals and the rest by livestock. The biomass density of Simanjiro compares well with other shortgrassland areas of East Africa. Values worked from densities of animals on the Athi-Kapiti plains (Petersen and Casebeer, 1970) give a total biomass density of 7676 kg/km^2. Lamprey (1964) gives a value of 6143 kg/km^2 for the Ngorongoro Crater. The biomass density worked from densities given by Watson et al (1969) for Loliondo is 6255 kg/km^2. It is only the Serengeti grassland area which has a much higher biomass density estimated from the population numbers to be about 30,000 kg/km^2 during the rains. Taking the game animals alone, the biomass density for the study area is twelve times that recorded for the Masai


SERENGETI
NAIROBI
LOLIONDO
MARA-LOITA
EASTERN SELOUS
LAKE TURKANA

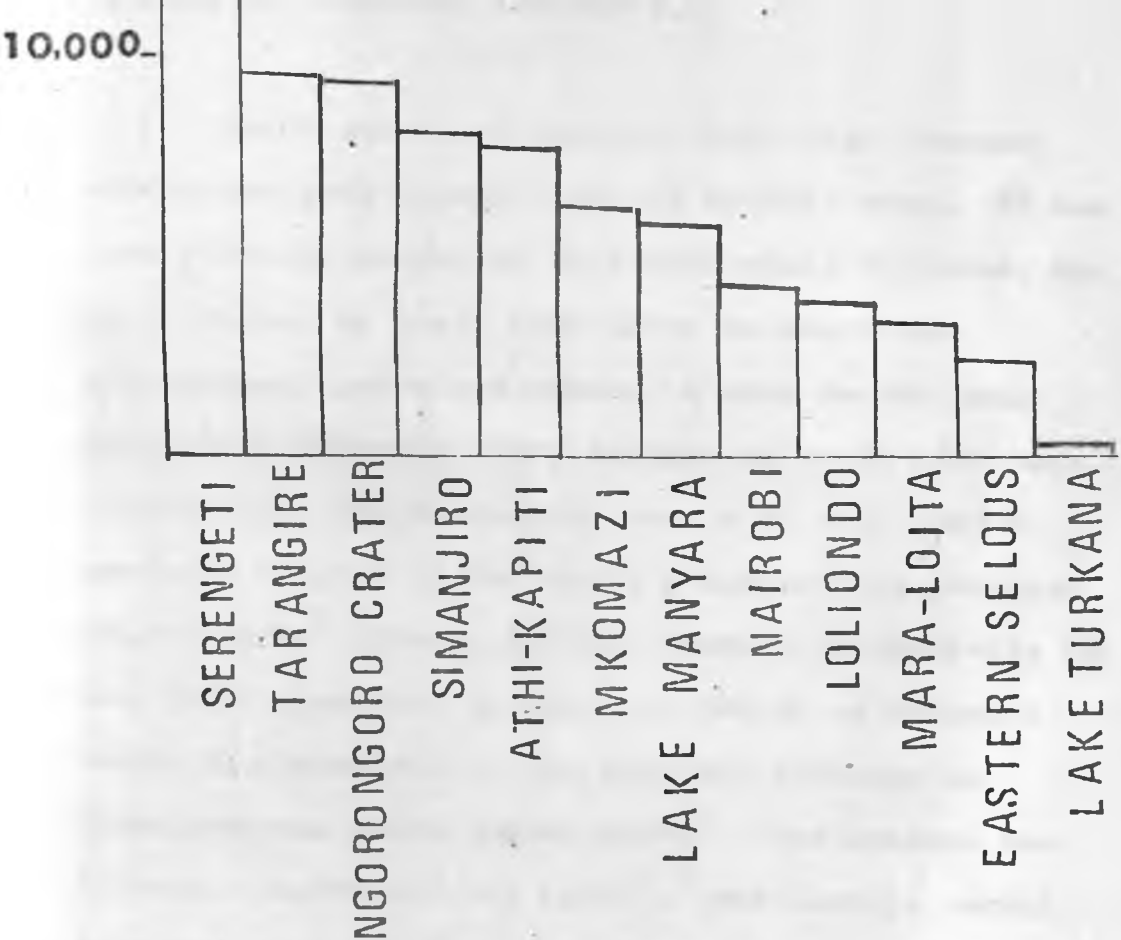
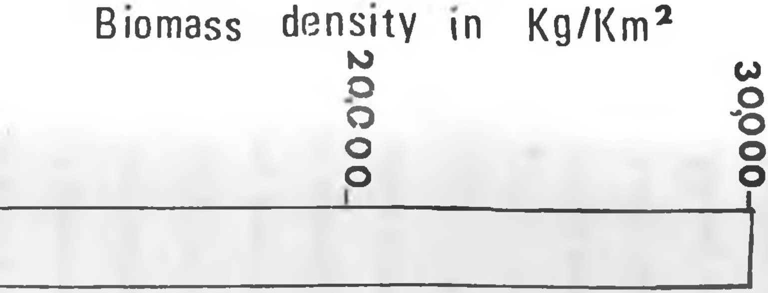


Figure 25

The biomass densities of large herbivores from different areas of East Africa. See opposite page for sources of data and habitat types.


Biomass density in Kg/Km²
20,000
30,000

Steppe dispersal area (Lamprey, 1964). This then shows that it is a very important area for supporting large herbivores during the rains within southern Masailand.

From the above figures, it can be concluded that Simanjiro area has a high biomass density. Such a density could not be supported if the productivity of the area was low. Since the major ungulate species that is zebra, wildebeest and cattle are grazers, it is the grassland productivity supplemented by the grasses within the woodland which supports this immense biomass of secondary consumers.

Short grassland habitats have high biomass production even though they are heavily used. It has been shown in Serengeti that harvesting frequency has an influence on yield from plots in short and transitional grassland zones. A plot in the long grass zone showed a sharp decline in yield with more harvesting. One harvesting over a 16 week period produced 250,000 kg/km^2 while 7 harvestings produced 70,000 kg/km^2 (Braun, 1969). Average productivity in the short grassland produced by 500 mm of rainfall which is equivalent to the rainfall recorded in Simanjiro was about 400,000 kg/km^2. The maximum was between 500,000-600,000 kg/km^2. The average aerial standing crop for the shortgrassland area of the

Plate 19
An aerial view of wildebeest with newly born calves at the beginning of the the rains

Plate 20
An aerial view of zebras migrating towards Simanjiro at the beginning of the rains

Plate 21
Hunting dogs in the bushland habitat

Athi-Kapiti plains with an annual rainfall of about 500 mm is upto 670,000 kg/km^2 (Casebeer and Koss, 1970). It can be safely assumed that the grass biomass density of the Simanjiro plains is about 400,000 kg/km^2. This means that every 50 kg of grass matter area supports 1 kg of herbivore matter.

This figure is an average which could be applicable to other similar areas and in particular the Athi-Kapiti plains. The only exception in East Africa is the Serengeti plains grassland. Since the average grass biomass is about 400,000 kg/km^2, each kilogram of herbivore is supported by about 13 kg of grass biomass. This very high carrying capacity of the Serengeti grassland during the rains is therefore due to other factors other than plain grass productivity. It is very likely caused by the fact that the Serengeti is composed of different grassland types whose species are highly nutritious. Even Grzimek and Grzimek (1960) have mentioned the fact that the grasses and sedges of Serengeti are highly nutritious. Anderson and Talbot (1965) list *Kyllinga* sp., *Sporobolus marginatus*, *Digitaria macroblephara*, and *Cynodon dactylon* as being the most dominant species there. Most of these species are among the best for grazing (Edwards and Bogdan, 1951).

(c) Animal migration

Zebra and wildebeest are the main ungulates migrating into Simanjiro during the rains. Over 95% of the zebra and practically all the wildebeest come from the Tarangire National Park. A very small portion of zebras come from the Njormormai, Kabongo, Komolo, Naberera and Loiborserrit areas. The Komolo area used to be one of the important dry season habitats in the last decade (Lamprey, 1963). Unfortunately human settlement has precluded wildlife use.

The reconnaissance flights and ground observations have conclusively shown that Simanjiro is the major wet season habitat for zebra and wildebeest from Tarangire. A very small fraction move to the Ardai and Mto-wa-Mbu plains. Besides the actual monitoring of the progression of zebra and wildebeest numbers between the two areas during migration, there is an inverse relationship between the population of the above mentioned herbivores between the two areas during the wet and dry seasons. The zebra population estimate for Tarangire is significantly lower than that recorded in Simanjiro thus supporting the idea that a fraction of the zebras come from areas other than Tarangire. On the other hand, the wildebeest population estimate for Tarangire is a bit higher but not significantly so than the Simanjiro one suggesting that only a small portion of the wildebeest come from elsewhere. Lamprey, (1963) in his studies showed that a portion of the wildebeest from Tarangire migrated to the plains around the southeastern shores of Lake Manyara. This movement though diminished in magnitude still takes place. One wildebeest tagged on the shores of Lake Manyara in 1963 was shot in the Simanjiro Plains (Hemmingway, pers. comm).

The migration of zebra and wildebeest represent a widespread ecological phenomenon in East Africa. It usually occurs between the Acacia woodlands and the short grasslands. The migration enables these ungulates to avail themselves of water and food throughout the whole year. The grasslands provide the wet season requirements while the woodlands provide the dry season requirements particularly water. The most spectacular migration takes place in the Serengeti National Park. It is the most publicized migration, being ranked by some enthusiasts as one of the wonders of the world (Swynnerton, 1958; Grzimek and Grzimek, 1969; Watson, 1967; Klingel, 1970; Skoog, 1970); while the distance covered in Simanjiro is about 30 kilometres, the Serengeti migration covers over 150 kilometres. Another migration occurs between the Nairobi Park and the Athi-Kapiti plains (Foster and Kearney, 1967). Also there is movement between the Serengeti and Mara (Talbot and Talbot, 1961; Skoog, 1969). Most of the migrations are orientated in an east-west direction during the rains and vice-versa during the dry season. The migrations usually take place along well established trails. Such trails can be easily seen near Oldonyo

Sambu hill southwest of the study area. Migration is an important ecological separation factor. In its broadest sense, it separates the migratory species from the non-migratory ones. Such a function has been noted in Tarangire (Lamprey, 1963). Also the time lag between the movement of zebra and wildebeest is an important factor in the grazing succession (Vesey-Fitz-Gerald, 1960; Bell, 1969).

The migration of elands is not well documented. They are known to be migratory in Tarangire and Serengeti. The migratory patterns are rather obscure as they show extreme fluctuations even during the same season (Lamprey, 1963; Sinclair, 1972). This was also shown during the rains in Simanjiro.

The presence of permanent water in the plains removes it as the only migratory factor for zebra and wildebeest from Simanjiro during the dry season. Scarcity of grazing is also an important factor in the migration. This is reflected in the fact that zebras whose food is mainly the rough herbage which is in scanty supply at the beginning of the dry season move out first. When in Tarangire, the herbivores find a large supply of herbage which has grown there having been very little utilized during the rains. The feeding habits of the ungulates in Tarangire has already been recorded (Lamprey, 1963). Most of the

Tarangire grasses upon which these ungulates feed are medium height grasses. It has been shown in the Selous that such grasses have a very low protein content during the dry season (Rodgers, 1969). This is because such grasses have a large stem portion which contributes the low protein content. Studies in South Africa have shown the content to be as low as 2% (Chippindall et al.1954). Fires sweep annually through the Tarangire (Lamprey, 1963). Although such fires destroy the available herbage, they cause a green flush of grass to appear. Such grass has a high protein content as studies in Selous have shown and are thus beneficial to the herbivores (Rodgers, 1969). This also explains the annual burning of grasses by the Masai. Unfortunately burnt grass is very sensitive to grazing pressure as studies by Pratt (1967) have shown. It is only fortunate that in Tarangire the grasses are subjected to a very minimal grazing pressure as the major grazers are outside the reserve during the rains when grasses are growing. Therefore the Tarangire is a sort of dry season food reservoir for the migrant game.

Thomson's gazelle in Simanjiro are non migratory. This is contrary to observations in Serengeti where this species follows the same migratory pattern as the zebra and wildebeest (Brooks, 1961). The same author also suggests that there are migrations between

Lake Basuto and the Yaida Valley on the shores of Lake Eyasi. Also he suggests migration between Wembere Plains and the Kitalala area south west of Lake Eyasi. Also he suggests migration into the Sanya plains from the Meru Corridor and possibly from the Ngaserai plains and Amboseli plains. Observations during this study have shown that much of these migrations have been disrupted by human occupation. The only viable migration is the Serengeti one. There are limited movements between Sanya, Ngarenanyuki and Ngaserai area.

The sedentary nature of Thomson's gazelle in Simanjiro is besides availability of permanent water is facilitated by the grazing pattern set out by cattle thus exposing the tender growth for the former to feed in. In Serengeti where there are no cattle, they have to follow behind in the grazing succession set out by migrating zebra and wildebeest (Gwynne and Bell, 1968).

In East Africa, migration is not only restricted to zebra and wildebeest. The other major migratory species is the elephant. Studies in Tarangire show that elephants from the Masai steppe migrate there during the dry season (Lamprey, 1963). There are also movements within the Serengeti ecosystem (Watson and Bell, 1969; Croze, 1972). Movements also occur between the Tsavo/Mkomazi ecosystem (Watson et al, 1969). The movements are geared to water and food supply. In Manyara where both commodities are in plentiful supply throughout the year the elephants are more or less non migratory (Douglas - Hamilton, 1969). The Kabarega National Park has two populations which are also resident (Laws and Parker, 1968).

In South Africa, before man decimated them to pitiful remnants, enormous numbers of springbok Antidorcas marsupialis used to migrate in search of new pastures. The last known such large-scale migration was in 1896 (Brown, 1965). The other land mammal which migrates over large areas is the north American buffalo and caribou Rangifer tarandus.

7. Stability of the herbivore populations

It is rather difficult to determine the changes taking place in a population of herbivores in a short term ecological study of this nature. A study of population dynamics is required to be able to accurately determine changes taking place in any given population, the former being defined as "the changes in the characteristics of population resulting from intrinsic and external variations caused by environmental resistance" (Mosby et al, 1963). Such a study usually takes several years and includes age specific mortality and reproduction enabling life tables to be drawn (Odum, 1963). The most ideal way would be to obtain the age structure of the population at the beginning and follow it through the total life span for that species. This is rather difficult and takes a long time. In the present rapidly changing world where rapid results are required for implementing vital management decisions such a study cannot be afforded. So the population structure is usually used to determine the population trend (Mosby et al, 1963). This permits remedial measures to be applied in time. The ideal way of determining the exact age structure of a given population is to examine all the individuals. A classic example of this occured in Denmark where a complete population of roe deer was exterminated and the material analysed (Mosby et al, 1963). However this is undesirable where conservation is the aim as there would be no more animals to conserve at the end of such a study! The usual method adopted is to sample a proportion of the population. In Kabarega, formerly Murchison National Park and Tsavo National Park complete herds of elephants were collected as samples for studies on population structure, condition and trend (Laws and Parker, 1968). This is however not the usual method used in population studies within the conservation areas of East Africa. The most commonly used method is by field observation using external characteristics of animals to determine their age. Dentition is the most commonly used method of aging large herbivores. It was first used in the United States on Mule Deer Odocoiles hemionus (Robinette et al, 1957). It has since then been applied to various bovids (Mosby et al, 1963). In East Africa tooth eruption and wear was first used in aging elephants and zebra (Laws, 1966; Klingel, 1966). The technique has recently been applied to Thomson's gazelle (Robinette and Archer, 1971). In all these studies usually the lower jaws of dead animals are collected for aging. However, tooth impressions of the live animals have been made (Mosby et al, 1963). Besides this method other body characteristics can be used in aging. Brooks (1961) used horn shape and size for Thomson's gazelles. Spinage (1967) also used similar characteristics in water buck. Western (1973) in Amboseli used these characteristics for wildebeest. In Serengeti, this technique has been refined by photography to obtain the age structure of wildebeest and buffalo (Watson, 1967; Sinclair, 1969). Eye lens weight has been used in elephants for aging (Laws, 1967).

In this study only the adult sex ratio and general age groups were classified and it would be erroneous to draw life equations based on the data obtained. However general conclusion can be made.

(i) Zebra

The group composition of this species in Simanjiro consisted mainly of family groups and stallion groups. This is typical of the species (Klingel, 1969). However the maximum group size was larger in the study area. This could be mainly due to poaching and hunting pressure. It has been pestulated elsewhere that elephants where they are much disturbed by excessive hunting tend to aggregate in unusually large groups (Laws and Parker, 1968). On the other hand, the percentage of adult stallions in the study area is smaller than that in Ngorongoro (Klingel, 1969). This is mainly due to the fact that both poachers and licenced hunters select for the males. Such selective shooting of males in elephants has been observed to create such a result (Laws and Parker, 1968). However, the constant turnover of stallions in zebra groups ensures continued availability of males for reproduction (Klingel, 1969).

Foaling in Simanjiro reaches its peak between January and February and is similar to Ngorongoro and Serengeti (Klingel, 1969; Skoog, 1969). This gives the newborn a long enough time for feeding on the short-grassland habitat so that by the time they migrate to the more nutritionally insufficient dry season habitat, they are able to withstand the rigours of the environment. Although the percentage of foals and sub-adults per mare is lower than that of Ngorongoro, it is higher than that for Kruger National Park. Klingel (1969) found a correlation between this value and rainfall. Considering that the rainfall in Simanjiro is lower than that in Ngorongoro but higher than that in Kruger, this is adequate recruitment.

Zebra mortality in Simanjiro through predation is low. The main predator of zebras is lion (Kruuk, 1970; Schaller, 1972). The density of lions in Simanjiro is $0.07/km^2$ which is low compared to that of other areas. In Serengeti it is $0.1/km^2$ (Kruuk, 1970). In Nairobi and Ngorongoro it is $0.2/km^2$ (Schaller, 1969). The Tarangire density is also higher than that of the study area (Lamprey, 1964). However, the lions do not migrate with the ungulates. Studies in Serengeti also show that the majority of lions there do not migrate with the ungulates (Schaller, 1972). Predation by other predators is not common in Simanjiro. It has been shown that besides lions, spotted hyenas and hunting dogs prey on zebras (Kruuk, 1970; Estes and Goddard, 1967; Schaller, 1972). These species are fewer in Simanjiro. Spotted hyenas though common were always found in small packs. Large packs are needed for successful hunting of zebra (Kruuk, 1970).

The low incidence of predation then leaves poaching and hunting as the major source of mortality. The latter represents a very minor fraction of mortality. It is poaching which has reached alarming proportions. This amounted to nearly 10% of the entire population. Adult animal mortality was estimated to amount to 16%. This compares well with mortality for the Athi-Kapiti population estimated by Petersen and Casebeer (1972) to be 17%. The actual mortality for Simanjiro should be somewhat higher since a considerable portion of the mortality particularly poaching goes unnoticed. The Athi-Kapiti study shows the foal mortality to be between 30 - 60%. Klingel (1969) working in Serengeti estimated it to be 30% from May - October. So the annual foal mortality in Simanjiro should be at least 30%. Taking into consideration that annual reproduction constitutes 16%, this means that the zebra population in Simanjiro is on the downward trend mainly because of poaching. If this goes on unchecked, it could deplete the zebra population within a few years. This should be taken seriously as excessive hunting decimated hitherto large numbers of bison in America (Dasmann, 1968). Similar decimation on a variety of herbivores occured in South Africa (Brown, 1965).

The aerial census conducted in Tarangire shows a marked increase from that estimated earlier by

Lamprey (1963). It is rather unlikely that this large increase is due to natural recruitment. It is largely due to a reduction of the former dry season concentration areas between Tarangire and Lake Manyara thus forcing the displaced animals to seek refuge in the park. Recent concentrations of elephants in the Tsavo National Park have been attributed to rapid reduction of their former habitat in the surrounding areas (Laws and Parker, 1969).

(ii) Wildebeest

The average group size of wildebeest in Simanjiro was 15.4 animals. This is close to that of 16.7 for Serengeti (Estes, 1966). Likewise the preponderance of females is the same as in Serengeti (Watson, 1967). Group composition was also the same. Territorial males in Simanjiro tended to maintain their territories longer than the transient pseudo-territories which are established in Serengeti. Simanjiro territoriality is very similar to Ngorongoro (Estes, 1967). The population in the latter area is non-migratory while the Serengeti one is highly migratory and the wildebeest form temporary territories en-route whenever they rest. Although the wildebeest in Simanjiro are migratory, the movement is completed within a short period. The territorial males reach the plains first where they then establish their territories. This means th t by the time the nursery herds arrive, the territorial males have already settled down and gathered enough strength for the reproductive activities to follow.

The synchronized calving of wildebeest observed in the study area is typical of the species. It usually takes place between January and February (Talbot and Talbot, 1963; Estes, 1967; Watson, 1967). The percentage of calves of the year in the population is about 20%. In Ngorongoro one it is 2[illegible]% (Turner and Watson, 1964). It can therefore be concluded that reproduction in Simanjiro is normal considering that Ngorongoro is a better habitat. The figure given for 1971 for the Athi-Kapiti population is 21.5% (Petersen and Casebeer, 1972) and is almost idential with the Simanjiro one.

Predation on wildebeest in the study area constitutes small mortality. This is because of the low density of predators as already explained. Where there is a high density of lions, wildebeest are the main prey species (Kruuk and Turner, 1967). Similarly where hyenas are in large numbers such as in Ngorongoro, wildebeest form the major prey species (Kruuk, 1970). Hunting dogs which were intermittently seen in the Simanjiro plains during the rains, were the only predators seen killing wildebeest calves. Also verbal reports of a similar nature were common. This then ranks wild dog as the main wildebeest predator in the area. This might be because of the scarcity of Thomson's gazelles. In Serengeti where they are abundant, they form the main prey species of the hunting dog (Kruuk and Turner, 1967; Estes and Goddard, 1967; Lawick-Goodall and Lawick-Goodall, 1972). Similarly both hunting and poaching in Simanjiro are low.

It can be concluded that the wildebeest population in Simanjiro is a healthy one having adequate recruitment and average mortality. It is more stable than the zebra population. The total number of this species counted during this study in Tarangire, is twice than that estimated earlier by Lamprey (1960). This could be partly due to natural increase caused by the successful reproduction and low mortality in Simanjiro. The wildebeest population in Serengeti is postulated to have been increasing within the last decade as is the case with buffalo (Sinclair, 1973). The displacement of wildebeest from its former dry season habitat has also contributed to the increase in numbers in Tarangire.

(iii) <u>Grant's gazelle</u>

The social organisation of this species in the study area is similar to that observed in Ngorongoro

(Estes, 1967) and is typical of the species. The average herd size was smaller in the former area. This is because of the smaller population in Simanjiro and lower productivity caused by low rainfall. It has been shown that zebra herds are larger in Ngorongoro than in Serengeti, and the former area has a higher rainfall (Klingel, 1966). It has been shown in Serengeti that grassland productivity is highly correlated with rainfall (Braun, 1966).

Calving was spread out but had a distinct peak during the rains. This is similar to observations in Ngorongoro. Mortality in the study area was low. The major predators of this species namely cheetah, leopard and hunting dog are scarce. Even where they are abundant, they prefer other species (Kruuk and Turner, 1967; Schaller, 1968; Goodall, 1972). On the other hand jackals prey considerably on fawns in Serengeti (Lawick-Goodall and Lawick-Goodall, 1972).

The population of this species in Simanjiro is adequately maintained as is the case with wildebeest.

(iv) <u>Thomson's gazelle</u>

The group structure and behaviour of this species observed in the study area is very similar to that of the preceding species except for the more overt defence of territory in the former. This is typical of the species (Brooks, 1961; Estes, 1967; Walther, 1969). The average herd size in Simanjiro is smaller than it is in Ngorongoro or Serengeti (Estes, 1967; Bradley, 1972). The possibility of the discrepancy being due to rainfall and hence productivity is rather unsound as the Serengeti National Park with rainfall similar to that of the study area has a very high density and group sizes. The very high cattle density and non-migratory nature of this gazelle results in competition for the limited food resources available at that time. This is a major factor in limiting the population size of this species. Surprisingly, complete exclusion of cattle might not increase the population as this would disrupt the grazing succession upon which Thomson's gazelles depend. The best solution would be to regulate cattle numbers.

Hunting and poaching on this species constitute a higher mortality percentage because of its small population. The selection for males further upsets the sex ratio as is even the case with zebra. The meat of this species has practically no cysts (Sachs, 1969). This makes it a favourite menu species.

Predation on tommy is also relatively high. Jackals were the main predators on newborn animals. It is also preyed on by hunting dog and cheetah and even feral dogs. So it is the most vulnerable species to predation in Simanjiro. This is also the case in Serengeti and Ngorongoro (Brooks, 1961; Kruuk and Turner, 1967; Estes, 1967; Lawick-Goodall and Lawick-Goodall, 1972).

Reproduction of this species follows a similar pattern to that of Grant's gazelle. However whatever little recruitment there is, which is the smallest among all species when population size is taken into consideration, is exposed to the predators. It can therefore be concluded that the population of this species in the study area is declining due to competition with cattle for grazing, low recruitment and high mortality. In all, the decline of this species is due to a large extent by the activities of man.

Ostrich

The social organisation especially in regard to breeding compares to that observed in Nairobi Park. The timing of breeding is likewise similar (Hurxthal, pers. comm.). The number of chicks hatched is high but declines rapidly. In Nairobi chick mortality in one year was about 90% (Hurxthal, 1973). This is because ostrich chicks are preyed on by a large variety of predators. In Nairobi they include jackals, raptorial birds, lions and hyenas. Additional ones in Simanjiro were the hunting dog and cheetah.

Ostrich is a fast runner and both of these predators depend on their running prowess for successful hunting. The hunting and poaching on adults and particularly males is an important source of mortality.

Although the density of ostriches compares well with other areas, the biased sex ratio is partly due to the killing of cocks by hunters and poachers. If this continues to reduce male numbers especially the experienced older breeders, there is a potential threat to breeding success and thus adversely affecting the stability of the ostrich population in Simanjiro.

Others

The loose social organisation of giraffes in Simanjiro is the same in Nairobi and Transvaal in Southern Africa (Foster, 1966; Innis, 1958). There was no predation observed in Simanjiro although predation by lion is likely. Lion is the major predator of this species (Spinage, 1968; Guggisberg, 1969). There was no hunting or poaching mortality. All this means that the population of giraffes shows some stability.

The social organisation of impala was similar to that observed in Serengeti (Jarman, 1969). The suspected major predator in Simanjiro was leopard. Impalas are favourite prey species of leopard (Dorst and Dandelot, 1970). However predation mortality in Simanjiro was low. Hunting and poaching represented a higher mortality. Although no figures were obtained reproduction seemed to be adequate. This species was also stable.

(vi) Livestock

The cattle population is the most fluctuating of all herbivores. It is sensitive to drought and a considerable number of cattle died in both 1971 and 1972 due to shortage of rains. In the 1960 - 61 drought a high number also perished (Voorthuizen, 1971). This happened in all Masailand including Amboseli (Western, 1973). Cattle are also susceptible to a number of the diseases such as East Coast Fever, rinderpest, foot and mouth disease and anthrax just to mention a few. Before veterinary facilities were made available in Masailand, these diseases took a heavy toll of cattle. The rinderpest outbreak of 1896 devastated the cattle herds in Masailand by more than 80% (Western, 1973). Similar ravages of cattle herds occured in South Africa. It is estimated that 2.5 million herd of cattle succumbed to this scourge (Henning, 1956). Introduction of veterinary measures and water has changed things. These two factors keep the cattle population high not only in Simanjiro but in other pastoral areas of East Africa. Annual reduction through auctions represents a very small take off (Fallon, 1963).

Goats are even better off than cattle because

Plate 22
An aerial view of a Masai boma with goats in an enclosure

Plate 23
An aerial view of the school at Mboreti with encroaching cultivation in the short grassland habitat

Plate 24
A truck load of zebra skins captured from poachers in Simanjiro by the Game Division Anti-poaching squad

Plate 25

A dead eland which was found with bullet wounds

Plate 26

A dead zebra spotted during aerial censusing. Note vultures on the left and a Masai on the right

Plate 27

A dehorned rhino killed by poachers near Njormorani springs, Kenolo north of Terrat they are subject to less diseases. Drought does not affect them much and they can survive in more arid conditions (French, 1944).

8. Stability of the habitat

In order for any population of animals to survive in a given area, their habitat must be stable. One of the reasons the great bison herds of North America vanished was because their habitat, the vast prairie grasslands, were appropiated by man (Lawrence, 1966). The large herds of antelopes which once inhabited the veld of South Africa suffered a similar fate. Even in East Africa, the once abundant herbivores on the grasslands, especially in the Kenya highlands vanished because their habitats were taken for farming and ranching (Brown, 1965). In addition to the diminishing grasslands, most of the dry season habitats for herbivores in Northern Tanzania have been destroyed by human settlements (Lamprey, 1963). The once large elephant populations have been much reduced because of the reduction of their former habitats (Lamprey et al, 1967; Laws and Parker, 1968; Croze, 1972). The literature abounds on how the natural environment is being devastated by the population boom of man and his voracious appetite (Leopold, 1933; Odum, 1959; Dumont, 1966; Ziswiler, 1967; Western, 1971; Parker, 1972).

Since Lamprey (1964) did his study, things have been getting worse. Large tracts of the grasslands in East Africa besides Sanya and Ardai already explained are being cultivated. The Narok area is being ploughed for wheat. The Basotu grassland once the habitat of zebra, wildebeest and Thomson's gazelle have now been ploughed for wheat. Modern ranching is being introduced in the Athi-Kapiti plains. Pressure for land is threatening part of the dry season habitat of the Serengeti herbivores such that a study has been started by the Serengeti Research Institute into the ecological effect of human activity on the ecosystem (Kurji , 1973). Besides grassland habitats, large tracts of *Acacia tortilis* woodland are being hacked down by charcoal burners (Olindo, Pers. Comm). Since the hue and cry of our governments is more production of crops to meet our rapidly expanding population, it is inevitable that more wildlife habitat will fall under the hoe. Even grazing pressure is increasing. In 1972 part of the Serengeti was open to grazing. Fortunately a few ecounters of the would-be grazers with buffaloes and the President saved the situation. It is therefore vital that habitats contained in the ecosystem of parks and reserves should be safeguarded.

The habitat in Simanjiro is still much better than most of the others outside the protected areas. However there is no room for complacency as human pressure is mounting. So the different vegetation types constituting the habitat are going to be discussed as to their stability.

(a) Short grassland

Since this is the most important part of the Simanjiro Plains, the future of the area lies in its stability. It has been suggested by Heady (1960) that this grassland was once part of an extensive Themeda-Hyparrhenia formation. Both Themeda and Hyparrhenia are still found in Simanjiro but only the latter is found in some localities in the grassland. It has been long established that annual fires are responsible for maintaining the large areas of Themeda in East Africa and even South Africa (Phillips, 1930; Edwards, 1951; Heady, 1960). In the absence of fire, the dominance of this species falls. Reduction of fire is caused by the presence of short or scanty grass cover. One of the causes of this is over-grazing. There is ample evidence that the Simanjiro grassland is over-grazed. The carrying capacity of the area is 25 cattle/km^2 as already discussed. The stocking rate is 32 cattle/km^2 during the dry season. The range is therefore overstocked by cattle at a time when it is most vulnerable to overgrazing. Besides the overstocking which resulted from a cattle population boom brought by the introduction of veterinary facilities in Masailand (Western, 1971), the introduction of dams and boreholes in Simanjiro in 1953 contributed much to overstocking. A Masai elder (Tiepes, pers. comm.) recalls that before dams were built in Simanjiro the cattle population was less than half of what it is now. Introduction of permanent water in many parts of East Africa's rangelands has resulted in overstocking (Heady, 1960).

It would appear that the excessive grazing pressure by livestock is causing overgrazing in Simanjiro with a reduction of the ground cover to less than 50%. In the arid rangelands of the United States, a cover rating of less than 50% is considered to be low (Stoddart and Smith, 1943). This figure should also be applicable to the arid rangelands of East Africa. Because of the grazing pressure in Simanjiro the climax formation has been set back to a stage classified by Heady (1966) as the short grass stage. Less palatable species such as _Pennisetum mezianum_ are assuming dominance. Worse still, _Microchloa kunthii_ and _Harpachne schimperi_ are becoming widespread. _Aristida_ species are also present. All these species are indicators of overgrazing (Edwards and Bogdan, 1951). Worst of all, the unpalatable spiny _Barleria ramulosa_ is a dominant shrub. Both _Indigofera basiflora_ and _Heliotropium eduordii_ are common. Their increase in the Ngorongoro short grassland has been interpretated as a sign of overgrazing (Anderson and Talbot, 1965). Also *Ipomoea hildebrandtii*, *Astripomoea hyscyamoides*, *Solanum incanum*, *Tephrosia subtriflora* and *Crotalaria barkae* grow in Simanjiro. Besides being of little or no browsing value, the last three are reported to be poisonous (Verdcourt and Trump, 1969).

Besides the increase in undesirable invading plants, overgrazing has much reduced the incidence of fires. Only 2% of the area in 1972 was burned. This has created a favourable environment for the regeneration of woody species. *Acacia tortilis* is now regenerating on ridges within the grassland. It is a well known fact that the absence of fire in open grassland results in regeneration of woody species (Glover, 1968). Studies in Serengeti have shown that woodland regeneration and especially regeneration of *Acacia tortilis* is suppressed by annual fires (Herlocker, 1972). It has also been shown that fruits of several common Acacia species burnt in normal grass fire cannot germinate except *Acacia albida* whose thick pods protect the seeds (Lamprey and Makacha, 1969). It has been shown in South Africa that the absence of fire coupled with overgrazing results in a marked increase of Acacias and woody shrubs (Phillips, 1930). If the present trend in Simanjiro continues, more woodland regeneration can be expected.

Besides overgrazing, another factor disturbing the grassland is cultivation. So far, only less than 1% of the area is under cultivation. There is however mounting pressure for cultivation from the north and if this is permitted, the whole of Simanjiro can be written off as habitat for the herbivores. It has already been discussed how cultivation is the most rapid mode of habitat destruction. Increasing emphasis for modern ranching is another factor which will affect the stability of the grassland. It is a well known fact that modern ranching and wildlife preservation are incompatible. This is because ranching involves intensive veterinary measures and fencing developments. As Heady (1960) put it, "fences should be encouraged when the right conditions develop because they are important as a tool in proper land management." Wildlife harbour a host of ticks which are vectors of East Coast Fever, anaplasmosis, red water, heartwater and other diseases. Wildlife also is subject to cysticercosis, echinococcosis and sparganosis (Heady, 1960). So this has led to the development of a long drawn controversy as to the role of wildlife in transmission of diseases particularly acting as reservoirs of rinderpest and malignant catarrh fever, brucellosis and trypanosomiasis (Robson et al, 1959; Plowright, 1963 and 1965; Sachs et al, 1968). The rancher is therefore rather ill disposed towards wildlife. The development of such ranching in Simanjiro will therefore mean an end to the wildlife habitat.

(b) Woodland

Factors affecting the stability of this habitat are mainly fire, and direct cutting of trees. Annual fires are started by Masai herdsmen between September and October in order to stimulate new grass growth. This type of burning is very widely practiced by African pastoralists (Chippindall et al, 1955). As shown earlier, fires suppress new regeneration. In the mature stands of Acacia-tortilis where fires sweep through annually there is practically no regeneration of this species. Where ground cover is low and no fires burn through annually there is up to 35.59% regeneration. It has also been shown in Serengeti that no regeneration occurs under big mature Acacia tortilis trees (Lamprey and Makad 1969). The Commiphora species are not effected by fires. So the mosaic of burnt and unburnt patches in the woodland in Simanjiro creates a dynamic system through which mature trees are being cleared while new one regenerate thus maintaining the woodland habitat.

Another factor affecting the woodland is tree cutting. The cutting of small trees for building bomas is very common in Simanjiro. It is also common with Masais elsewhere (Mmari, 1965). Fortunately this has

Plate 28
Acacia tortilis cutting for charcoal in an area just north of Terrat

Plate 29
Wheat cultivation within a short grassland game habitat at Basuto in Hanang District

Plate 30
An evening view towards Lolkisale mountain from Terrat camp

no adverse effect on the overall woodland as only a small fraction of the regeneration is involved the large portion being taken from bush species such as Acacia stuhlmannii and the Commiphoras which are plentiful. The habit of chipping trees by idling Masai particularly the old men and Morans exposes the cuts to invasion by black ants and some trees eventually die. But such activities do not restrict tree growth.

Charcoal burning which was fortunately discontinued in Simanjiro is the most destructive activity to mature trees particularly Acacia tortilis which is favoured because of its durable charcoal. Such charcoal burning is responsible for the receding woodlands in East Africa.

In 1952 a clearing of trees and bushes was done from Loiborserit to Simanjiro in order to eradicate tsetse flies. Most of the Commiphoras regenerated faster thus dominating the area. Later on the bush regenerated and the tsetse was restored. Acacia tortilis growth was much retarded. The whole exercise was a total failure besides upsetting the habitat. Much misdirected efforts have gone to waste in a number such seemingly well intentioned schemes in Tanzania (Napier, 1943).

(c) Bushland and seasonally waterlogged bushed grassland

The vegetation of these habitats has practically not been disturbed. The bushland has a dense growth of *Acacia stuhlmannii* which is only used for building bomas by Masai. So far, no herbivores were seen to feed on this species in Simanjiro. Also only those empty spaces within the bushland are grazed on to a limited extent. The high alkalinity of the soil and water logging, limit this habitat to those plants capable of withstanding these conditions. So the stability of this habitat will be maintained as long as these conditions persist. Change can only be brought by alterations in topography which can only be caused by volcanic action or land upheaval which is highly unlikely.

Chapter VIII

RECOMMENDATIONS FOR CONSERVATION

1. Importance of Simanjiro in the ecosystem

It has already been amply shown that the Simanjiro plains shortgrassland habitat is vital as wet season habitat main for zebra and wildebeest from the Tarangire National Park. According to this study this amonts to 18 % of the Tarangire large herbivore biomass supported for about 6 months. If the plains were obliterated through human use, two major species of plains game would certainly disappear from the Tarangire ecosystem thus reducing the latter's potential as a tourist attraction. That would indeed be the end of the only viable zebra and wildebeest population in northern Tanzania east of the Rift Wall thus ending the viability of the area as a complete ecosystem. Out of the 8000 sq mls indicated by Lamprey (1963) to be the dispersal area of the Masai country, only 570 km^2 now support the zebra and wildebeest within the ecosystem during the rains. The elephants which range far and wide in their dispersal might still utilize the vast bushland of southern Masailand. Zebra and wildebeest on the other hand are confined to the grasslands. So in addition to the major grasslands of East Africa namely Serengeti, Mara-Loita, and Athi-Kapiti which support the two plains game, Simanjiro should also be added. Because of the vital function played by these grasslands in supporting the migratory plains game it can be concluded that the zebra and wildebeest populations of East Africa are directly proportional to the area of the short grassland. It has even been shown in the Selous where water is plentiful that the amount of short grass limits the population of these species (Rodgers, 1969).

The success of any given animal population in propagating itself and surviving in any given environment depends upon its breeding potential. That is the population is a product of breeding potential minus the environmental resistance factors. It has already been shown in the discussion that the nutritious short grasses are necessary for the breeding potential of the plains game to be realised. In that way the Simanjiro plains act as density dependent factor in regulating the populations of the said herbivores. In fact the short grasses are a critical factor in breeding success.

Not only is Simanjiro important in supporting the various wild and domestic herbivores, the area is important ecologically as a unique vegetation community. Heady (1960) pointed out that the grassland is a variant of the traditional Themeda/Hyparrhenia grasslands of East Africa. This study has also shown that the species composition is peculiar. This in itself merits consideration for being conserved as a specific grassland type. Conservation efforts in East Africa should besides protecting animals be aimed at protecting unique or important vegetation types.

2. Conservation of the Simanjiro plains

In the current emotionally charged sense, wildlife conservation and wildlife protection seem to be synonymous. However for the purposes of this study they will be considered as two separate terms. The origin of conservation was discussed in the introduction. Wildlife conservation here will include the control of the activities of man so as to perpetuate a viable population of the species in question. This includes wildlife protection, and controlled resource use. On the other hand protection includes any activities which are directed at protecting the physical well being of a given species excluding all other activities of man except viewing.

(a) Wildlife protection

In Simanjiro the major activity which jeopardises the physical well being of wildlife is poaching and hunting. Since the latter is sanctioned by government as an economic venture it will be discussed later. Poaching will be considered first.

(i) Anti-poaching measures

It would be rather difficult to protect the wild herbivores in Simanjiro particularly zebra which is the most sought after if the conservation status continues only as a controlled area. This is because everybody has free access. So as a first step, the area should be upgraded to a partial game reserve where people would need a permit to enter. That way anybody found inside without a permit can be assumed to be a poacher either directly or as a collector of already poached trophies.

Since Lolkisale game controlled area provides the corridor connecting Simanjiro and Tarangire National Park, it should be gazetted as a full game reserve in which no human activity is allowed. Presently the only activity there is poaching as heavy infestation by tse tse flies precludes Masai livestock. Even the cultivators have not been able to invade the area yet. Besides providing the corridor during migrations, the area acts as a buffer zone for any animal spill over from Tarangire national park during the dry season. The Lemiyon mbuga containing zebra and wildebeest which use the Matete water extends into the Lolkisale area. Besides this function, the Lolkisale area provides a sizeable portion of the wet season habitat for buffalo.

Besides upgrading the conservation status of Simanjiro and Lolkisale controlled areas, anti-poaching patrols should be stepped up. The Game Division camps at Terrat and Lolkisale should be manned permanently as they are the main entry points to Simanjiro from Arusha. Likewise, a new camp should be built at Loiborserrit to check entry from Kondoa. Motorised patrols should be stepped up with at least one land-rover at each camp full time during the rains when the migrants are in the plains. In order to make the anti-poaching work a success, it should be coordinated between the Game Division and National Parks. The use of radio communications should provide a vital link during such operations. This means that the now defunct radio communication between the Game Division headquarters at Arusha and the out-posts should be renewed. It is pertinent to point out again that anti-poaching measures being implemented by the East African governments cannot alone stop poaching. These efforts must be supplemented by international efforts not only in financial aid towards anti-poaching work but to curb the lucrative international market for trophies. It is no good for advanced nations in Europe to bewail the slaughter meted to elephants in East Africa while thousands of tons of ivory from the same elephants enter the same countries freely. The main incentive in commercial poaching is the lucrative price. and unless this is curbed it will be impossible to effectively control poaching. If the advanced countries have yet to ratify an ecologically sound treaty to curb the whaling industry which is threatening the conservation of this mammal, it is rather absurd to expect the poor East African countries to control poaching which is directly supported by markets in the developed countries.

It should be pointed out here that the Military Training Area extends down to Lolkisale only 19 kms northwest of Lolkisale. A clause should specifically be put in the proposed game reserve stipulating that no part of the Simanjiro plains should be excised for military training. The disturbance and mortality caused by military training excercises cannot be overemphasized. This is made worse by the fact that military personnel are always itching to pull the trigger at something and especially animate objects and wild animals are particularly enticing. Morover some of the personnel are only too aware of the lucrative trophy market and the immunity of the former from search.

(ii) <u>Control of hunting</u>

The Simanjiro is in the middle of a controlled area which has been subjected to licensed hunting for as long as the hunting safari industry in Tanzania. The area has been especially favoured for lion and leopard.

Other animals hunted there include buffalo, elephant, eland, Thomson's and Grant's gazelles, and impala. Even rhino were at one time hunted in the bushland near Njormormai and near Lolkisale and Loiborserrit. Zebra and wildebeest have in the past been mainly hunted by local hunters from Arusha. This is because they go into the plains during the rain season while the main hunting season is when it is dry.

While hunting brings in a limited amount of income, the practice must be properly controlled so as not to be a danger to wildlife. It always holds that any hunter left to himself will engage in some excess. Also a hunter on active pursuit only wants to gratify his passion to kill, be it for a trophy, meat or to build his ego. It is therefore imperative that he must be controlled.

Among the activities which animals do in order to survive and propagate themselves are feeding, drinking and reproducing. Any activity of man which interferes with any of those activities jeopardises the survival of the animals. While hunting only disturbs an insignificant portion of the eating time of animals, it disturbs a considerable portion of the drinking and reproducing activities. Fortunately the law prohibits anybody to hunt where animals drink. Unfortunately the game laws in East Africa only forbid one from killing a mother with young but does not protect the reproductive activities. To be able to do this, the law has to set a no hunting season during the breeding season. Hunting seasons are a common feature in both North America and Europe (Leopold, 1933) and they are a tool of game management.

In East Africa, the breeding season of most of the animals is during the rains. Any hunting season would have to be after the rains. It so happens that zebra and wildebeest migrate to Simanjiro during the rains and this is the time when they should be protected. Hunting should be prohibited from January to June. This would also protect the young animals by not breaking the mother-young bond. Hunting during this time would greatly disturbs the nursery herds particularly those of wildebeest. Wildebeest calves are easily separated from their mothers through such disturbance. It has been observed that wildebeest calves are easily separated from their mothers through disturbance resulting in a stampede of herds (Talbot and Talbot, 1961). The explosions of gun fire during hunting is a major disturbance. Fortunately enough, the Tanzania Government has decided to introduce a hunting season permitting hunting only from July to December and leaving the other months for breeding and rearing purposes. This is a very welcome move.

The other point needing consideration whether to prohibit hunting or not besides breeding is the size of the population of the quarry. If the population is small, hunting should stop. The population of Thomson's gazelle in Simanjiro happens to be only about 200 and is by all standards, a very small one. So this species should not be hunted at all in the Simanjiro plains. The Game Division of Tanzania fortunately realised this in time and prohibited the hunting of this species in Simanjiro since 1972. The ban should not be lifted when hunting in Tanzania resumes after the total ban imposed in 1973 as a result of widespread poaching of elephants, zebra and leopard. However it would leave a loop-hole if hunting was allowed on the other species as anybody could go in and poach Thomson's gazelle under the pretext of hunting something else. In order to avoid this, all hunting should be banned. The number of species which could be hunted leaving out zebra, wildebeest and Thomson's gazelle would not constitute much income from fees.

(b) Proper land use

Needless to say, wildlife conservation cannot be done without proper land use. This is where the control of the activities of man comes in. Without such control the haphazard land utilization would invariable ruin the wildlife habitat. So in addition to upgrading the

Simanjiro plains to partial reserve status, no cultivation should be allowed in order to protect the short grassland habitat which is just starting to be invaded. Similarly charcoal burning should not be allowed in the area in order to protect the Acacia tortilis trees.

(c) Proper regulation of livestock grazing and compatible development

Although livestock grazing adds another dimension in obtaining a high degree of range utilization excessive grazing is detrimental to the habitat. The ecological consequencies of overgrazing have already been discussed. In order to obtain balanced utilization the grazing capacity of the range should not be exceeded.

The carrying capacity of the Simanjiro plains is 25 livestock units/km^2 (Voorthuizen, 1971). This means that the Simanjiro plains should contain not more than 14,250 livestock units. The average zebra and wildebeest populations are 5500 and 4200 animals respectively. Since a zebra exceeds a zebu and a wildebeest is exceeded by a zebu in biomass we shall treat a zebra and a wildebeest as equaling two zebu cattle. So the amount of livestock units represented by these two species in Simanjiro is about 9700. However they utilize the plains during half of the year and during the wet season when the range can withstand a higher grazing pressure than during the dry season. So this means halving the livestock units represented by the two wild herbivores. Subtracting the total number of livestock units represented by the wild herbivores from the total livestock units the range can carry leaves 9400 livestock units. This means that the present cattle population should be reduced by 7600 cattle.

In order to dissipate the grazing pressure exerted around the permanent dams, water-holes and springs, several smaller watering points should be established throughout the plains. Such an arrangement saves the energy expended by cattle in going to drink. There should be sufficient dips and crushes for carrying out the nesessary livestock health measures. This necessitates the stationing of qualified and sufficient veterinary personnel in Simanjiro.

In order for livestock and wildlife to co-exist on the Simanjiro plains, any developments for livestock must be compatible with wildlife. Erection of fences will not only be a hinderance to free moment of game but will be a source of conflict. If wild animals knock down a fence, the livestock owner is aggrieved and as already pointed out, one of the reasons why game animals were butchered in the newly opened ranch-lands of Kenya was because they knocked down fences. In order to avoid such conflict which inevitably end up with the game being the loser. The entire Simanjiro plains should be treated as one ranch. The Masais have always treated Masailand as one huge ranch supplying both the dry season and wet requirements successfully and there is no need to change the system.

One might argue that in any well managed ranch not only is wildlife a physical menace but also a health hazard. Arguments have been put forward by traditional veterinarians that wildlife is an endemic source of diseases which affect cattle. Wildebeest is especially victimized. Granted, studies by Sachs (1969) in Serengeti has shown that wild animals harbour a lot of parasites. However research has not conclussively shown that wild animals are a source of diseases which infect cattle. Wildebeest are accused of infecting malignant catarrh fever to cattle when the former are calving. In his research on malignant catarrh, Plowright (1965) stated that, "The method of transmission of the virus from wildebeest to cattle and the mode of its spread among wildebeest was not determined". Presenting research conducted recently on the subject Rweyemamu et al (1974) state that "We have not been able so far to demonstrate unequivocally whether wildebeest excrete virus nasally in a stable infectious cell-free state." Earlier work on rinderpest showed that rinderpest virus isololated from eland only caused mild symptoms in cattle. So it can only be concluded that wild animals are better able to withstand diseases better because of natural selection. The case of cattle is made worse by the use of prophylactics. Also uncontrolled high densities create favourable conditions for outbreak and transmission of such diseases.

3. Future research

The present study would be a wasted effort if no more research was to be done. There is a need for continuity of research to obtain information on ecological changes taking place in order to adjust the conservation activities accordingly. It is encouraging to note that another research in Simanjiro has already started in order to determine livestock/wildlife stocking rates (Peterson, pers.comm.).

(a) Vegetation studies

Permanent transects should be marked in Simanjiro particularly the short grassland area in order to monitor trends in range condition. Also studies should be started to correlate grass productivity with changes in wildlife populations.

(b) Large herbivore studies

The population dynamics of each of the major herbivorous species should be studied. Also one census should be conducted in the middle of the rains and one in the middle of the dry season to check the general trends. Studies on range utilization should be initiated in order to determine the best wildlife/ livestock stocking rate.

(c) Multiple land use studies

It has become more and more clear that the pastoralists of East Africa mainly the Masai are becoming increasingly reluctant to give up their land for exclussive wildlife use. It is therefore imperative that studies should be made to find out the best management of both livestock and wildlife as a form of multiple land use. Simanjiro offers such an opportunity. Besides the stocking rates already mentioned, the best way of installing permanent structures for livestock management should be determined. Methods of prevention of diseases among livestock involving movement of livestock, siting of water and prophylactic measures should be determined.

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Appendix I

A check-list of the common vascular plants collected in the Simanjiro Plains, northern Tanzania

PTERIDOPHYTES

(FERNS)

Family

ADIANTACEAE

Adiantum capillus-veneris L.

MARSILEACEAE

Marsilea macrocarpa Presl

ANGIOSPERMS

(i) DICOTYLEDONS

PTERIDACEAE

Actinopteris semiflabellata Pic. Ser.

ACANTHACEAE

Barleria ramulosa C.B. Clarke

Blepharis integrifolia (L.f.) E. Mey

Blepharis maderaspatensis (L.) Hayne

Blepharis stuhlmannii Lindau

Crabbea velutina S. Moore

Crossandra subacaulis C.B. Clarke

Dyschoriste radicans Nees

Disperma kilimandscharicum (Lindau) C.B.Cl.

Ecbolium revolutum (L.) C.B.Cl.

Hygrophila spinosa T. Anders.

Justicia anselliana T. Anders.

Justicia flava Vahl.

Monechma debile (Forsk.) Nees

Ruellia patula L.

Thunbergia alata Sims

Gisekia pharnaceoides L.

Glinus lotoides L.

AMARANTHACEAE

Achyranthes aspera L.

Aerva lanata (L.) Juss.

Amaranthus hybridus L.

Cyathula cylindrica Moq.

Cyathula orthocantha (Asch.) Schinz.

Digera muricata (L.) Marts.

Pupalia lappacea (L) Juss.

Sericocomopsis hildebrandtii Schinz.

ANACARDIACEAE

Lannea stuhlmannii (Engl.) Engl.

Rhus vulgaris Meikle

Sclerocarya birrea (A.Rich.) Hochst.

APOCYNACEAE

Carissa edulis Vahl

ARALIACEAE

Cussonia holstii Engl.

ASCLEPIADACEAE

Gomphocarpus physocarpus E. Mey.

BORAGINACEAE

Cordia sinensis Lam.

Cordia ovalis DC.

Heliotropium steudneri Vatke

BURSERACEAE

Commiphora africana (A.Rich.) Engl.

Commiphora madagascariensis Jacq.

Commiphora schimperi (Berg) Engl.

CAESALPINIACEAE

Cassia mimosoides L.

CAMPANULACEAE

Wahlenbergia arabidifolia (Engl.) Brehm.

CAPPARIDACEAE

Boscia angustifolia A. Rich.

Boscia sp.

Cadaba farinosa Forsk. var. adenotricha (Gilg & Ben.) De Wolf

Capparis sepiaria L.

Cleome monophylla L.

Gynandropsis gynandra (L.) Briq.

Maerua crassifolia Forsk.

Maerua johannis Volk. & Gilg.

COMBRETACEAE

Combretum molle G. Don

Combretum zeyheri Sond.

Terminalia brownii Fresen.

Terminalia kilimandscharica Engl.

COMPOSITAE

Aspilia mossambicensis (Oliv.) Wild.

Athroisma psyllioides (Oliv.) Matt. f.

Bidens pilosa L.

Bidens schimperi Schult. Bip.

Conyza stricta Wild.

Emilia coccinea (Sims) G. Don

Erlangea cordifolia (Oliv.) S. Moore

Gnaphalium declinatum (L.f.) Less.

Hirpicium diffusum (Oliver) O. Hoffm.

Notonia coccinea Oliv. & Hiern.

Senecio discifolius Oliv.

Sphaeranthus steetzii Oliv. & Hiern.

Tagetes minuta L.

CONVOLVULACEAE

Astripomoea hyoschyamoides (Vatke) Verdc.

Ipomoea cairica (L.) Sweet

Ipomoea hildebrandtii Vatke

Ipomoea longituba Hall.f.

Ipomoea oenotherae (Vatke) Hall.f.

Ipomoea sinensis (Desr.) Choisy

CRASSULACEAE

Kalanchoe lateritia Engl.

Kalanchoe sp.

CRUCIFERAE

Erucastrum arabicum Fisch. & Mey.

CUCURBITACEAE

Cucumis aculeatus Cogn.

Cucumis prophetarum L.

EUPHORBIACEAE

Acalypha fruticosa Forsk.

Euphorbia candelabrum Kotschy

Euphorbia inaquilatera Sond.

Euphorbia systyloides Pax.

Phyllanthus maderaspatensis L.

Securinega virosa (Roxb.) Baill.

GERANIACEAE

Monsonia angustifolia A. Rich.

LABIATAE

Ajuga remota Benth.

Becium capitatum Baker

Leonotis nepetifolia R. Br.

Leucas glabrata R. Br.

Leucas neuflizeana Courb.

Leucas pododiskos Bullock

Ocimum kilimandscharicum Guerke

LYTHRACEAE

Ammania auriculata Willd.

MALVACEAE

Abutilon fruticosum Guillem & Perrott

Abutilon mauritianum (Jacq.) Medik.

Azanza garckeana (F. Hoffm.) Exell & Hillcoat

Hibiscus aponeurus Sprague & Hutch.

Hibiscus calyphyllus Cav.

Hibiscus cannabinus L.

Hibiscus trionum L.

Pavonia patens (Andr.) Chiov.

Sida alba L.

Sida ovata Forsk.

Sida rhombifolia L.

MIMOSACEAE

Acacia ancistroclada Brenan

Acacia brevispica Harms

Acacia clavigera E. Mey. subsp. usambarensis

Acacia drepanolobium Sjostedt

Acacia mellifera (Vahl) Benth.

Acacia nilotica (L.) Del. subsp. subalata (Vatke) Brenan

Acacia senegal (L.) Willd.

Acacia seyal Del. var. seyal

Acacia stuhlmannii Taub.

Acacia tortilis (Forsk.) Hayne subsp. spirocarpa (A. Rich.) Brenan

Albizia harveyi Fourn.

Dicrostachys cinerea (L.) Wight & Arn.

MORACEAE

Ficus sycomorus L.

NYCTAGINACEAE

Commicarpus pedunculosus (A. Rich.) Cuf.

NYMPHAEACEAE

Nymphaea caerulea Savigny

OLACACEAE

Ximenia americana L.

OROBANCHACEAE

Orobanche minor Smith

OXALIDACEAE

Oxalis corniculata L.

PAPILIONACEAE

Aeschynomene indica L.

Aeschynomene schimperi L.

Crotalaria agatiflora Schweinf. subsp. agatiflora

Crotalaria barkae Schweinf.

Crotalaria pycnostachya Benth.

Crotalaria spinosa Benth.

Crotalaria ukambensis Vatke

Indigofera arrecta A. Rich.

Indigofera schimperi Jaub. & Spach var. baukeana (Vatke) Gillett

Indigofera sisalis Gillett

Indigofera spicata Forsk.

Indigofera spinosa Forsk.

Indigofera volkensii Taub.

Macrotyloma maranguense (Taub.) Verdc.

Ormocarpum kirkii S. Moore

Rhynchosia minima (L.) DC. var. nuda (DC.) Kuntze

Tephrosia subtriflora Bak.

Vigna fragrans Bak.f.

POLYGALACEAE

Polygala sphenoptera Fresen.

Polygala usambarensis Gurke

POLYGONACEAE

Oxygonum sinuatum (Meisn.) Dammer

Polygonum senegalense Meisn.

PORTULACACEAE

Portulaca foliosa Ker.

Portulaca oleracea L.

Portulaca quadrifida L.

PRIMULACEAE

Anagallis arvensis L.

RHAMNACEAE

Ziziphus mucronata Willd.

RUBIACEAE

Oldenlandia wiedemannii K. Schum.

Pentanisia auranogyne S. Moore

RUTACEAE

Fagara chalybea (Engl.) Engl.

SALVADORACEAE

Salvadora persica L.

SCROPHULARIACEAE

Craterostigma sp.

Rhamphicarpa ajugifolia (Engl.) Skan.

Rhamphicarpa montana N.E.Br.

SIMAROUBACEAE

Balanites aegyptiaca (L.) Del.

SOLANACEAE

Datura stramonium L.

Solanum incanum L.

Solanum nigrum L.

Solanum setaceum Dammer

STERCULIACEAE

Dombeya rotundifolia Harv.

Hermania uhligii Engl.

Melhania ovala (Cav.) Spreng.

TILIACEAE

Grewia bicolor Juss.

Grewia tembensis Fresen var. kakothamnos (K.Schum.) Burret

VERBENACEAE

Lippia javanica (Burm.f.) Spreng.

Lippia ukambensis Vatke

Priva curtisii Kobuski

VITACEAE

Cyphostemma orondo Gilg. & Brandt.

ZYGOPHYLLACEAE

Tribulus terrestris L.

(ii) MONOCOTYLEDONS

AGAVACEAE

Sansevieria ehrenbergii Bak.

AMARYLLIDACEAE

Haemanthus multiflorus Martyn

ARACEAE

Pistia stratiotes L.

COMMELINACEAE

Commelina africana L.

Commelina albescens Hassk.

CYPERACEAE

Cyperus bulbosus Vahl var. melanolepis Kukenth.

Kyllinga alba Nees

Mariscus sp.

GRAMINEAE

Aristida adoensis A. Rich.

Aristida adscensionis L.

Aristida keniensis Henr.

Brachiaria eruciformis Griseb.

Brachiaria leersoides (Hochst.) Stapf

Brachiaria pubifolia Stapf

Brachiaria scalaris (Mez) Pilg.

Bothriochloa radicans (Lehm.) A. Camus

Cenchrus ciliaris L.

Chloris pycnothrix Trin.

Chloris roxburghiana Schult.

Cynodon dactylon (L.) Pers.

Cynodon plectostachyus (K.Schum.) Pilg.

Dactyloctenium aegyptium (L.) Beauv.

Digitaria macroblephara (Hack.) Stapf

Digitaria scalarum (Schweinf.) Chiov.

Digitaria velutina (Forsk.) Beauv.

Dinebra retroflexa (Vahl) Panzer

Enneapogon cenchroides (Roem. & Schult.) C.E. Hubb.

Eragrostis cilianensis (All.) Lutati

Eragrostis heteromera Stapf

Eragrostis racemosa (Thunb.) Steud.

Eragrostis superba Peyr.

Eriochloa nubica (Steud.) Thell.

Eustachys paspaloides (Vahl) Lanza & Mattei

Harpachne schimperi A. Rich.

Heteropogon contortus (L.) Roem & Schult.

Hyparrhenia filipendula (Hochst.) Stapf var. pilosa Stapf

Ischaemum afrum (J.F. Gmel.) Dandy

Lintonia nutans Stapf

Microchloa kunthii Desv.

Panicum atrosanguineum A. Rich.

Panicum coloratum L.

Panicum maximum Jacq.

Panicum poaeoides Stapf

Pennisetum mezianum Leeke

Setaria acromelaena (Hochst.) Dur. & Schinz

Setaria incrassata (Hochst.) Hack.

Setaria phleoides Stapf

Sporobolus festivus A. Rich.

Sporobolus fimbriatus

Sporobolus helvolus (Trin.) Dur. & Schinz

Sporobolus pellucidus

Sporobolus pyramidalis Beauv.

Themeda triandra Forsk.

Tragus berteronianus Schult.

LILIACEAE

Albuca wakefieldii Bak.

Aloe sp.

Anthericum kassneri Poelln.

Anthericum subpapillosum Poelln.

Asparagus buchananii Bak.

Gloriosa simplex L.

Ornithogalum longibracteatum Jacq.

Scilla indica Bak.

Scilla kirkii Bak.

ORCHIDACEAE

Disa stairsii Kraenzl.

TYPHACEAE

Typha domingensis Pers.

Appendix II

list of mammals seen in Simanjiro Plains, Northern Tanzania 1970-197

SECTIVORA	
inaceidae	
Atelerix pruneri hindei (Thomas)	Hedgehog
RIMATES	
rcopithecidae	
Papio anubis neumanni Matschie	Newmann's olive baboon
Cercopithecus aethiops johnstoni Pocock	Velvet monkey
HOLIDOTA	
anidae	
Manis temminckii Smuts	Temminck's ground pangolin
AGOMORPHA	
eporidae	
Lepus capensis L.	Cape hare
RODENTIA	
Hystricidae	
Hystrix galeata ambigua Lonnberg	African porcupine
Gliridae	
Graphiurus murinus isolatus Heller	Dormouse
Muridae	
Arvicanthus abyssinicus neumanni(Matschie)	Unstriped grass mouse
Lemniscomys barbarus L.	Striped grass mouse
Mus bellus bellus (Thomas)	Pygmy mouse
Pedetidae	
Pedetes capensis (Forster)	Spring hare
Sciuridae	
Xerus rutilus saturatus Neumann	African ground squirrel

CARNIVORA	
Canidae	
Canis familiaris Linnaeus	Domestic dog
Canis adustus Sundevall	Side-Striped jackal
Canis mesomelas Schreber	Black-backed jackal
Lycaon pictus (Temminck)	Wild dog
Otocyon megalotis (Desmarest)	Bat-eared fox
Mustelidae	
Mellivora capensis (Schreber)	Honey badger
Viverridae	
Genetta genetta (L.)	Common genet
Civettictis civetta (Schreber)	African civet
Helogale undulata rufula Thomas	Dwarf mongoose
Mungoas mungo (Gmelin)	Banded mongoose
Hyaenidae	
Proteles cristatus termes Heller	Aard-wolf
Crocuta crocuta (Erxleben)	Spotted hyena
Hyaena hyaena dubbah F.A.A. Meyer	Striped hyena
Felidae	
Felis catus Linnaeus	Domestic cat
Felis lybica Forster	African wild cat
Felis caracal Schreber	Caracal
Leptailurus serval Schreber	Serval cat
Panthera pardus fusca F.A.A. Meyer	Leopard
Panthera leo massaica (Neumann)	Lion
Acinonyx jubatus (Schreber)	Cheetah
TUBULIDENTATA	
Orycteropodidae	

Orycteropus afer (Pallas)	Aard-vark
PROBOSCIDEA	
Elephantidae	
Loxodonta africana africana (Blumenbach)	African bush elephant
HYRACOIDEA	
Procaviidae	
Heterohyrax syriacus prittwitzi Brauer	Rock hyrak
PERISSODACTYLA	
Equiidae	
Equus asinus asinus Linnaeus	Domestic ass
Equus burchellii Gray	Burchells zebra
Rhinocerotidae	
Diceros bicornis bicornis Linnaeus	Black rhinoceros
ARTIODACTYLA	
Suidae	
Phacochoerus aethiopicus aeliani	(Cretzschmar) wartho;
Giraffidae	
Giraffa camelopardalis tippelskirchi Matschie	Southern giraffe
Bovidae	
Strepsiceros imberbis australis(Heller)	Lesser kudu
Tragelaphus scriptus Newmann	Bushbuck

Appendix 111

OLIVETTI-101 PROGRAM FOR LARGE ANIMAL POPULATION ESTIMATE $\hat{Y} = (\Sigma x/n)N$ AND VARIANCE $S^2\hat{Y} = \frac{N(N-n)}{n(n-1)}\{\Sigma x^2 - (\Sigma x)^2/n\}$

Program	M	R	A	b	B	c	C	d	D	e	E	f	F
1 Av					Σx		Σx^2	n	N				
2 S	x												
3 b↑				x									
4 b↓			x										
5 B+			$x+\Sigma x$										
6 B↕			Σx		$\Sigma x+x$								
7 b↓			x										
8 Ax			x^2										
9 C+			$x^2+\Sigma x^2$										
10 C↕			Σx^2				Σx^2+x^2						
11 a↑													
12 d↓													
13 ↓			1										
14 d+			1+n										
15 d↕			n					n+1					
16 V													
17 Aw													
18 do													
19 B↓			Σx										
20 d÷			$\Sigma x/n$										
21 A◇													
22 S	N												
23 D↑									N				
24 Dx			$N(\Sigma x/n)$										
25 Ao			$\hat{Y}$										
26 B↓			Σx										
27 Ax			$(\Sigma x)^2$										
28 d÷			$(\Sigma x)^2/n$										
29 C↕			Σx^2				$(\Sigma x)^2/n$						
30 C−			$\Sigma x^2-(\Sigma x)^2/n$										
31 C↕			$(\Sigma x)^2/n$				$\Sigma x^2-(\Sigma x)^2/n$						
32 D↓			N										
33 d−			N−n										
34 Dx			N(N−n)										
35 B↕			Σx		N(N−n)								
36 A÷			1										
37 b↕			x	1									
38 d↓			n										
39 b−			n−1										
40 dx			n(n−1)										
41 B↕			N(N−n)										
42 B÷			$\frac{N(N-n)}{n(n-1)}$										
43 Cx			$S^2\hat{Y}$										
44 Ao			$S^2\hat{Y}$										
45 √A			$S\hat{Y}$										
46 B*													
47 C*													
48 d±													

P/S here x is used instead of y