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LAND USE IN MAASAI AMBOSELI GAME RESERVE, A CASE-STUDY FOR INTER DISCIPLINARY DISCUSSIONS

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INTRODUCTION

The purpose of this seminar is to provide a case-study for economic ecological and sociological discussions on a land-use problem. The case-study is Maasai Amboseli Game Reserve which is undoubtedly the most critical centre of conflict in East Africa between conservation, economic and traditional human interests.

Amboseli is one of East Africa's finest and most accessable game-viewing areas and as a result of the recent tourist boom, has the highest annual income of any of Kenya's game preserves. Despite this, the Kajiado County Council who administer the Reserve have still made no approach to resolving the problems, which becomes more crucial as the expanding livestock herds increasingly pervade the game-viewing areas. I suggest that the reason for this is not a lack of pressure from national and international levels, since it has been these pressures that pin-point Amboseli as East Africa more crucial conservation problem. The reason is simply a lack of information for the area on which a development programme can be based. This point is illustrated by the Kajiado Councils suppose of a UNDP/FAO Range Management Divisions Survey on optimal forms of land use in the Kaputei Section.

It seems to me that the recommendations for research on priority problems, made by the symposium on Wildlife Management and Land Use held in Nairobi, during July 1967, have not been followed up. If this were the case, Amboseli would have priority over areas such as Kaputei Section. The r asons for this statement are clear when one considers the role of Amboseli in the 8,000 square miles of Kajiado District. An area of 30 square miles set aside for game-viewing in Amboseli provided the Kajiado District with about £50,000 last year, that is over 60% of its total recenue. Although this source of revenue is threatend by the deterioration of the Amboseli ecosystem, no approach had been made to providing a management plan.

It is because there has been no official survey of Amboseli that I have biased my research to provide the basic ecological information. But a land-use survey cannot be based on ecological considerations alone, the success of a development programme depends on its insuring the ecological, economic and social stability of an area. The ecological survey began in December, 1967. An outline of the programme is attached. It is at this stage that the integration of the ecological work with economic and sociological aspects would benefit, since these approaches can then be integrated into management proposals. I feel that the criticism and suggestions on the whole land-use approach to Amboseli will benefit enormously from an interdisciplinary seminar, since the work and scope is beyond the capabilities of a single researcher. It will also serve as a much needed case-study for more general contact between various disciplines with overlaping interests.

LAND USE

The symposium on Wildlife Management and Land Use was held in Nairobi on July 5th - 8th 1967. Clear guidlines to land use were stated in a number of the paper presented, for instance, Riney, Davis, Pratt and Berry. The need for an interdisciplinary approach was repeatedly stressed. A notable omission was a case-study giving a full analysis of alternative uses of an area. What I intend to do here is to consider the Amboseli case-study using the guidelines proposed by authors mentioned above and hope that it will bring out a basis of discussion for the various fields.

WHY PLAN?

Berry outlined the reasons why land-use planning was necessary, particularly in East Africa. The principle reason is the conflicting demand for land as a result of population and economic pressures, particularly on undeveloped areas. In East Africa the need for planning is largely necessary to preserve game areas around which the tourist industry centres, and the ecological unit generally. Damage to the more important parameters of an environment particularly woodlands leads to a reduced productivity through erosion and the increase of unpalatable secondary growth.

President Mzee Jomo Kenyatta addressing the IUCN meeting in Nairobi, 1963 said "The Government of Kenya fully realizing the value of its natural resources pledes itself to conserve them for posterity with all the means at its disposal". Considering this clearly defined policy and the evident conflict for land in Amboseli, there is no doubt of its needs for a land-use plan.

CRITERIA IN PLANNING

"Two broad problems are encountered in making rational land-use planning work. One is the problem of defining goals and criteria. The other general problem is in identifying and measuring the alternative goals which a piece of land may be capable of producing" Davis from proceedings on the 1967 symposium.

The goals in wildlife management are usually the efficient utilization, (measured in ecological and economic terms) and conservation of natural resources. This is ideally true for an economically productive game area such as Amboseli. However, Davis goes on to say that Optimal land-use may be subject to various constraints. Physical, legal and cultural, which must also be taken into consideration. In Amboseli the optimal land use is clearly as a game viewing area, as will be demonstrated. However, one must take into account an important constraint, the needs of the resident Maasai.

WHAT INFORMATION IS REQUIRED?

Having defined the goals for a particular area the question must be asked, "what information is required for planning"? Berry lists these as:-

1. Land potential and water resources so that various land use forms can be compared

2. Current uses of land so that it is workable in terms of present ecological and Sociological conditions.

3. Existing or planned development.

interactions. From the outline of my research at the community level it will be evident that these factors are all gathered to demonstrate the ecosystem parameters which shape the community structure dynamics and stability.

LAND USE FOR AMBOSELI

Turning now to Amboseli case-study one can examin the optimal land-use form using the criteria mentioned.

The need to plan has already been demonstrated, resulting from the struggle for land within the Amboseli-basin andthe resulting deterioration of the environment and the consequent threat to Kajiado District's major source of income.

The possible goals in planning in Amboseli are limited. The area has too low a rain fall and saline soils to support crops. Apart from meerschaum there appears to be no mineral resources. Mining concessions have already been made for the exploitation of meerchaum on Lake Amboseli and the Claims do not conflict with principle cattle or game areas too much. The only other alternatives are game recenues through tourism and cropping, and livestock farming.

THE ALTERNATIVE USES

What then are the merits of the alternative land uses? In collaboration with Mr.F. Mitchell and Mr. T.J. Aldington, economists at the Institute for Development Studies, the economic yield from livestock farming and tourism has been roughly computed as follows:-

Livestock

Over the 600km^2 (220 sq. miles) of the Amboseli ecosystem the maximum sustained yield from Livestock has been calculated, if not game at all were permitted. The calculation is based on an analysis of potential production on Mbilin ranch, Kajiado by the UNDP/FAO. The ranch of 38,000 acres supports 2,735 cattle and 734 sheep and goats, producing an annual revenue of £2,550. After development, i.e. increasing cold dressed weight and annual off-take percentage by introduction of quality stock, the maximum gross annual revenue from the ranch would be £100,000. The development period covers 12 year, that is until 1980.

Since the yield has been worked out in considerable detail for Mbilin ranch, the same production potential can be applied for the Amboseli. Amboseli is about 3.5 times the size of Mbilin so the revenue for Amboseli would be £350,000 from livestock. However the productivity of the Mbilin grasslands are in the region of 6,000-12,000 kg/Hectare while those of the Amboseli-basin are only 900-4,000 kg/Hectare figure. That is only one third of the amount of food is available in the basin. This simply reduces the protein yield by the same amount and consequently the economic yield. Therefore Amboseli under maximum cattle yield could produce about £116,000 per annum, gross.

Tourism

Revenue for the current year amounts to a minimum of £248,000 including lodge receipts, lodge service charges and extra meals. At an expected rise of 15% and 20% annual tourist increase the finance projections for 1980 would be £1,221,000 and £2,160,000 respectively.

I do not intend to go any further into detail on the economic projections at this stage since they illustrate the optimal land use very clearly. However a more detailed discussion of the economics would be very valuable in the seminar.

It is very clear then that even without game cropping the economic potential of game is infinitely greater than livestock. It is in fact already producing a greater income than livestock could expect to produce at full potential.

Constraints

Although tourism is economically the optimal land-use form there are the constraints to consider. There are no existing or planned developments, but there are social factors. The Maasai in the 600 km^2 area possess 20,000 cattle and 5,000 sheep and goat. The basin has traditionally been their dry season water-source and it is probably only following the cattle increments of recent years that the game and Maasai have seriously competed for graze with wild game. Any land-use proposal for Amboseli will necessarily have to consider the alternative areas that the Maasai could move to in the event of vacating certain areas for game viewing. The continued social stability is particularly important for the success of any plan. It is on the Sociological aspects that information is badly needed since it is not so accessible as economic and possibly ecological data.

Planning

An area that defines the ecosystem of the game community has been determined from the ecological data and movements over the last four seasons. It is apparent that an area of about 150-200 square miles would preserve the community stability if entirely free of cattle. This could be used as a basis of negotiating with the resident Maasai since moves of only about four miles would take all basin bomas beyond the optimal game unit area. Alternative water could be supplied by piping from the swamps to open up new areas for the bomas involved in the move.

The defined ecosystem boundaries will act as a basin of negotiation between the Warden, Council and resident Maasai, to conserve as a stock-free area. The negotiations will probably make headway this time since the local Maasai will be offered some of the Amboseli profits which they have not received before.

Discussion

Questions

The main question in my own mind is whether the approach to this land-use problem that has been outlined is a valid one. I would invite comments on this in particular.

Other points of relevance are the idea of the community ecology approach as the logical framework for the integration of most of the diverse data. Its advantages are that it defines a functional unit which is relatively descrete and evaluates all the interactions of the physical, biotic and human environments in a single discipline. With the data on the structure, dynamics and stability of communities it seems to me that the other criteria of importance are sociological and economic goals. The optimal land-use is usually fairly clear to the ecologist since he can measure the production-potentials of a natural resource in terms of energy production and ecological efficiency. The economist has a basically a similar approach, but instead of energy-flow his criteria is monetary-flow. How far is there a common yard-stick them? This will be a useful point to discuss. As far as I can see at the moment the two approaches are identical in measuring say protein yield since the maximum economic efficiency. The law of diminishing returns are basic to both. The point of divergence is in the weighting of certain commodities since not all the natural food products are equally consumable. Even though human species would be more efficient as a primary consumer (plant products our dietary and social whims act as constraints.

Is there any common criteria for the economist, sociologist and ecologist? For a point of discussion I will propose efficiency and stability. The economist and ecologist think in terms of maximum sustained yield, the ethologist and sociologist in terms of social stability. How far do economist and ecologists consider stability? Social stability is undoubtedly necessary to some extent for economic stability and it is encouraging to see the increasing integration of these disciplines. But how does ecology fit in? Without going in to detail at this point I would suggest many of the community and population ecology parameters determine social stability.

An approach thrown out for discussion is that one must first of all ensure ecological efficiency and stability for social stability, which economists can them work on. Amboseli will provide a valuable case-study in this respect.

AN OUTLINE OF THE RESEARCH

APPROACH

DEFINING THE AREA

One of my initial tasks was to define the range of the community and then to adopt a method of approach for gathering the necessary data within this area. It became apparent that there are two fairly distinct ranges, corresponding to the wet and dry seasons. The game is dispersed over an area of about 2,000 Km^2 during the rains, but during the dry season, it concentrates around the permanent water of the Amboseli basin swamps. The dry-season range depends on the distance that the various water-dependant species can travel from water to feed. The movement beyond this range by water independent species constitutes less than 5% of the total biomass of the community. One can therefore describe an area of about 500 Km^2 as the dry season econsystem for 95% of the water-dependent species. The defined area could be extended to include an increasing percentage of the community i.e. lines of probability including the ranges of 93%, 94% ... 99% of the numbers, but such an increase for a statistically insignificant percentage would lower the sampling level per unit time disproportionately. The real value of defining the dry season ecosystem is that it describes limited time and area that ultimately regulates the community. Here the interaction between species will be maximal and here the community structure, dymanics and stability can be measured mose efficiently.

Having established an area and season for maximum efficiency of measurement, a technique of gathering infor-

SAMPLING

The systematic accumulation of data on a complex community presents a major problem owing to the large number of variables involved. The analysis and presentation pose further problems. Owing to the lack of community studies other than by qualitative (Vesey-Fitzgerald, 1965) or energy-flow (Lindemann, 1942) approaches methods of data gathering and analysis are relatively undeveloped. The only feasable approach to such a problem is based on sampling techniques from which statistical inferences can be made for the whole community. A random sampling technique using a method of selecting areas with probabilities proportional to size (Cochran, 1963) has been adopted. The sampling technique has been found sufficiently accurate using a known population of animals in Nairobi National Park.

Samples over the 600 Km2 of the study area, which incorporates the dry-season ecosystem, are taken at 15% to 25% each month using driven transect lines. Along each transect, data is collected on vegetation zones, state of grass at 2 Km intervals (e.g. grass height, cover, growth stage and components grazed), climate, game species, numbers of males, females and of each juvenile age category, activity, intraspecific associations, distance from water and time of day.

The analysis of the data is done by standard statistical techniques. The approach basically involves assuming a uniform distribution of animals and taking this as the Null Hypothesis. Then by processing the data from the random sample on the Treasury ICL 1900 Computer, the Null Hypothesis can be tested for all possible combinations, e.g. distribution of all species (expressed as densities per unit area) against each other, vegetation zones, grass height, growth stages, distance from water, etc.. This approach is particularly useful in detecting seasonal patterns. The subject of methodology will receive fairly detailed consideration owing to its importance in future research.

Having broadly outlined the approach to the subject, I will discuss the specific aspects of the study, that is, the community perameters, and its structure, dynamics and stability.

THE ECOSYSTEM (THE PHYSICAL ENVIRONMENT)

The value of the ecosystem approach (Tansley, 1935) in defining a limited area and time for measuring the community most efficiently has been mentioned. The ecosystem approach is useful in another way. By recording the physical features of the system, one can detect the more important perameters of the community by correlating the changes in the physical environment with the reactions by the animals. In order to provide a framework within which to describe the community, information on geology, soils, climate, hydrology and biotic features are being collated. Fortunately, much of this information is readily available , in particular from a geological survey by Williams (1967), on hydrology by Cambell (1958), climatic records and surveys I have completed on soils, analysed by the National Agricultural Laboratories, and vegetation. Owing to the recent geological activity of the area, linear relationships between geology, soils and vegetation produces a seasonal pattern to which the community responds in a consistent manner.

THE BIOTIC ENVIRONMENT

Although the physical parameters of the environment shape the community, it is at the biotic level that this study particularly concentrates, since the biotic organization reflects the physical influences and also its own internal environment. For descriptive convenience the biotic environment can be examined in two parts, the fauna and flora, but both will be treated as a

THE FLORA
DESCRIPTION

The first two months were spent in describing and mapping the vegetation of the 600 Km^2 detailed study area. Thirty zones were established on the basis of composition and cover and the area covered by each zone was calculated. During the initial sampling all vegetation zones were recorded, but after two complet seasons the utilization of vegetation zones by the various game species was examined. The vegetation zones used similarly by the community were then grouped together. The major categories are more or less ecological units reflecting flora/fauna interactions. The method is not dissimilar from Poore's 1962 method of successiv approximation in classifying plant communities. The initial description is qualitative while the subsequent grouping is quantitative, based on ecological associations which can be determined by association analysis. Each major category will eventually be described more quantitatively for floristic composi-tion.

PRIMARY PRODUCTIVITY

To provide the necessary data for energy-flow analysis and food availability, seasonal productivity estimates are made for th grasslands. It appears that the standing crop at the end of the rains is, except for swamp-edge grasses, equal to the total yeild for a full season, i.e. there is little or no growth in the dry season. The game, except for a few animals, does not occupy the basin during the rains, so that by the time they move back in the dry season the standing crop is the total amount of grass availab to tide the ungulates over until the next rains. It also means that productivity estimates are relatively simple, determined by mowing sample strips just prior to the inward game movements. Exclosures are used to check whether there is any growth during the dry season and to apply the necessary corrections if this doe occur. Monthly estimates of standing crop are also being made, initially by sample mowings. However, this is very low level sampling and experimental plots are being used to establish possible correlations between dry-weight of grass and height. Hopkins (1968) found a close correlation between these two measurements in Nigerian savannah. Should the correlation be reasonable, the 15% grass height sample of the grassland taken every month can be used as a large scale extimate of the standing crop.

Other determinations include water-content of grasses on a monthly basis, calorific values and chemical composition of the main grass species and their component parts.

THE COMMUNITY

The "community" refers to the Amboseli-basin large mammal community. The word community is used here in Allee's (1951) context to mean an assemblage of organisms in dynamic equilibrium with their environment to such an extent that it is relatively independant of other such communities, that is, self-maintaining.

STRUCTURE

For each month ground and generally aerial samples provide an estimate of total numbers. A few examples can be given

April 1968	Estimated Total	Standard error
Wildebeest	1535 (3350)*	310 (903)*
Zebra	1060 (3450)*	320 (924)*
Oryx	610	175
[illegible]	1535	220

The number and group composition per month serve as a basis for further calculations. By obtaining the mean population numbers, biomass for each species is derived. A more accurate method of assessing the relative contribution of each species to the community is by the amount of energy they use (MacFadyen, 1957). This aspect will be considered in the dynamics of energy flow through the community.

DYNAMICS-

COMMUNITY METABOLISM

One method of tackling dynamic aspects has been to work out the metabolism or energetics of communities (Lindemann, 1942: Teal, 1957; Odum and Odum, 1955). More recently an approach to explain numbers and interactions has been initiated (MacArthur, 1955, 1958; Slobodkin, 1966). The approach so far has been to analyse simple discrete communities, particularly pond invertebrates. The metabolism approach is being applied to Amboseli by tracing the energy flow through the community. The relevance of invertebrate energy-flow models to vertebrate communities can then be examined, particularly from the ecological information likely to be gathered for the Ngorongoro community. The relevance of the Ngorongoro study to the present work will be outline later.

The energy-flow for the Amboseli community is expressed by determining the total available energy from primary production, and tracing the offtake by the herbivore levels and the carnivore levels in turn. From the raw data, food chain and ecological efficiencies can be determined.

PATTERN

The metabolism approach is of limited value in describing the relationship between trophic levels and particularly between species of a given trophic level. It is apparent in the Amboseli-basin ecosystem that the seasonal pattern is particularly relevant in demonstrating the reasons for the community structure and interactions. The interaction of climate and vegetation results in a gradual change of both water and food distribution and availability. The relationship between these changes and the community reaction, for example structure and activity, is being examined. In particular this includes the manner in which large numbers of ungulate species utilize the grasslands, the efficiency of utilization, ecological separation, competition and interdependancies. The simplicity of the Amboseli-basin vegetation is particularly conducive to an examination of these relationships. It is evident that a grazing succession similar to that described by Vesey-Fitzgerald (1965) and Bell (1968) accounts for most of the observed patterns within the Amboseli community.

GRAZING SUCCESSION

The grazing succession depends on the larger herbivores moving into long grass areas and reducing the level which smaller animals can then utilize (Vesey-Fitzgerald, 1965). This accounts for the associations between species in the late dry season and fullfills the Gausian axiom of ecological separation between species. The nature of the grazing succession is currently being studied by Bell (1968) who carried out his field work on the Serengeti plains game. The selection of different components of grass species has been demonstrated by Gwynne and Bell (1968) contrary to the ideas of Talbot and Talbot (1963) who suggested that the ecological separation of plains ungulates was based on species selection.

The precise nature of the grazing patterns in Amboseli is being studied; the relationships between body size, energy requirements and amount of grass necessary to maintain an energy balance, succession works down the lake although only a single species of grass Oddyssea jaegeri, is available. Through analyses of the standing crop of grass down the lake, a chemical composition of the different parts available, a selection of components by a succession of ungulates determined from gut samples, and faecal analysis, a clear picture of the causitive features of this pattern should emerge.

WATER DEPENDENCE

Other features to consider are the size of an animal, its water-dependence, and from these features the range it can travel from water to obtain graze. The analysis must also consider grazing preferences as well as grazing pressures and it is here that multivariate analysis will be most useful. At the moment it is evident that as grazing pressure increases, the swamps act as a buffer, opened up by a grazing sequence of larger herbivores, elephant, hippo and buffalo. The plains-game succession will then follow on in prolonged dry periods.

HUMAN ECOLOGY

The human ecology of Amboseli is by far the most significant contribution to the energy flow, if one considers livestock with pastoralist activity. In fact, human ecology contributes over 70% to the biomass of the total community. As far as possible human ecology will be subject to the same approach as the community generally. The Ikisongo Maasai who inhabite the area are still largely traditional pastoralists. From the ecologist's point of view this simplifies the study because the pastoralists are still largely subjected to local environmental conditions and are not buffered by trading with areas outside the basin. To date there have been no objective ecological studies of any human group in relation to the community of which it forms a part. It is this aspect that is expected to contribute most significantly to the Amboseli situation and the broader issues of land-use practices

The approach is basically similar to that described for other members of the community. The occupancy for the Maasai and their livestock is assessed from monthly samples or total counts. By obtaining age structure of the Maasai and juvenile age weight distribution the total number can be converted to biomass. Energy flow data can be determined in the same way as for other mammals (Lamprey, 1964), and the contribution of pastoralism to the total energy budget can then be shown. In fact, this has already been worked out for some seasons, as mentioned above.

Specific data on livestock production, milk, meat and blood yield, on maintenance requirements of the Maasai, on range travelled from water and on grazing patterns is being accumulated. Population data on the Maasai is gathered to correlate with cattle data. If possible, information on the sale of stock and the purchase of other foods and materials will be taken into account since this is relevant to a consideration of energy balance.

STABILITY

One of the most important aspects of the Amboseli-basin community is the apparent instability, believed to be caused by the recent increase of cattle and other livestock. Whether this belief, which has caused so much concern over the future of Amboseli, is valid, must be considered objectively. A solution will depend on an accurate diognosis of stability so that a precise formulation for a solution is possible.

APPROACH

My approach to stability aspects of the Amboseli-basin community is to describe the long-term trends, the possible alteration of trends in recent years and to guage from the present community features what state the community is in.

LONG TERM TREND

From the information on the geological history of Amboseli (Williams, 1967) it is possible to trace the early phases of the basin's history. From cores taken from the lake bed for pollen analysis by D.A. Livingstone at Duke University, North Carolina, it may be possible to gather further data on the early stages. Drying up of the lake in the late Pleistocene or Recent, resulted in colonization and succession of plant communities. The lake did not, however, dry out all at once and some parts are still seasonally flooded. From these areas to the original lake shore which dried out earliest, a succession of plant communities is found which probably represent the seral phases of succession that colonization has taken. This starts with a single grass species, Oddyssea jaegeri, and progresses through to Acacia tortilis woodlands. This means that one can very conveniently trace the evolution of at least the soils and vegetation. The development of the animal community might also be possible. For instance the large herbivores begin grazing from the woodland areas in the dry season, the grassland areas presumably not being productive enough. The plains game, on the other hand, follow a grazing succession, that traces the seral phases of the plant community, i.e. from the seasonal lake grasses to the Acacia tortilis woodlands. This grazing succession simply follows the increasing complexity and productivity of the grasslands. One could therefore assume that the larger ungulates could not have used the lake bed until sufficien production of grass, e.g. the woodland grasses for elephants, had built up. Some of these relationships might be assessed by working out the energy requirements of the herbivores and the energy available at particular seral stages of the succession.

RECENT CHANGES

The simplest way of tracing possible changes in trends in recent years is by the stereoscopic analysis of a series of aerial surveys in 1950, 1961, 1963 and 1967. From these survey photos it is apparent that there is a considerable change in the direction of plant succession in the areas of dry-season concentration. The most significant feature is the die-off of Acacia xanthophloea woodlands, regressing to plains grasses rather than progressing to Acacia tortilis woodlands. Comparison with areas of the basin which are not within the dry season concentration area emphasises this feature very clearly and these factors will be quantified by the use of sample plots on the aerial photos. Another method of approach that may prove useful is a comparison with other saline lake-bed areas e.g. Naivasha, Nakuru, Manyara, Magadi and Rukwa.

COMMUNITY CHANGES

Another approach to the problem of assessing stability is to examine the structure and dynamics of the community. A convenient way of doing this is to compare these features to those of a known, or assumed, stable community. A study has been initiated in Ngorongoro Crater for the purpose of such a comparison. For each area the community structure, energy-flow, ecological efficiency and food-chain efficiency are being compared. The essential comparison is between the livestock dominated community of Amboseli and the essentially natural community of Ngorongoro.

PRESENT VIEWS

From the information on long term trends, the recent changes and the effects on the community, an objective appraisal of the situation in Amboseli should be possible. With the information available to date a tentative assessment follows.

The normal seral succession will pass from simple to complex communities (Odum, 1957) with increasing stability (MacArthur,1955) The Amboseli-basin is still in a relatively early stage of succession, and it appears that the increase in livestock figures since the introduction of rhinderpest innoculations in 1948 have had a detrimental effect on the Amboseli-basin ecosystem. The effects of the overstocking is to hold the area in a disclimax, possibly even causing a regression of seral phases. In particular the die-off of Acacia xanthophloea woodlands indicates a change of trend, mainly the result of elephant damage. An analysis of woodland damage shows that 97-99% of the trees have received elephant damage. It is not clear as yet what the underlying causes are, but one feature may be the grazing sequence of cattle. The cattle move into the late dry season woodland grasses at the beginning of the dry season and take off most of the available graze before the game community has grazed into these areas. This means that the grazing sequence is contrary to that of the rest of the community. This would leave the large herbivores such as elephant short of graze and the de-barking of Acacias may reflect this. There is no damage to Acacias during the rains.

Both MacArthur (1958) and Slobodkin (1966) have advanced the hypothesis that community stability increases with an increasing complexity of the food web. With the increasing livestock numbers the Amboseli community food web is clearly becoming simplified and it will be of interest to see if this is coupled with a decrease of stability as predicted by Slobodkin's prognoses.

BIBLIOGRAPHY

ALLEE, W.C., 1951 Cooperation among animals, with human implications, New York : Schuman, 233 pages.

BELL, R.H.V., 1968 Grazing Succession in the Serengeti Plains. Third annual report to the University of Manchester.

CAMPBELL, G.D.M., 1958 Report on Amboseli water supplies investigation Phase two. Unpub. Rep. Min. Works Kenya.

COCHRAN, W.G., 1963 Sampling techniques. 2nd. ed. New York, 413 pp.

GAUSE, G.F., 1934 The struggle for existence. Baltimore: Williams & Wilkins. 163 pp.

GWYNNE, M.D. and BELL, R.H.V., 1968 Selection of Vegetation Components by grazing ungulates in the Serengeti National Park. Nature Vol.220 No. 5165, pp 390-393.

HOPKINS, B.,1968 Vegetation of the Olokeneji Forest Reserve, Nigeria. V The vegetation on the savanna site with special reference to its seasonal changes. J. Ecol. 56, 97-115.

LAMPREY, H.F., 1964 Estimation of large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. E. Afr. Wildl. J. 2: 1-46.

LINDEMANN, R.L., 1942. The trophic-dynamic aspect of ecology. Ecol., 23(4): 399-418.

MACARTHUR, R., 1955 Fluctuations of animal populations and a measure of community stability. Ecol., 36(3): 533-536.

MACFADYEN, A., 1957 Animal ecology; aims and methods. London: Sir Isaac Pitman and Sons Ltd. 255 pp.

ODUM, H.T., 1957 Trophic structure and productivity of Silver Springs, Florida Ecol. Monogr., Vol. 27, 55-112.

ODUM, H.T., ODUM, E.P., 1955 Trophic structure and productivity of a windward coral reef community on Eniwetok Atoll. Ecol. Monogr., Vol. 25 , 291-320.

POORE, M.E.D., 1962 The method of Successive Approximation in descriptive ecology. Advances in Ecological Research 1 ed. Cragg.

SLOBODKIN, L.B., 1966 Growth and regulation of Animal Populations. Holt, Rinehart and Winston.

TALBOT, L.M. and TALBOT, M. (19636) The Wildebeest in Western Masailand East Africa. Wildl. Monogr. No. 12.

TEAL, J.M., 1957 Community metabolism in a temperate cold spring. Ecol. Monogr., 23: 41-78.

TANSLEY, A.G., 1935 The use and abuse of vegetational concepts and terms. Ecol. 16. 284-307.

VESEY-FITZGERALD, D.F., 1965 The utilization of natural pastures by wild aminals in the Rukwa Valley, Tanganyika. E. Afr. Wildl. J. 3: 38-48.

WILLIAMS, A.J.W., 1967 The Kilimanjaro Volcanic Rocks of the Amboseli Area, Kenya. Unpublished Ph.D. thesis submitted to the University of East Africa.