Effects of Fire on Vegetation Composition and Forage Productivity in the Nyabushozi Pastoral Ecosystem, Mbarara District, Uganda

By

Emmanuel Kyagaba, BSc. (Hons), M.U.

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DECLARATION

I Emmanuel Kyagaba, hereby declare that this thesis is based on the work done by me, that this work is original and has not been presented at this or any other University

Signed ....

Date ....29 7 1998..............

This thesis has been submitted with our approval as the University supervisors

Dr Kassim O Farah
Senior Lecturer

Signature ....
Date ....5 Oct 1998..........

Dr E N Sabiiti
Associte Professor

Signature ....
Date ....25/7/98..........

DEDICATION

Dedicated to my mother Joyce, my late father Jonathan and my late brother Fenny whose belief in education has always been my source of encouragement

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ABSTRACT

A survey was carried out in Nyabushozi County, Mbarara District in south/ western Uganda to study the effects of fire on vegetation composition and forage productivity, assess the indigenous perception of fire, its use, role and effects on the vegetation dynamics in pastoral ecosystems This aimed at verifying the indigenous perspectives using scientific approaches Four vegetation communities were studied, namely,

1. *Acacia hockii Cymbopogon afronadus Themed triandra*, shrub savanna
2. *Euphorbia candelabrum Dichrostachys cineria Sporobolus pyramidalis T.triandra*, seasonally flooded grassland
3. *Rhus natalensis A.hockii Loudetia kagerensis* shrub savanna
4. *A.hockii R.natalensis C.afronardus Brachiaria decumbens* deciduous riverine thicket

From each community, observations were made from a burnt and unburnt site during the dry and wet seasons Aspects of vegetation analyses, included biomass production, species diversity, vegetation cover, density of woody species and forage quality, crude protein (CP%), neutral detergent fibre (NDF%), and *in vitro* dry matter digestibility (IVDMD) were used to assess forage quality Stratified and transect sampling was used to get representative sample communities.

The study revealed a positive perception of burning among the pastoralists despite range land burning having been outlawed for 20 years in Uganda The desire to burn vegetation/pasture by pastoralists also depended on

the type of vegetation, *C. afronardus* and *Loudetia kagerensis* grass communities being the most frequently burned. Results from this study further indicate that burnt communities had a higher species diversity index. The similarity indices showed levels of similarity above 80% indicating that the burnt and unburnt sites were at close secondary successional stages. The concetration of dominance was higher on unburnt sites being most significant on *C. afronardus* grassland.

Herbaceous biomass yields were generally high in this ecosystem ranging between 2.04±0.24t/ha to 12.12±1.04t/ha. The highest biomass recorded was on community one which ranged 6.94±0.5t/ha to 12.13±1.04t/ha. Up to 70% of the herbaceous biomass on community one was made up of *C. afronardus* which is regarded an unpalatable grass species to livestock. The difference in DM production between the dry and wet season was not significant ($P<0.05$). The dry season was short and mild during the study.

Forage quality studies indicated that forage from the burnt site was of better quality even after 1 to 1½ years after a burn. The difference in CP% between the burnt and unburnt sites was still significant ($P<0.05$).

It is concluded from the present study that the frequency of burning in the study area, which annual is high given that the forage is still actively growing. The use of fire as a management tool in the rangeland needs to address the effects of fire on the various vegetation types because the desire to burn is influenced especially by the type of grass, the desire to maintain a certain type of vegetation cover and to help regeneration of the desired forage.

This study further gives weight to the increasing recognition of traditional systems in natural resource management and the role of fire is one such important aspect. The results from vegetation analysis shows that the pastoral communities have practical experience based on a long period of observation which, however, is not documented. A consideration for use of controlled burning in the pastoral areas can be based on the results and recommendations from this study.

CHAPTER I

INTRODUCTION

1.1 Pastoral Ecosystems of Uganda

The pastoral ecosystems of Uganda are located in rangelands These are characterised by very low and erratic rainfall, high temperatures and evaporation rates, soils that are often shallow, rocky, sandy or have a high content of salt and clay, and terrain that is often steep This does not support conventional rain fed agriculture In East Africa, the term rangeland is often used to include areas of agricultural potential which consists mainly of natural grassland, bushland, or woodland, either under or over-utilised and whose development depends on the application of an extensive type of rangeland management for livestock production (Perbedy 1969) Pastoral herding in Uganda is practised in the districts of Kotido and Moroto in the north east, Mbarara, Masaka, Mubende, Luwero, Rakai, Kabarole and Mpigi districts in the south and south west, and parts of Soroti and Kumi districts in east of the country The main pastoral communities are the Karamojong and Bahima in the north /east and south /western Uganda, respectively

According to the above definition, Uganda is approximately 76% rangeland with about 39% of the total land area being available for range livestock use (FAO 1988, Mugerwa 1992, Mbuza et al 1993) The rest of the rangeland comprises of rocky mountain slopes, game reserves and National Parks The use of rangelands has been primarily grazing by wild and domestic animals, which mainly comprise cattle, sheep and goats utilising the native vegetation.

1.1.1 Use of Fire in the Pastoral Ecosystems

The pastoral ecosystems of Uganda are located in the Savanna grasslands where fires are frequent and widespread. Existing literature (West 1965, Kruger 1986, Mentis and Taiton 1986, Sabiiti et al 1991, Sabiiti and Wein 1991), shows that when properly used fire improves herbage quality and quantity of forage species grazed by livestock. Fire is also important in the control of bush encroachment when there is a browsing component (Harrington 1974, Sabiiti and Wein 1991)

Fire is widely accepted as a valuable tool in the management of natural vegetation. It is a resource modifier and can be used to change the composition of vegetation and its cover or to maintain plant communities in a certain stage of succession (Edward 1986). There are several reasons why people burn natural vegetation (Scott 1947, Campbell 1960, West 1965, Pressland 1982) namely, that fire, removes unpalatable growth and accumulated materials from the previous season, stimulates vegetation growth including plant seeding, can be used in preparation of seedbeds for natural or artificial seeding. Further more, fire controls encroachment of undesirable plants and aids in better distribution of animals. It creates fire- breaks against wild fire and destroys parasites of animals

Fire in the pastoral ecosystems is used by the indigenous people who use it traditionally on the rangeland. This type of fire may run out of control and destroy extensive areas of the rangeland. It is clear that the pastoralists use fire in range management but this traditional burning has not been documented

1.1.2 Rational Use of Fire

Fire may not bring about any positive effects unless the burning occurs in the appropriate vegetation, season and intervals (Pratt and Gwynne 1977) Fire which is misapplied can remove desirable forage, leaving behind fire resistant and less desirable species of woody plants It can contribute to reduced soil quality and even result in denudation, which is then followed by erosion and/or reduced water infiltration Under the present conditions, fire is a problem in Nyabushozi as the range vegetation is burnt without control. Pirie (1982) has also expressed fears of frequent savannah burning

Fire has long been used as a management tool in grazing management of range vegetation There is archaeological evidence from Uganda (Posnasky 1965) that fires, natural or man made, were used by early man as far back as 10,000 B C It is thought that the present open grasslands were partly maintained by frequent annual fires

Nearly all the fires that occur in Uganda are uncontrolled The use of fire in the study area was irregular with no specific regime Limited studies have been carried out in Uganda rangelands to identify existing fire use and determine the likely impact on vegetation dynamics. Some work has been done in National parks (Harrington and Ross 1974, Sabiiti 1985, Edroma 1986) The management objectives in the National Parks is, however, different from those under the pastoral production systems While the Park authorities target improved distribution and visibility of game to the tourists, the pastoralists emphasise increased herbage yeild and disease and parasite control

Estimates on primary production and analyses of the quality of forages, mostly grasses and shrubs have been conducted (Long et al 1969, Edroma 1986, Lock 1967, Field 1968, Kuccera and Ehrenreich 1961) All these have shown a trend of increased grassland production associated with burning There is, however, scanty information on the effect of traditional burning on plant biomass production and quality in pastoral areas

Fire regimes differ according to the prevailing environmental conditions and studies conducted in areas utilised for different production objectives are not universal There is also a worry and concern among the pastoralists in Mbarara District on whether the deteriorating quality of pastures due to invasion of unpalatable species especially *Cymbopogon afronardus* and thorny bushes dominated by *Acacia hockii* is not due to uncontrolled bush burning

Studies by Ford and Clifford (1968) report a high probability of change in grazing and/or fire pattern as being responsible for weed and bush encroachment in this area Harrington (1974) considered fire as having the dominant ecological influence in this area and stressed urgent need to quantify this information for management purposes No detailed research has been carried out in this area to further understand the response of traditional burning by pastoralists on vegetation dynamics It is against this background that this study was formulated

1.1.3 Objectives

The study aimed at assessing the effects of traditional burning on herbage production and quality under indigenous management systems, identifying the various burning regimes, comparing vegetation production, cover and composition, determining forage quality particularly dry matter (DM%), crude protein (CP%), neutral detergent fibre (NDF) and in-vitro dry matter digestibility (IVDMD)

This was in the view of determining how use of fire confounded with grazing are likely to influence vegetation dynamics of pastoral ecosystems It was also intended to take inventory of forage resources as a function of habitat potential and (resource levels) assess external factors of fire, grazing and other human activities The confounding effects of bush fires and grazing, together with other human activities form a basis for formulation of proposals, as principles and guidelines to the formation of management policies for the pastoral production systems in this area

1.1.4 Operational Definition

This study considered strongly the indigenous use of fire in the study area The following are the operational definitions

Indigenous system; refers to an organisation or social activity which has been set up primarily as a result of local initiative. It refers to techniques that are endogenously generated, enforced and maintained Indigenous systems for natural resource management include both biological management and the social arrangement by which access to natural resources are regulated (Rai and Thapa 1993).

Fire regimes: These are systems of deliberate administering of fire to certain vegetation in order to achieve targeted objectives It refers to the various criteria that are used to decide whether and when burning should be done This is an important consideration because it has a direct bearing on the impact of the fire such as, intensity of the fire depending on the amount of fuel that has accumulated, the severity which is determined from the amount of fuel consumed by the fire, and the frequency of burning determined by the interval between successive fires over the same area

1.1.5 Conceptual Basis

The study is based on the concept that local people have a potential, which if supplemented with scientific and technical knowledge would achieve practical and appropriate range management strategies Besides, local knowledge has an element of cost effectiveness, practical application, appropriate technology and is sustainable It is regarded important to consider some kind of integrated approach that incorporates the knowledge of local people with modern technological interventions to be able to come up with rational policies and management principles when dealing with pastoral communities

CHAPTER II

REVIEW OF LITERATURE.

2.1 Historical and traditional use of Fire

According to Naveh (1974), fire was the first forceful tool for energy input and ecosystem manipulation used deliberately by primitive man Fire has been an evolutionary force shaping the African vegetation from time immemorial (Stewart 1955, Bartlet 1956, Edroma 1986). Philips (1930) described the East African vegetation as a subclimax resulting from frequent burning In Uganda Langdale-Brown et al (1964) stated that the non forested land up to 1,800 m above sea level is burnt at least once every three years. Hall (1986) divided such fires into two categories, extensive regimes and intensive regimes, where, extensive regimes are those where uncontrolled fire is used in grassland in order to remove litter and encourage seasonal regeneration over large areas Intensive regimes can then follow where fields of crops or pasture are to be sited These fire regimes are not exclusive and may be used in conjunction with one another An intensive regime, which results in the removal of closed vegetation, may be replaced by an extensive regime in the subsequent secondary grasslands or open woodlands (Hall 1986)

The various regimes are also associated with broad economic categories Whereas farmers have used extensive and intensive fires, pastoralists have been responsible mainly for fires of an extensive scale because pastoral production systems involve large tracts of land and some degree of mobility.

2.1.1 Extensive Fire Regimes

Extensive burning is undoubtedly the older practice (Posnasky 1965, Deacon 1976, Hall 1986) Before the arrival of the first farming communities most economies in the region were hunter/gatherer and pastoral type With some minor exceptions, hunter/gatherer communities exploited the surplus of plant and animal populations without significantly altering the web of interactions controlling the distribution and abundance of resource species Within such economies, it is not likely that there was concern to change the structure of the environment by the use of fire Burning would have been employed where there was adequate natural accumulation of combustible fuels, such as in seasonally dry grasslands and savannas, but there would be little reason to introduce fire into closed woodlands or forest (Hall, 1986)

Archaeological evidence is generally too ephemeral to definitely indicate the way in which fire was used during the stone age, although Deacon (1976) suggested that burning was a conscious management technique in the southern cape during the early Holocene Posnasky (1965) could not differentiate whether fire in Uganda at that time was natural or man made

Although one of the characteristics of the pastoralists life is pronounced by mobility, with Kraals occupied for short periods and then abandoned in accordance with fluctuating availability of resources, recent research has shown that such movement was not random (Oba and Lusigi 1986, Toloumbaye 1994)

Mobility between regular seasonal grazing are regarded as traditional forms of pasture rotation Mobility provided for pasture rotation, deferment, herd dispersion, protection and regeneration of woody plants Burning of vegetation could also be dependent on the movement pattern of the pastoral communities (Toloumbaye 1994)

Frequency of burning, which denotes the time between two consecutive fires at a given point, would have depended on whether these communities visited the same area every year or ranged widely within each region While archaeological evidence of use of fire in Uganda remains scanty, it is reasonable to assume that fire has been used in association with animal husbandry ever since domestic animals were first part of the economic systems in this area (Harrington 1974)

2.1.2 Intensive Fire Regimes

The intensive anthropogenic fire regime is recorded to be far more recent and has probably been less widespread (Hall 1986) These are associated with clearance of savanna and forest for fields by farming communities Archeological research done in Southern Africa has shown that the first farming settlements in this part of the subcontinent were during the third century AD and it is deduced that these communities introduced the practice of shifting cultivation. This has had a pronounced effect, associated with farmers manipulating their environments, changing the structure of the biota in order to allow the cultivation of crops and for livestock grazing

2.1.3 Anthropogenic Fire Regimes on a Global Perspective:

Existing literature addressing a global perspective shows that anthropogenic fire as a factor of some antiquity in the ecosystems of Uganda is in keeping with interpretations in other parts of the world

In North America, Biswell (1974) concluded that the Indians set burns to prepare feeding grounds for game and to make hunting easier, to facilitate collection of seeds, bulbs, berries and fibre plants and to increase yield of useful plants In Australia, Kayal (1974 citing stokes 1946), writing of the Voyages of H M S Beagle, recorded natives burning the bush

Records from archaeological evidence have suggested that from about 10,000 B C onward, fires were recurrent in arid savannas of Rajasthan, India It was suggested that these reflect the burning of grasslands by Mesolithic populations in order to improve grazing quality (Jacobson 1979) Mesolithic populations have also been held responsible for the replacement of upland forests in Britain by more open vegetation (Simmons 1969) It can therefore be concluded that man has through his use of fire played a major role in the evolution of many ecosystems

2.2 Fire Use in Different Ecosystems

Studies conducted in South Africa by Kruger (1986) reveal that in the short term, where large herbivores and fire are excluded, plant material accumulates In the short term, it is rapid in savannah grassland and very slow in woodland and forest With accumulation of plant material, plants become moribund The time scale depends on both gross primary yield and vegetation type (West, 1965) In the humid grassland and savannah, the moribund stage is reached in 2-3 years In arid grassland and savannah, the process may take up to 10 years

Kruger (1986) further reveal that in contrast, trends in accumulation of herbage in absence of fire, grazing and browsing in Southern Africa had a low net accumulation rate over a period of 2-3 years in a few protected sites This is attributed to the intensity in grazing, browsing and fire on most land Defoliating agents like fire, grazing and browsing have been recorded to maintain the vegetation in a productive stage (Kruger 1986)

2.3 Effect of Fire on Vegetation Structure and Dynamics

Structural variables sensitive to fire include, biomass, cover, height, species composition and the relative proportion of woody to herbaceous species Observations from Kruger National Park and at Mara Research Station in the northern Transvaal indicate that the development of vigorous grass cover and withdrawal of fire resulted in the significant dying of *Dichrostachys cineria* and some *Acacia* species. (Pienaar 1959)

2.3.1 The Grass/Bush Balance

Pienaar (1959) states that burning mainly destroys the aerial portions of trees and shrubs causing them to coppice and produce numerous stems and shoots However, he also observed that when increase in bush is still in the initial stages, it is possible to control it with fire

Van Wyk (1971) refuted the observation by Pienaar (1959) that *Dichrostachys cineria* is a fire dependant and unsuccessfully competes with a dense grass cover. He concluded from quantitative data obtained from Kruger National Park that *D. cineria* increased in density with the exclusion of fire and showed no increase in numbers on burnt plots

Generally tree and shrub species of the savannah are very resistant to fire due to dormant buds at the base of the stem from which coppicing occurs (Trollope 1974) In the higher rainfall regions, above 600 mm yr^{-1}, it is possible to maintain the balance with fire alone because even though the bush species coppice, rainfall is sufficient and reliable enough for adequate grass material to accumulate under grazing conditions to support frequent fires which burn the coppice growth and control bush seedlings

It can hitherto be hypothesised that in the past, under conditions of low human habitation, and domestic stock numbers, fierce fires destroyed the aerial growth of encroaching bush species, thus providing coppice growth at an acceptable height and in a highly acceptable state for browsing by wild ungulate species Here the degree to which fire and browsing will influence the balance of grass and bush will be determined by the intensity of the fire, the acceptability of the different coppicing bush species and the intensity of browsing The composition and structure of woody vegetation in a grassland depends on the protection from fires and grazing pressure The regeneration of trees is usually prevented by a combination of fire and browsing (Buechner and Dawkins 1961, Spence and Angus 1971)

Eltringham (1976) emphasised the importance of a controlled burning policy in the Queen Elizabeth National Park in Uganda, especially in areas where tree destruction mainly by browsers was taking place Lock (1977) indicated that intense annual grass fires inhibit the development of trees, while others exist as coppice shoots arising from buried tubers He demonstrated that tree regeneration is greater in areas protected from both fire and browsing than in areas protected from either fire or animals singly These results are similar to those of Buechner and Dawkins (1961), Spence and Angus (1971), and Harrington and Ross (1974). The importance of fire increased as the vegetation changed from wooded grassland to open grassland due to an increase in inflammable grass material Late burn was more effective than early burn in destroying most of fire resistant tree species from studies conducted in Murchison Falls National Park (Buechner and Dawkins 1961) West

(1965) reported a different view that late burn was less efficient than early burn in reducing woody vegetation growth in Africa Sabiiti et al (1991) and Harrington (1974) stated that saplings and mature trees were more resistant to fire damage than are other phases of growth Harrington (1974) reported that woody plants which achieve heights in excess of 3 6m become immune to fire effects This is comparable to 3.0 m height reported by Norton-Griffiths (1979) in Serengeti National Park in Tanzania Studies so far done in Uganda agree that for maintenance of diversity of habitat in protected areas, there should be effective management of fires (Massefield 1948, Harker 1959, Lock 1971, Edroma 1974, Harrington 1974, Eltringham 1976)

2.3.2 Fire Regime and Community Diversity

The general principles to explain the responses of various structural changes, have not yet clearly emerged from exiting literature Kruger (1986) hypothesised that community diversity changes with succession and fire regime, therefore species richness changes with pyric succession in vegetation-apparently increasing with fire frequency, though succession and fire frequency-effects interact and have yet to be separated Relative changes in diversity seem to depend on the relative dominance of overstorey plants (Campbell and Van der Meulen 1980), so that reductions in diversity occur in the tall dense shrublands than else where In savannah, marked increases in numbers of trees and shrub species occur where fire is differed (Hall 1986)

The effect of fire frequency is relative to the circumstances under consideration According to Kruger (1986), the optimum is higher for humid grassland than for arid areas Changes in vegetation dynamics in East Africa have mostly been attributed to fire (Norton - Griffiths 1979, Pratt and Knight 1971, mostly been attributed to fire (Norton - Griffiths 1979, Pratt and Knight 1971, Harrington 1974)

2.4 Effect of Season of Burning on the Grass Sward.

Little published quantitative data is available on the effect of season of burning on the grass sward production in Uganda The results from burning experiments in most cases are confounded with grazing There is a cumulative effect of grazing after fire. The effects of grazing season makes it difficult to identify the true effect of burning on the herbaceous grass layer

Edroma (1986) observed that ten years of annual burning had a dramatic effect on the potential for dry matter production of individual grass species The dry matter of the grasses found to be nutritious, palatable and important to ungulates (Lock 1967, Field 1968) were significantly raised by burning.

West (1965), Trollope (1980) report that the physiological state of the grass plant, rather than the season of burning is the most important factor determining the response of the grass fire Actively growing plants are more susceptible to damage by fire than dormant plants (Kruger 1986). West (1965) reporting on the season of burning on the grass sward in Zimbabwe stressed the importance of burning when grass is dormant and advocated burning just prior to the spring rains, if the objective is to control bush encroachment It is also difficult to ascertain the effect of season of burning on trees and shrubs in savannah because generally it is confounded with fire intensity

2.4.1 Effects of Fire on Seed Germination

This has been studied from the point of view of a heat treatment. West (1951) found that Germination of *Themeda triandra* seed was significantly increased by a heat treatment-involving pre-drying at temperatures of 30 to 40^{0}C. Trollope (1980) conducted an investigation in savannah of the eastern cape which indicated that fire may stimulate the germination of *Themeda triandra*. In the same study, a survey conducted on burnt and unburnt veld, dominated by *Themeda triandra*, 18 days after a wild fire burnt an extensive area found the density of *Themeda triandra* seedlings was 190.5m^{-2} in the burnt area and 0.2m^{-2} in the unburnt area. Germination tests on seed collection from the soil surface in the burnt and unburnt areas showed that only the seed from the unburnt area germinated (2.7% germination). Mowing the unburnt area to expose the soil surface failed to stimulate any germination of *T. triandra* seeds. These results suggest that in the burnt area, only seed that was embedded in the burnt area germinated.

2.5 Effect of Fire Frequency on Vegetation

In considering the effect of fire frequency on vegetation, two complementary variables must be born in mind. These are the number of times that the treatment has been applied and the type of management that is used during the interval between fires.

Kenman (1971) found that initially, annual burning had the most deleterious effect on trees and shrubs. As the grass sward deteriorated with the application of this treatment, it became progressively less damaging to the bush.

Van Wyk (1971) observed that overgrazing of the grass sward was a very serious problem in many of the experimentally burnt plots and was correlated with the frequency of burning The most apparent was manifested on the annual and to a lesser extent biennial burning treatments Van Wyk (1971) concluded that factors such as overgrazing and drought often complicate the interpretation of the results to such an extent that cause and effect are indistinguishable Different fire intensities resulting from different fuel loads accumulating during the interval between fires are another compounding effect in burning frequency treatments applied under conditions of no grazing Generally the longer the interval the greater the fuel load and therefore the greater the fire intensity

Where the reason for burning is to remove accumulated old growth, the frequency of burning is dictated by the speed at which litter accumulates In grazed pastures this depends on the degree of utilisation that is obtained In practice the interval between burns required to remove accumulated old growth varies widely (West 1965) Where the reason for burning is to suppress bush, and prevent encroachment, experimental results from Zimbabwe showed that the effect usually increases with frequency of burning with annual burning producing the most remarkable response (West 1965)

In East Africa, studies by Pratt and Knight (1971) on bush control by burning and grazing recorded an accumulated effect in repeated burning. In one experiment, Pratt and knight (1971) repeated an effect of less than 75% of the population of woody plants on the first burn The second burn caused the death of appreciable numbers of woody plants

The accumulated effect of fire was seen in the manner in which the final burn caused the death of several bushes of *A brevispica* Previous fires had been recorded not kill any plants of this species but they had checked growth and encouraged grass to spread between the stems It was this growth of grass that permitted a conflagration at crown level sufficient to sever the stems and cause death The more frequent the fire, the greater the herbaceous component This relationship is however not sufficiently understood to allow proper management of vegetation (Kruger 1986)

2.6 Short Term Effects of Fire

Kruger (1986, Citing Drewes 1979), showed that where perennial grasses of the humid grasslands have remained undefoliated for some time, individual plants become moribund or composed largely of mature tillers Defoliation at this stage will stimulate basal tillering

Where a sward of perennial grasses is defoliated frequently, plant material may not accumulate sufficiently enough to inhibit basal tillering If fire is applied at this stage, it may destroy the apices of a large portion of actively growing tillers at least in swards dominated by T *triandra*. Gross accumulation in the post fire period is then depressed

Fire effect on perennial grasses is recorded to be variable *T. triandra* produces flowers in the second dry season after burning, others like *Eragrostis curvula* flowers in the immediate posts burn period (Field - Dodgson 1976)

In annual plants, fire may stimulate germination and growth and therefore increase the gross accumulation rate in the short term. This happens where the burning removes a canopy, which has been sufficiently dense to restrict the growth of annuals through smoothening by the canopy of perennials

2.7 Long Term Effects of Fire

Frequency of fire affects botanical composition of communities (Wright 1986, Mentis and Taiton 1986), since plant communities differ in their productive capacity, fire frequency may be expected to affect overall gross accumulation rate and yield In South Africa grasslands, periodic fires 4-30 years were found to rejuvenate the woody components of fymbos and probably those of savannah as well (Kruger and Bigalke 1986) However in humid grasslands the long-term absence of fire leads to little decline in gross accumulation rate

This sharply contrasts with the short-term effect of the absence of fire Possible reasons given include, first the change in floristic composition induced by excluding defoliation is often towards a dominance of robust, relatively unacceptable, highly lignified plants such as *Cymbopogon* in grasslands The dead material from the robust grasses is likely to decompose more slowly than say that of *T. triandra* and its associates

Plants that have developed to survive fire and grazing may also depend on both for continued regeneration (Heady and Heady 1982) Elimination of fire in these grasslands that have traditionally burned usually results in a build up of dead material on the soil surface Regeneration decreases and more woody plants grow To remain in a healthy condition, a grassland needs water, soil minerals, grazing, energy from the sun and occasionally fire (Heady and Heady 1982)

Hopkins (1965), Pirie (1982), indicate that although fire stimulates the renewed growth of many savannah species, it severely damages many of the woody plants This damage is increased with intensity of burning both in terms of frequency and of severity of each fire Savannah woodland can only exist where the annual fires are light With several annual fires, the vegetation degenerates and eventually if severe fires are continued for years, it degenerates to a shrub or grass savannah.

2.8 Effect of Fire on Forage Acceptability and Availability.

Kruger (1986) observed that spring regrowth in selected high veld grasses on burnt grassland compared to unburnt grassland had a higher nitrogen and ash content The difference was however short lived Traditionally the grazer in Africa has burnt for the reason that post-fire growth is more available and acceptable to livestock Large wild herbivores have also been shown to select strongly for recently burnt grassland (Taiton and Mentis 1986. Tindigarukayo 1989) The effect of fire on the acceptability of forage so far considered are essentially of short term nature Long term effect include the role of fire frequency in determining botanical composition (Kruger 1986). The species composition of a community which is partly determined by the fire regime, therefore influences the general acceptability of the plant material to herbivores. Heady and Heady (1982) has shown that forage availability in terms of accessibility of forage by herbivores is achieved by making fresh regrowth readily available and to remove the diluting effects of herbage from the previous seasons Forage producing bushes may grow out of reach of mammalian herbivores, in this case hot fires may be used to kill aerial plants and either induce coppicing or regeneration from seed Therefore appropriately applied fire has an important effect of increasing availability of browse material to mammalian herbivore since controlled burning is also for the purpose of controlling bush

Without fire, tall grass vegetation could give way to shrubs and thus limit the production of accessible and palatable forage (Mentis and Taiton 1986, Heady and Heady 1982).

CHAPTER III

MATERIALS AND METHODS

3 1 Study Area

The study was carried out in the Ankole Ranching Scheme (ARS), Nyabushozi County, Mbarara District, south/western Uganda (Figure 1) It is generally a plain landscape with a few isolated hills Nyabushozi lies between 0^{O} 10"N, 0^{O} 45"S, 30^{O} 35"E and 31^{O} 05"E and is estimated to cover an area of 2930 km^2 and an average altitude of about 1210 meters above sea level

3 1 1 Geology, Topography and Soils

The area is underlain by very ancient Pre-cambrian rocks of the basement complex some of which appear as outcrops that often form hill summits The major hill formations are dissected by truncated ravines that ascend the hills from characteristically wide flat valleys that become narrower northwards (Uganda Government 1967). The central lowland is mainly composed of ferrallitic sandy loams of Precambrian metamophosed - Karagwe - Ankole argillites and arenites on the west, central and south eastern areas On parts of central and north eastern parts of Nyabushozi, it is also sandy loams of Precambrian cover formation but wholly granitized and metamorphosed undifferentiated gneisses (Uganda Government 1967)

3.1.2 Agro-ecological Classification

The area is classified as zone III and IV by Pratt et al (1966) with dry sub humid and semi arid climate having moisture indices -10 to -30 and -30 to -40 for zone III and IV respectively

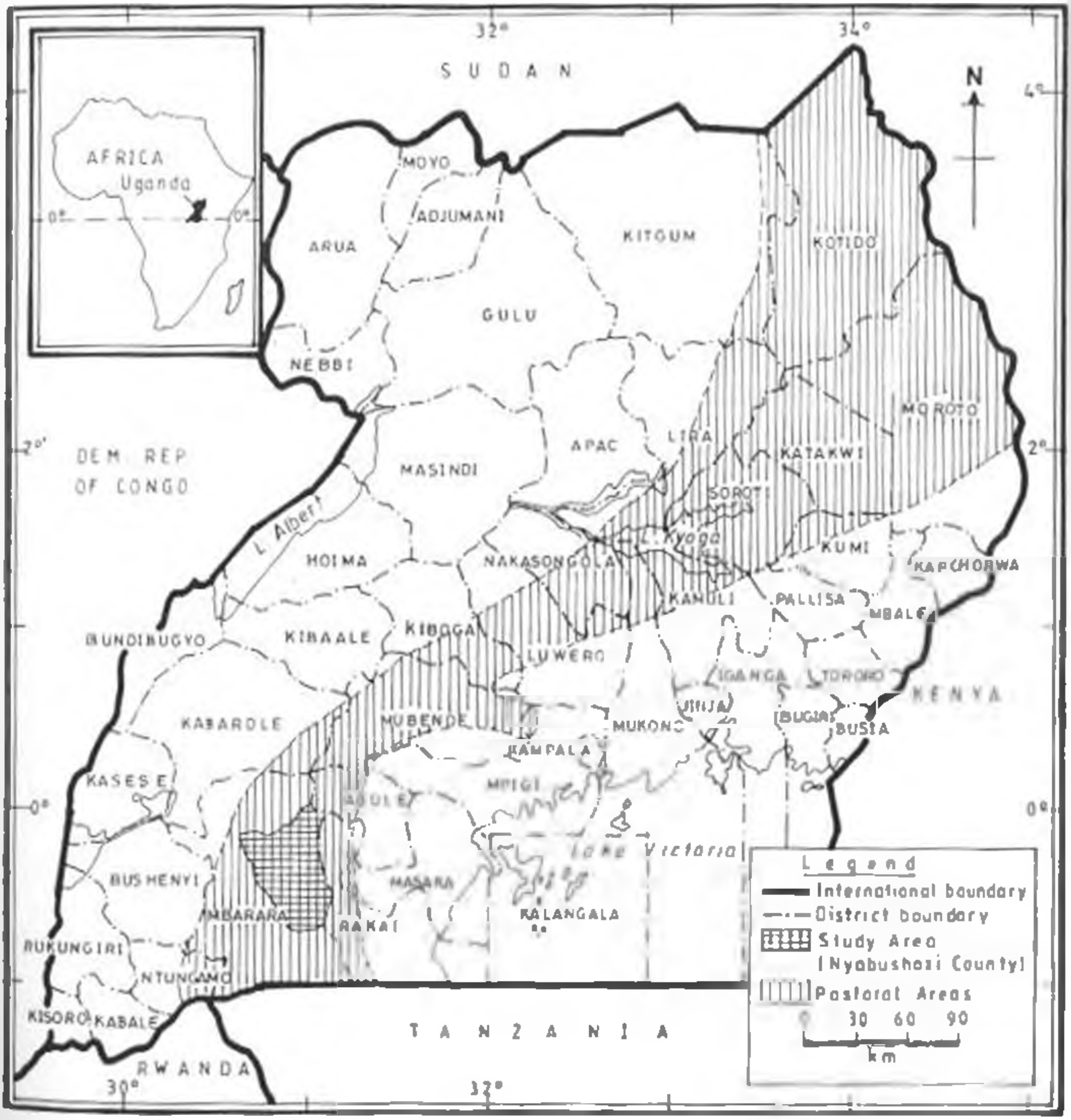

Fig. 1. Map of Uganda showing Study Area and distribution of Pastoral Areas

3.1.3 Climate

Rainfall is mainly convectional and about 1,125 mm per annum but ranges between 750 mm to 875 mm per annum in drier zones of the pastoral areas. Rainfall is in two peaks April to May and September to November with two prolonged dry seasons in June to July and December to February. Temperatures can rise to $29^{0}C$ with daily variation of 2 to $7^{0}C$ (Uganda Government 1967). Rainfall recorded during the study period is shown in Figure 2. The study started during the 'short dry' season which begins in December and ends in February and covered the period of the 'long rains' which stretched from March to May.

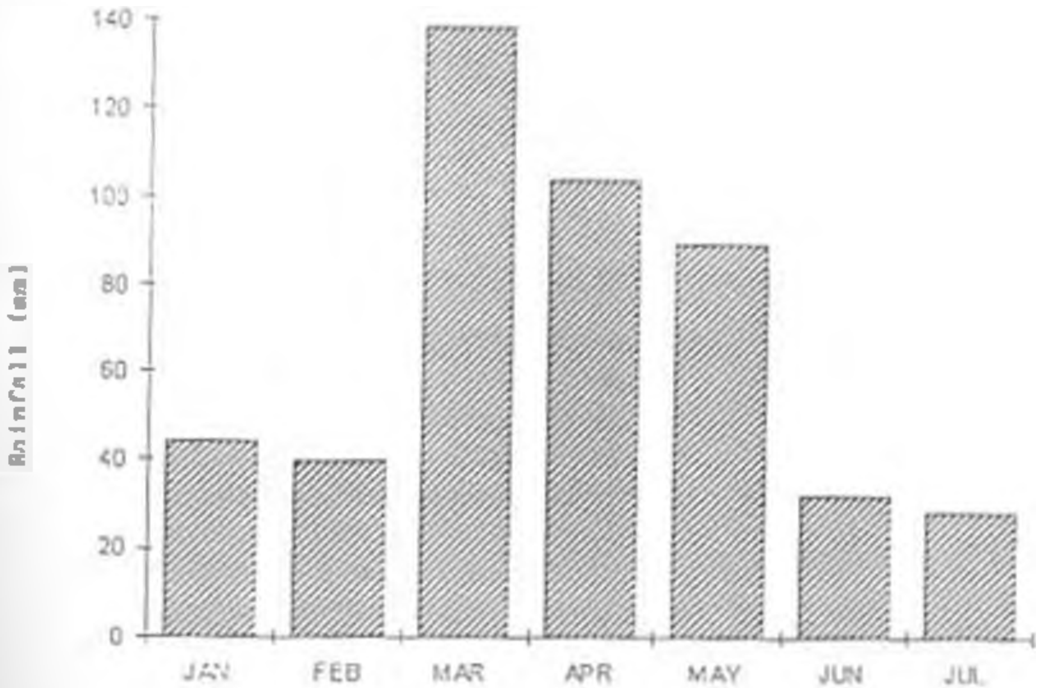

Figure 2 Rainfall records during the study period (January - July 1995)

3.1.4 Vegetation

The type of climate tends to support wooded savanna vegetation with predominantly dry *Acacia* savannah in the east and grass savannah in the southern part A large area of *Themeda - Hyparrhenia* exists in the area with scattered to dense stands of woody plants dominated by *Acacia hockii* and *A. gerradii* On the soils that are moderately to well drained, vegetation physiognomy changes from wooded grassland, to bushland and bush grassland on the western end of the county There is open grassland in the northern part and shrub grassland in the central, with occasional evergreen and deciduous woodland associated with seasonal streams in the area The southern sector of Nyabushozi has wide areas characterised by seasonal flooded grassland and permanent swamp that surround lakes Kachera, Mburo and Kazuma in Lake Mburo National Park. The herbaceous layer is dominated by perennial grasses, primarily *Cymbopogon afronardus, Themeda triandra,Sporobolus pyramidalis* and *Brachiaria* species. There is a marked reduction in the occurrence of *C. afronardus* in the southern sector of the Nyabushozi pastoral zones A few broad leafed plants that include legumes of *Vigna* spp, *Neonotonia* and *Desmodium* occur in the herb layer Various species of the sedges occur in all the plant communities

3.1.5 The People and Land use Practices

The area is traditionally occupied by the Bahima pastoralists According to the 1991 population census results (GOU 1991), Nyabushozi county had a human population of 75,845 comprising largely of semi-nomadic Bahima pastoralists and some sedentary Bairu (the Bairu are cultivators with a non pastoral background) The pastoralists herd long horned Ankole Cattle which accounts for about 20% of all the cattle in Uganda (Ministry of Agriculture, Animal Industry & Fisheries (MAAIF,

1991) Traditionally, the people used the pastoral land communally but recent changes show increased private ownership of land (Kisamba - Mugerwa 1991) and ranching is gradually replacing nomadic pastoralism The Bahima lived and grazed along the cattle corridor up to Lake Kyoga They keep large herds and milk is the main product Land used to be communal property of the tribe and every member of the tribe could graze as many animals as he liked The herd of livestock is the property of the family head being able to bequeath the animals to his sons at his own discretion

Generally several families lived and migrated together, building temporary kraals and huts at seasonal watering points Bahima women traditionally do not practice crop husbandry and move along with their men folk from place to place

Though traditionally land was communally owned, individualisation is common in this area through the practice of continually using a parcel of land for purposes of cultivation or grazing by an individual or group of individuals Because of the pressure on rangeland resources and because movement of livestock in a traditional pastoral pattern is no longer feasible, a strong sense of individualisation of land rights has cropped up among pastoralists In Nyabushozi county Kisamba-Mugerwa (1992) estimated that communal grazing property accounts for only 10% of the land area, while individualised land accounts for 37% of the area The rest of the area comprises the Ankole Ranching Scheme and Lake Mburo National Park

Besides, it is now the policy of the Government of Uganda to encourage agro-pastoralism through water development and restructuring of the existing government sponsored ranching schemes At the time of study, most of the pastoral households in the study area had been assigned land within the Ankole Ranching Scheme, which is within Nyabushozi County Some households had been advised to move to Singo ranching scheme in Mubende District where they were to be settled

The pastoralists , because of their mobility burnt the rangeland as part of there rotation, usually burning the area before moving to fresh pasture and then returning to graze the same area after it has regenerated

3.1.6 Genesis of Rancher - Squatter Categorisation

The Government of Uganda and the East African High Commission in the early 1950's agreed that a scheme to reclaim tsetse infested Nyabushozi county be carried out During that time, there was a tsetse fly belt north of Mbarara-Lyantonde road, which was estimated to measure about 640 km^2 By 1957 the area had increased to 2560 km^2 Despite bush clearing, the *Glossina morsitans* continued to spread in the area while at the same time, attention was being made to rationalise land use In 1963, the Ankole Ranching Scheme (ARS) was started This aimed at obtaining a rapid development of land use and animal husbandry practices in the area that had been cleared of the tsetse fly. The financial assistance came from the World Bank and USAID and was aimed at encouraging commercial ranching This involved bringing into productive use, large tracts of land which were infested with the tsetse fly, agriculturally marginal and were only seasonally inhabited by nomadic pastoralists

After clearing the area of the tsetse fly, 640 km^2 were set aside for the Ankole Ranching Scheme The scheme was divided into 50 ranches of approximately 13 km^2 Each ranch was fenced, provided with a dip tank, at least two valley tanks, feeder roads and fire- breaks were constructed The ranches were then allocated through a "Ranch Selection Board" to successful applicants who had a sound educational and financial background, and a reasonable experience in cattle ranching as business management (Mugerwa 1988) This selection criteria was too elaborate for native pastoralists to cope with and therefore the majority of traditional pastoralists did not qualify therefore left out of the ranching business They remained landless grazing in communal areas outside the ranching scheme

The pastoralists came into the ranching scheme as "squatters" (they occupied the land but did not own it) following the breakdown of law and order during the 1970's and 1980's civil strife in Uganda Some had been displaced by civil war, others were opportunists coming to get access to unutilised land while others were previous tenants of absentee landlords on the ranching scheme The set up of ranches as commercial enterprises therefore broke down due to the influx of squatters in the Ankole Ranching Scheme

3.1.7 Livestock

The district reports showed an estimated population of 273,000 head of cattle in Nyabushozi County (Anon 1994) Mbarara District has the highest population of livestock in Uganda having been estimated at about one million heads (MAAIF, 1991) The pastoral communities in Nyabushozi therefore, contribute more than 25% of the district cattle population and approximately 6% of the national herd which is estimated at about 5 3 million heads of cattle (MAAIF, 1995)

3.1.8 Wildlife

Part of Lake Mburo National Park is within the boundaries of Nyabushozi County There are large mammal populations, which also extend into the pastoral areas around the Park

The large animal populations comprise of impala, oribi, zebra, reedbuck, topi, buffalo, waterbuck, eland, bushbuck, sitatunga, bushduiker, giant forest hog, bush pig, roan antelope, warthog, klipspringer Other species include the aardvark, leopard, hyaena, hippo, some primates and several medium sized mammals have also been recorded in the area (Tindigarukayo 1989). These animals cross into the pastoral areas in search of grazing and water The spatial and temporal distribution and diversity of these animals on pastoral lands is not understood However, it is common to find ungulates like impala, zebra, eland, reedbuck and oribi grazing together with cattle in the pastoral lands neighbouring the national park

3.2 Methodology

3.2.1 The use of Questionnaire and Interviews

A questionnaire and interviews were used to collect data on the indigenous perspectives and technical knowledge on use of fire in rangelands Thirty pastoral house hold heads and fifteen ranchers/ranch managers were randomly selected and interviewed (Appendix D)

3.2.2 Pre-Study Visits

Prior to the survey, visits to the study area were carried out to assess the situation with regard to animal husbandry practices During this initial visit, intensive discussions were held with agricultural extension agents, government officials and leading opinion leaders in the area

3.2.3 Sample Frame

The respondents were put into two categories, namely, ranchers and squatters Ranchers were those with infrastructure like fences, permanent water, residences and personnel Pastoralists/squatters kept indigenous cattle on communal or unenclosed pasture. A total of thirty pastoralist/squatter families and fifteen ranchers were interviewed using closed and open- ended questions

3.3 Vegetation Sampling

Vegetation sampling was carried out by the method of stratification combined with transect sampling Stratifying the area into zones characterised by the major habitats (based on habitat structure and terrain) helped to create sample areas where each comprised relatively similar conditions of habitat distribution The method of stratification in community studies has also been used in studies of animal populations (Coughlev 1977, Elliot, 1970, Friend 1980, Norton - Griffiths 1978, Lamprey 1964, Tindigarukayo 1989).

The study area was stratiied into four major communities based on habitat structure that was noted during a four week preliminary survey The four communities relate to vegetation structure zonation given by the lands and survey department 1961 and Langdale - Brown et al (1964) Some of the physiognomic vegetation types used were derived from unmapped compositional units based on dominant species The communities are,

1 *Acacia hockii, C. afronardus, T. triandra*, shrub savannah
2 *Euphorbia candelabrum, Dichrostachys cineria, Sporobolus pyramidalis, Themeda triandra* seasonally flooded grasslands.
3 *Rhus natalensis, Acacia hockii, Loudetia kangerensis* shrub savannah
4 *Acacia hockii, Rhus natalensis, Cymbopogon afronardus, B decumbens* deciduous riverine thicket

The description differed from that given by Lands and Survey Department (1961) and Langdale Brown et al 1964, due to the reported increase in thorny bushes and prevalence of *Cymbopogon afronardus* in the study area Stratifying reduced the level of variation within samples taken from transect sampling and quadrats This method was particularly suitable for the study area (Nyabushozi County) because of the marked difference in temporal and spatial conditions of the habitats demarcated by the study

Coughley (1977) and Norton-Griffiths (1978) were of the view that sampling is maximised through stratification and effort is allocated efficiently through appropriate random sampling of the different habitats This basically agrees with the sampling procedure and objectives of the study Under this study, sampling was maximised through allocation of transects representatively within each community

3.3.1 Study Site Boundaries

Each community was demarcated into two sites - one burnt and the other unburnt. Sampling site boundaries were carried out by means of transects crossing the boundaries perpendicularly to the disturbance line in this case burnt and unburnt sites. Transects of 100 elemental sampling plots of 0.25 m^2 were laid with 50 plots in both the burnt and unburnt sites. Species abundance was recorded on all plots. The disturbed ecosystems were in differing successional stages having been burnt the previous year.

One analytical procedure was employed to study the boundary. This described the kind of transition across the boundary and was based on the study of alpha diversity along the transects. This was used to detect "ecotones" and "ecolines" which are lines or transition zones that demarcate clearly differing physiognomic vegetation types or habitats. In addition, using casual observations accompanied by guidance from the pastoralists it was easy to locate the boundaries. On two study sites there were functional fire breaks.

3.3.2 Species Diversity

The diversity of species in the herb layer was recorded. Species diversity is a measure of community interactions in ecosystems. Plant community is an organised complex with a typical floristic composition and morphological structure which have resulted from the interaction of species through time (Shimwell 1971, Sharma 1986, Casado 1986). Species diversity was measured using Shannon's Index using data on percent composition and biomass measurements (Mueller, Dombois and Ellenberg 1974). Shannon Index is expressed as follows -

$H_1 = -\Sigma P_i \log P_i$

where, H_1 = Shannon-Weiner index

$P_i = n_i/N$ is the proportion of species i in the sample

n_i = number of individuals of the i^{th} species in the sample

N = is the total number of species in the sample

n_i/N = proportion of the i^{th} species represented in the sample

3.3.3 Similarity Relations

The similarity relations between the disturbed communities are expressed using indices of similarity coefficients (Mueller - Dombois and Ellenberg (1974) Community similarity is a useful parameter in getting a comparison of plant species composition over space and time The community similarlity was measured in terms of presence or absence of the main plant species in the herb layer Sorensen Index shows the levels of similarity and is expressed as IS = 2C/A + B x 100

where, A is the total number of species in the community A,

B is the total number of species in community B,

C is the number of species common to both communities

3.3.4 Concentration of Dominance

The Dominance Index was calculated based on biomass records as a measure of "importance" This employed the following formula:-

$C = \Sigma \{n_i/N\}^2$, Odum (1971)

Where n_i = Importance value (biomass contributed by species I)

N = Total importance value (total biomass)

3.3.5 Cover

Vegetation cover was assessed using a point frame at study site number three The frame was placed after every five paces along the transect, the pins lowered and the data recorded

The percent cover was estimated as,

$$\% \text{ Total cover} = \frac{\text{Total number of hits} \times 100}{\text{Total number of pins}}$$

This site was on a slope and vegetation was scanty The vegetation cover on the rest of the sites was close to total cover

3.3.6 Density

Density of woody vegetation was sampled using belt transects Transects of 25 meters length and two meters width were marked using a tape measure and a two meter long measuring stick respectively The total density was calculated as,

$$\text{Total Density} = \frac{\text{Number of plants inside plot}}{\text{Area of plot}}$$

3.3.7 Biomass

Standing crop biomass was determined by double sampling technique (Pechanec and Pickford 1937, Wilm et al 1944) Twenty 0.25 m^2 quadrats were clipped at predetermined intervals giving paired measurements The paired measurements included the range of biomass values in the study area The paired sample was used to develop a relationship between actual herbage weight (Y) and estimated weight (X) This regression was then used to correct the estimates of herbage weight obtained in the large sample

An equation Y = a + bx was fitted and the corrected weight (Yc) was established as

Yc = a + (estimated weight x b).

a = the point where the line crosses the vertical axis,

b = the amount by which Y changes for each unit change in X,

X = the value on the horizontal axis, (Figure 3)

This method was described by Pechanec and Pickford (1937) and Cook and Stubendiek (1986) The method was preferred for this study due to the predominance of rank vegetation The advantages of this method were-being fast, reasonably accurate and relatively non destructive This was appropriate for the type of vegetation Clipping was regularly done to cross-check the estimated and clipped weights

3.4 Forage Quality

Proximate analysis was carried out on key forage species This was done from the samples sorted from the clippings on each study site Four parameters DM%, CP%, NDF and IVDMD were determined The criteria for selecting the forages was based on livestock preferences as well as species considered by pastoralists to best maintain the health and productivity of the stock

i Dry Matter (DM)- was estimated by drying clipped vegetation samples in an electric oven at 80^0C for two days

ii Crude Protein-CP% was determined using the micro Kjeldahl method (AOAC 1965)

iii Neutral Detergent Fibre (NDF) was determined by the Procedure outlined by Van Soest and Marques 1964

iv In Vitro Dry Matter Digestibility (IVDMD) was determined using a two stage technique of Tilley and Terry (1963) and modified by Barnes (1969)

3.5 Statistical Analysis

Regression Analysis and Analysis of Variance (Steel and Torrie (1980) were used in data analysis for testing the difference in forage quality and productivity between the burnt and unburnt sites and the wet and dry season.

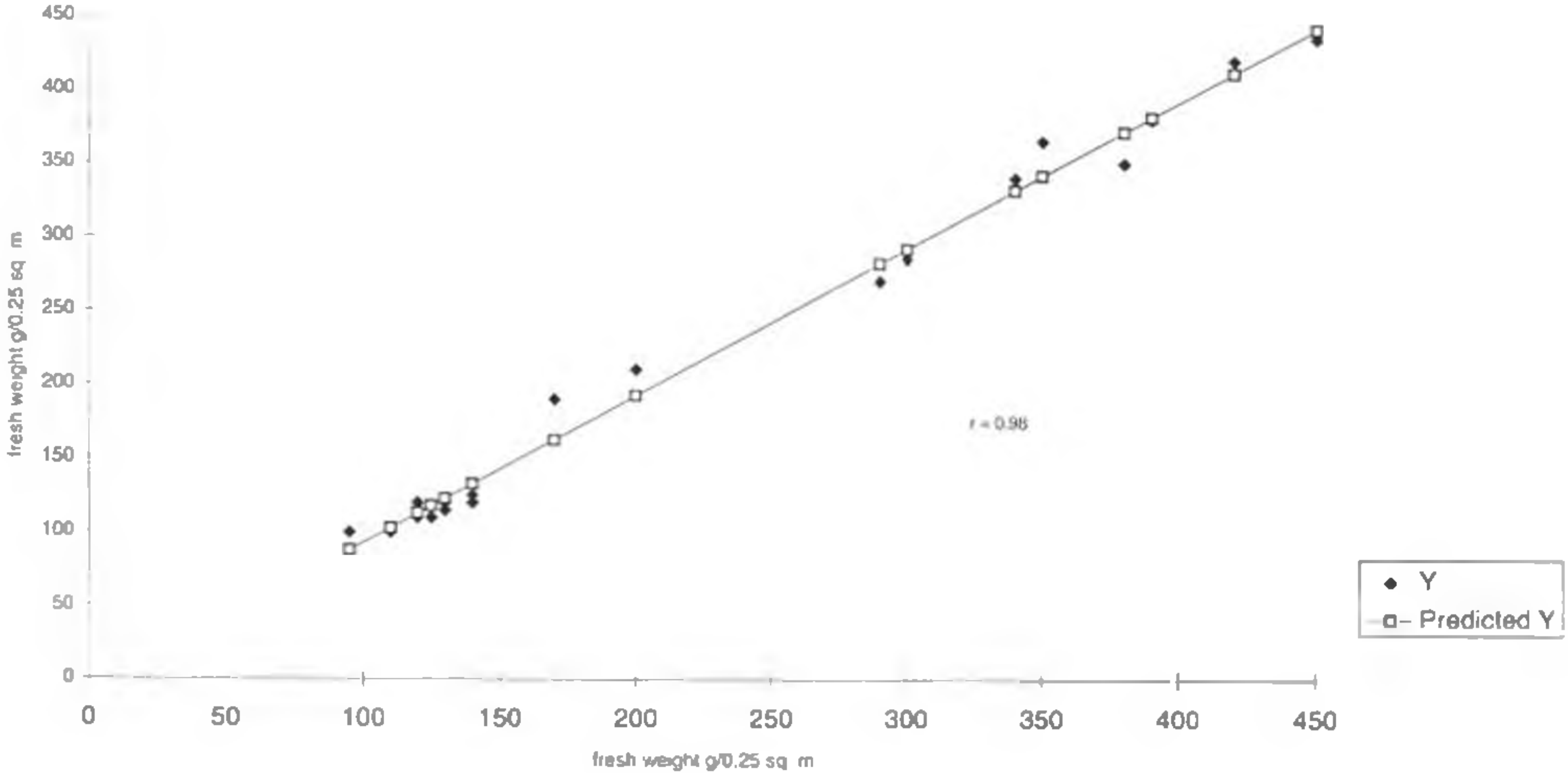

Figure 3 Relationship between actual herbage weight (y) and estimated weight (x)

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Questionnaire Responses

The questionnaire centred on extensive use of fire in the grazing areas based on social-cultural and indigenous knowledge and practices

4.1.1 Education Status

Of the pastoralists interviewed, only 31% could read and write and had attended school up to primary level The highest level of education recorded was primary six This study considered those who could only read and write their names were regarded as literate Most of the ranchers and ranch managers were literate and comprised 96 4% of the respondents

4.1.2 Extension Staff

This sought to know whether extension agents were visiting the farmers on invitation or whether there was routine check by the extension agents. Only 22% of the pastoralists were visited by extension agents while 41 6% of the ranchers were visited Some pastoralists were only visited on mandatory programmes like vaccinations The costs of the vaccinations were met by the pastoralists, on what the government introduced as a cost sharing system The extension staff involved in these campaigns are paid per animal vaccinated by the livestock owners, which served as an incentive to the extension personnel

4.1.3 Reasons for Burning

Extension agents in the area did not discuss the use of fire in the management systems of the rangelands Among the pastoralists who were visited by extension staff, only 13% discussed the use of fire However, those few visits of the extension personnel who talked about use of fire all discouraged its use The existing information and official position on burning available to extension staff mainly depicts burning as a bad practice

Most of the respondents gave more than one reason for burning. The ranchers (97.6%) gave arson as the main cause for most of the fires. Among the pastoralists (81.8%) gave encouraging fresh growth as the main reason for burning.

All the ranchers and pastoralists (100%) interviewed agreed that the frequency of burning had reduced. Reduced frequency of burning was attributed by 78.4% to land shortage while 48% of the respondents gave legislation as the other reason for the reduced frequency of burning.

The fire frequency problem affected the pastoralists and ranchers alike. A fire was recorded on part of the property by 58.4% of the respondents every year. The rest of the respondents indicated that they hardly spent two years without experiencing a fire on part of their grazing land. A ban on extensive burning was instituted by presidential decree in Uganda since 1974, (Government of Uganda 1974). The fires are reported as accidental by the pastoralists for fear of being charged for the offence.

The respondents (55.2%) indicated fire as having an effect of reducing bush. While 13.8% thought the existing fire regimes had contributed to increasing bush. The other 31% did not attribute the current state of bush encroachment to burning.

Among the pastoralists, 83.3% of the respondents believed that burning had helped sustain an increased and good amount of pasture while 16.7% thought that there could have been a reduction in amount of pasture. Those who thought that the amount of pasture had reduced attributed it to uncontrolled burning.

On animal condition, a comparison of the health and productivity of animals grazing recently burnt and unburnt pasture showed the majority of the respondents

(93 3%) agreeing that stock grazing recently bu rnt pasture (after 8-12 weeks) appeared better in condition, had higher milk yield and weight gain Two common grass species namely *Cymbopogon afronardus* and *Loudetia kagerensis* were reported unpalatable when not burned for more than two growing seasons

4.1.4 Control of Fire

The responses indicated that most of the fires (93 3%) burn uncontrolled The 6 7% who attempted to control the fire only mobilised manpower and beat out the fire using large green boughs This method can not be effective with extensive fires in areas of high dry plant biomass accumulation

The respondents all indicated that the August and September fires were most severe These are late burns The vegetation is usually dry and the biomass is still high following the previous season's growth The long rains which stretch from March to May usually produce more growth

4.1.5 Grazing Systems

Grazing for both the pastoralists and ranchers followed a rotation that considered the watering point for the day, distance from the kraal and season The pastoralists who never had a rotation in mind were mainly grazing on parkland in Lake Mburo National Park and therefore tended to roam within reach of the water source Among the ranchers interviewed (87%) followed rotational grazing The ranchers who no longer followed a rotation were those whose stock numbers had drastically reduced and had a lot of trouble with the "squatters" on the ranch

4.1.6 Crop Production

Pastoralists had not taken to serious growing of crops The respondents (73 6%) did not grow any crops, the major reason they gave was lack of security of tenure Those who grew food crops however, were able to have enough for the household for that season The crops grown included, bananas, beans and maize

The ranchers who did not grow food mainly advanced the reasons of wild animals such as bush pigs which destroy crops Some of the pastoralists who had acquired private land still had a problem of land shortage to carry out both livestock and crop production On grounds of comparative economic advantage, they opted for livestock Perennial crops, particulary banana plantations were beginning to emerge in the area This showed an increased trend towards developing agro-pastoral production systems by these formally nomadic societies

4.2 Discussion

4.2.1 Legislation against Fire.

In the savannah areas of Africa, fire is recognised as having an important ecological role in the development and maintenance of productive and stable savannah communities (Phillips 1965, West 1971) Except for wild life areas, the official government position regarding the practical use of fire in Uganda is negative In Uganda this view arose through the wide spread extensive burning of the rangelands, the effects of which were unknown to policy makers A presidential decree in 1974 which (Government of Uganda 1974) sought to ban extensive burning was put in place Strict procedures were laid and the practice of burning in savannah became a crime However, lack of quantitative information on savannah burning in the pastoral ecosystems of Uganda has lead to maintaining these negative attitudes on burning Nevertheless, savannah burning continues to be clandestinely used in all the grassland areas in Uganda

Uncontrolled grassland burning has been discouraged at some stage in many places in the Worlds history In South Africa, grassland burning was legislated against in 1658 with regulations prohibiting re-enforced in 1661 and 1687 respectively (Scott 1984, Quoting Botha 1924) In Australia and the United States, the official attitude that burning was always harmful held sway until recent times Burning was outlawed by legislation Research done in USA, at the Tall Timbers Research Station in Florida between 1960 and 1976 (Scott 1984), brought about a change of official attitude toward fire, from anti-burning to controlled burning and then fire management In Australia, the advantages of controlled burning are now also recognised.

4.2.2 Current Fire Regime

In the commercial ranching areas of the Ankole Ranching Scheme, use of fire is controlled by legislation, which has as its objective, the conservation of vegetation resources This underlying objective has had the effect of significantly reducing the frequency of fires in the areas used for commercial ranching When fires occur, they are recorded as being by arsonists wanting to destroy the pasture Prior to the study, there was a conflict between the pastoralists who were squatters and ranchers There was resentment by the pastoralists against losing their grazing lands to ranchers and government institutions that included a National Park and resettlement scheme. This bred negative sentiments among the pastoralists The Government of Uganda had to intervene in 1988 and set up a ranch restructuring board to accommodate the pastoralists in the Ankole Ranching Scheme and other government sponsored ranching schemes

In areas occupied by traditional pastoralists, the fire regimes are theoretically controlled by legislation similar to that in the commercial ranching areas However, in practice, this legislation is completely ineffectual and fires are commonly applied by the pastoralists at the peak of the dry season. The fire regime is largely determined by the availability of grass fuel and the prevailing weather conditions The intensity of fire is influenced by the season of burning and related moisture content of the fuel In Nyabushozi County, fires are applied to different areas before the short rains - August/September Conversely fire intensities are relatively low in the burns applied during the short dry season of January/February However, the major portion of Nyabushozi is burnt at the end of the dormant season resulting in fires of relatively high intensity

4.3 Results from Vegetation Sampling

4.3.1 Species Diversity

Species diversity as a factor of evolutionary time was considered This is a measure of community structure and interactions in ecosystems The proportion of species is given by alpha diversity, which is determined by use of the Shannon Weiner Index (H) calculated based on biomass records The calculated (H) values are presented in Table 1

Table 1 Diversity Index (H) of species in the herb layer on the burnt and unburnt sites on communities 1, 2, 3, and 4

Community	Burnt Site (H)	Unburnt Site (H)
1. *A. hockii, C. afronardus, T. triandra* shrub savanna	0.477	0.406
2 *E.candelabrum, D. cineria, S. pyramidalis, T.triandra*, seasonally flooded grassland	0.502	0.505
3 *R.natalensis, A.hockii, L.kagerensis* shrub savanna	0.67	0.65
4 *A.hockii, R.natalensis, C.afronardus, B.decumbens*, deciduous reverine thicket	0.65	0.64

Results from this study showed a trend of slightly higher diversity indices on the burnt sites. The (H) value for the different sites is nearly the same.

The Shannon-Weiner Index (H) combines the variety and evenness components as one overall index. The small difference in diversity indices could be due to the relatively high frequency of burning indicated from the interviews with the pastoralists.

The increased trend of diversity on the burnt sites could be a result of burning which reduces the sizes of plants, keeping the surviving plants small, thus enabling more individuals to be accommodated per unit area.

The effect of burning also eliminated competition by taller growing pants. Burning can therefore become a continuously operative factor that produces a diverse environment.

Species diversity also tends to be influenced by the functional relationships between the trophic levels (Odum 1971, Whittaker 1965, 1970). On communities dominated by unpalatable species, diversity remained low probably due to the dominating effect of the unpalatable species. Absence of prominent herbivores utilising *C. afronardus* could be having an effect on the functional relationships of this ecosystem.

4.3.2 Community Similarity

The community similarity of burnt and unburnt sites is shown in Table2. The similarity coefficients have been used to compare the community structure. These are based on presence or absence of species on the study sites of the communities studied. The index of community similarity refers to the probability that individuals drawn randomly from each of the two communities will belong to the same species relative to the probability of randomly selecting a pair of specimens of the same species from one of the communities (Mueller-Dombois and Ellenberg 1974).

Table 2 Similarity indices of burnt and unburnt sites on communities 1, 2, 3, and 4

Community	Number of Species		Number of Species Common to both sites	% Similarity Index (S)
	Burnt Site	Unburnt Site		
1 *A.hockii C.afromardus, T.triandra,* shrub savanna	24	19	18	83.7
2 *F candelabrum, D.cinerea, S.pyramidalis T.triandra* seasonally flooded grassland	12	11	10	87
3 *R.natalensis A.hockii, L. Kagerensis* shrub savanna	15	10	10	80
4 *A.hockii R.natalensis, C.afromardus, B.decumbens,* decidous riverine thicket.	15	12	11	82

The degree of similarity allowable in combining individual communities into the same association varies However, from the given threshold values of Presence-Community coefficients, an S value exceeding 50% is regarded very high(Mueller-Dombois and Ellenberg 1974) However, results from this study indicate high levels of similarity between the burnt and unburnt sites which indicates the two sites to be at very close succession stages This could be due to relatively high frequency of burning which as a stress factor in the ecosystem maintains the sites at close succession stages

4.3.3 Concentration of Dominance

The dominance indices for the burnt and unburnt sites during the study are shown in Table 3

Table 3 The dominance indices for the burnt and unburnt sites from communities 1 2, 3, and 4 during the two seasons of the study period

Community	Burnt Site		Unburnt Site	
	Dry Season	Wet Season	Dry Season	Wet season
1 *A hockii C afronardus T triandra*, shrub savanna	0 43	0.52	0 60	0.57
2 *E candelabrum*, *D cinerea*, *S pyramidalis T triandra*, seasonally flooded grassland	0 42	0 59	0 39	0 59
3 *R natalensis*, *A hockii*, *I kagerensis* shrub savanna	0.25	0 25	0 26	0.35
4 *A.hockii*, *R natalensis*, *C Afronardus*, *B decumbens*, decidous riverine thicket	0.25	0 27	0 27	0.27

Community one and two registered the highest concentration of dominance while communities three and four had a low concentration of dominance A high dominance index shows that few species have more concentrated dominance while low value shows that dominance is shared by a large number of species A dominance index value of 1 would indicate total dominance by one species

The high concentration of dominance recorded for community one is largely contributed by *C afronardus* The species contributed the highest percentage biomass in the communities It is unpalatable to stock except in its very young stage of growth or after it has been burnt It is widespread in the communities studied

The calculated values of the concentration of dominance according to plant species are tabulated in appendix B and presented in Figure 4 This shows that even at the current burning regime *C. afronardus* remains dominant even when burning slightly reduces its concentration of dominance at least in the short run as shown in Figure 4

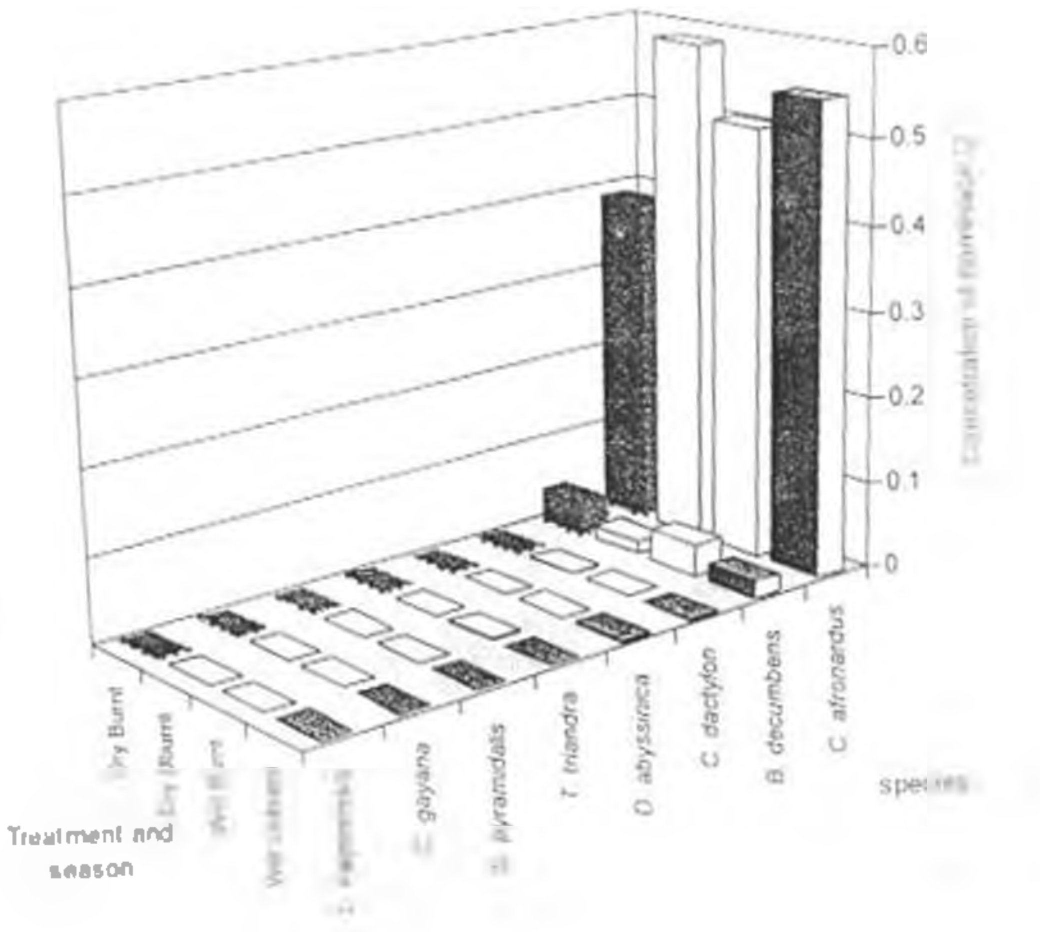

Figure 4 Concentration of dominance by species between burnt and unburnt sites on community 1

4.3.4 Vegetation Cover

A comparison of vegetation cover was done for community three The vegetation cover on the other communities studied was from observations made during the preliminary study found to be close to total cover The terrain and nature of the soils on community three could have contributed to slow growth and consequently poor vegetation cover

The vegetation cover on the burnt site was 40% during the dry season. This increased to 60% at the peak of the wet season. The vegetation cover on the unburnt site was 70% during the dry season increasing to 80% at the peak of the dry season.

Vegetation improved during the wet season due to increase in foliage on this community. The burnt area still showed poor vegetation cover 10 months after the burn. Burning on slopes tended to expose the soil longer and increased dangers of soil erosion.

4.3.5 Density of Woody Species Table 4 shows the density of woody species as observed from the various transects laid during the study.

Table 4 Density of woody species (No/ha) on study sites in community 1, 2, and 3

Community	Burnt site	Unburnt Site
1 *A.hockii, C.afronardus, T.triandra* shrub savanna	5164±1376	6973±1845
2 *E.candelabrum, D.cinerea, S.pyramidalis, T.triandra* seasonally flooded grassland	2780±553	3100±653
3 *R.natalensis, A.hockii, L.kagerensis* shrub savanna	3280±405	4500±603

There was no significant difference (P<0.05) between the burnt and unburnt communities for communities one and two. The difference on community three was significant (P<0.05). Community four formed thickets of woody species. The trend generally showed that burnt areas tended to have less density of woody species than unburnt areas. Lock (1977), and Buechner and Dawkins (1961), indicated that tree regeneration is greater in areas protected from both fire and browsing than in areas protected from either fire or animals singly. These findings agree with results from this study.

4.3.6 Biomass

Table 5 shows standing biomass of the species in the herb layer for the communities sampled The major vegetation communities were stratified based on the composition of both woody and herbaceous species

Table 5 Mean Standing Biomass t/Ha of the major grass species in the herb layer during the different seasons in communities 1,2,3 and 4

Community	Burnt Site		Unburnt Site	
	Dry Season	Wet Season	Dry Season	Wet Season
1 *A hockii, C afronardus, T triandra* shrub savanna	6 94±0 5	10 24±0 8	10 4±0.92	12 13±1 04
2 *E candelabrum D cineria S pyramidalis T triandra* seasonally flooded grassland	2 04±0 24	3 96±0 44	2 78±0.3	4 18±0 45
3 *R natalensis, A hockii, I kagerensis* shrub savanna	2 40±0.13	3 91±0 2	3 45±0 19	4 22±0 23
4 *A hockii, R natalensis, C afronardus, B decumbens,* deciduous riverine thicket	2.92±0.15	3 79±0 19	3.35±0 17	3 99±0 57

The effect of burning increased the rate of biomass accumulation on the burnt sites The rate of accumulation was calculated from the difference between biomass recorded during the dry and wet season, divided by the wet season weight and given as a percentage The burnt sites had a higher percentage increase than the unburnt site during the growing period Community one recorded a rate of accumulation of 32% on the burnt site compared to 14% on the unburnt site while community two recorded 48% on the burnt site compared to 33 5% for the unburnt site Community three and four had biomass accumulation 39%, 23% and 14%, 16% for the burnt and unburnt sites respectively Standing crop increased during the rainy season The difference on the sites was however not significant (P<0 05) During the period of this study, the dry season was short and mild (Fig 2) This gave relatively high biomass figures

Relationships between seasonal rainfall and biomass yield have been used to predict forage availability. Deshmukh (1984) calculated an average ungrazed yield of 8kg DM/ha per mm of rainfall for some major grassland types in Eastern and Southern Africa. Braun (1973) and Sinclair (1979) recorded average yields of 4 to 6 kg DM/ha per mm in the Serengeti plains.

4.4 Forage Quality

Forage quality was assesed from chemical analysis of composite samples. This was carried out between January and June 1995. This considered both quantity (discussed under biomass) and quality (chemical composition) of the pasture for the different seasons and burning effects. These studies were through analyses of nutrient content by proximate analysis of the herbage.

Figure (5) shows CP% of forage from burnt and unburnt sites during the dry season.

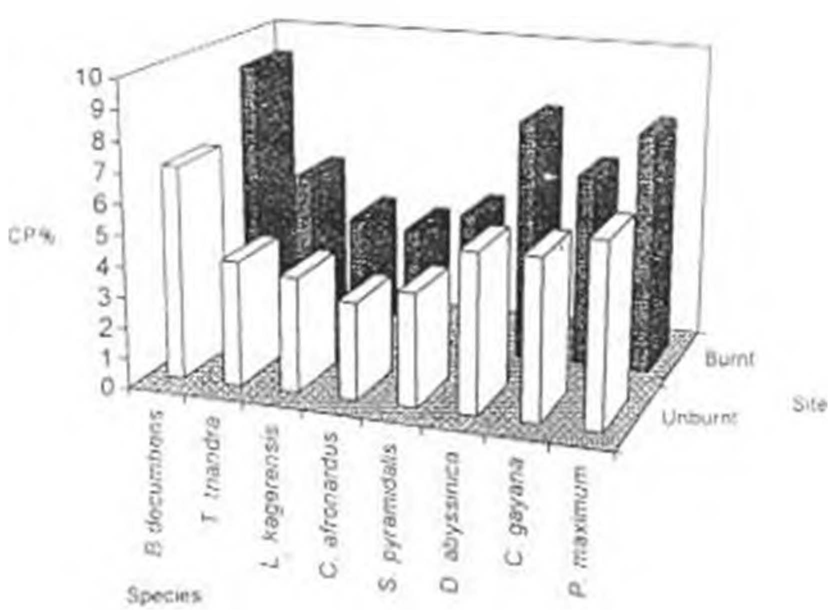

Figure 5. CP% of forage from burnt and unburnt sites during the dry season

For each grass species, CP% improved with the burning treatment being highest during the wet months and declined during the dry season. The year preceding the study was a wet year with above average rainfall (1220mm). The first forage samples were taken in January. The CP% values for this season were higher on the burnt than the unburnt sites for each of the species studied.

When different species were compared, it was found that *B. decumbens*, *P. maximum* and *C. gayana* displayed the highest level of crude protein and fluctuated much less between the two study seasons. In both the burnt and unburnt sites, these species displayed a similar pattern. The rest of the species *I. triandra*, *L. kagerensis*, *C. afronardus* and *D. abyssinica* showed the lowest CP levels. The apparent differences were tested using a t-test. During both seasons, (dry and wet) the samples from the burnt and unburnt sites were both significantly different ($P<0.05$) in their crude protein content.

The crude protein patterns obtained in this study are in agreement with those of Long et al (1969) obtained from the same study area. Long et al (1969) had not stratified according to burning treatments but observed that the relatively high CP level obtained from his study was partly due to a high frequency of burning.

The results from this study showed that there were seasonal changes in the crude protein content of all the grasses in the study area. In the dry season, the trend showed all the grasses had a low content which increased as the wet season approached. The observed seasonal changes had been observed by other workers (Wilson 1981, 1982). When each species was considered individually, it was found that the extent to which the protein content declined was characteristic of that grass.

The CP% of herbage from the burnt sites was still higher than that from the unburnt site. The difference was still significant ($P<0.05$). The CP%, however, on average was poor in relation to livestock feed requirements especially cattle which are the major type of livestock reared in this area Only two plant species, *B. decumbens* and *P. maximum* had CP% values exceeding 7%, a figure below which livestock production on pasture becomes limiting, the rest of the species were lower than this

Figure (6) shows the CP% of the herbage during the wet season

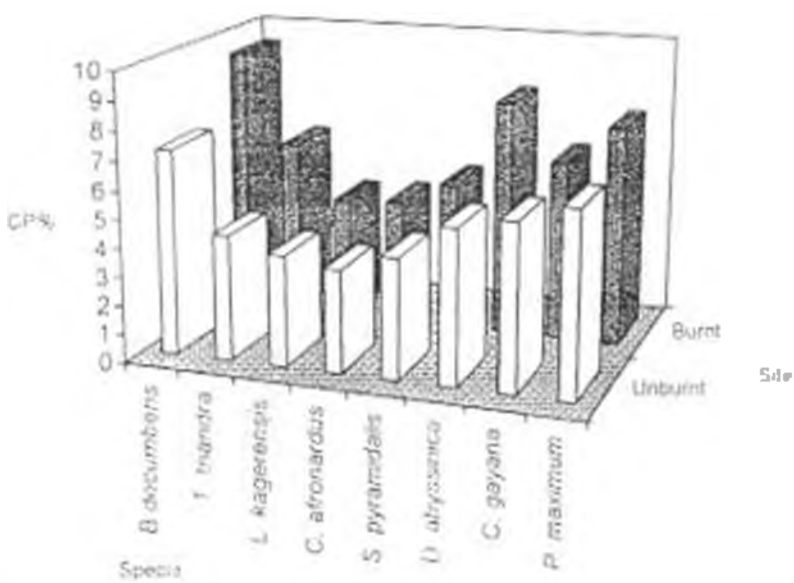

Figure 6 CP % on the burnt and unburnt sites during the wet season

The difference in CP% of the herbage between seasons was not significant ($P<0.05$) The trend however, showed the wet season had higher CP% values

The NDF% of the herbage from the burnt and unburnt sites for the dry season is shown in figure 7

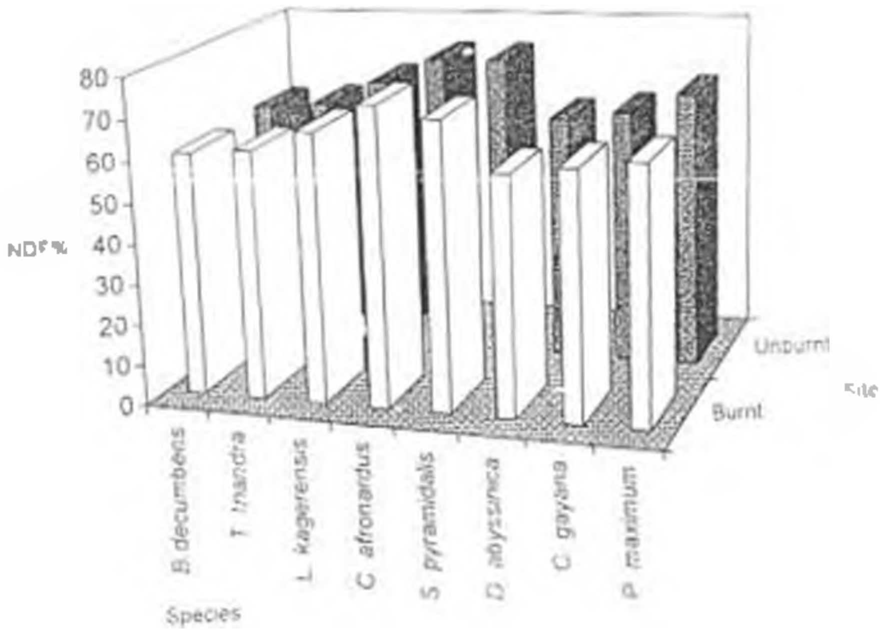

Figure 7 NDF% on the burnt and unburnt sites during the dry season

NDF% in all the species bear an inverse relationship with CP content As figure (7) shows the NDF was higher during the dry season This corresponded with low protein content *P. maximum* was however exceptional showing both high levels of CP% and NDF% during this study

During the dry season, *C. afronardus*, *S. pyramidalis*, and *L. kagerensis* had highest NDF (Figure 7) The trend was maintained during the wet season Plants with a high NDF% factor have been found from the questionnaire inquiry with the pastoralists to be least palatable Although NDF% content seems to be a very important factor in animal selection, it may not be the sole factor governing the selection of grass by animals since it fails to explain the insignificant relationship between NDF and CP% for *P. maximum* NDF% changed less and never showed any significant difference ($P<0.05$). The trend was the same for the wet season (Figure 8)

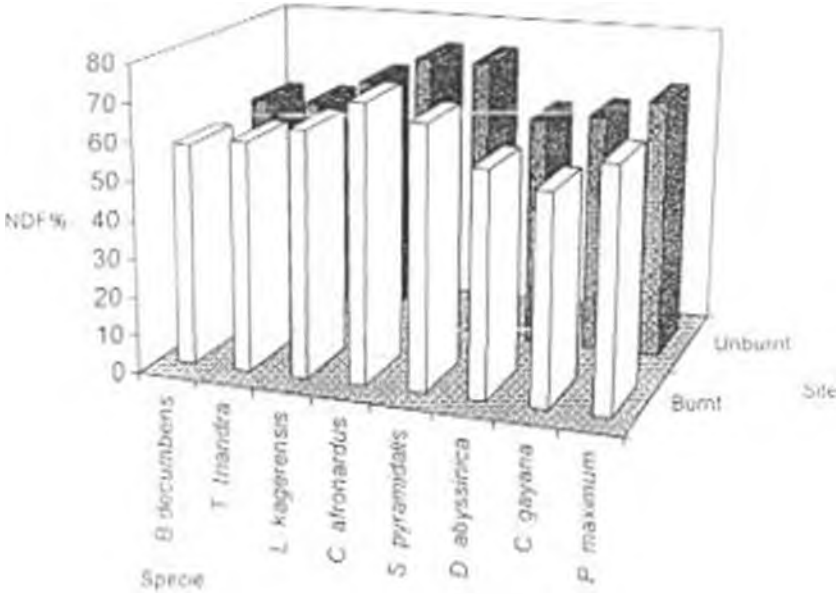

Figure 8 NDF on the burnt and unburnt sites during the wet season

IVDMD% of the herbage from the burnt and unburnt sites for the dry season is shown in figure (9)

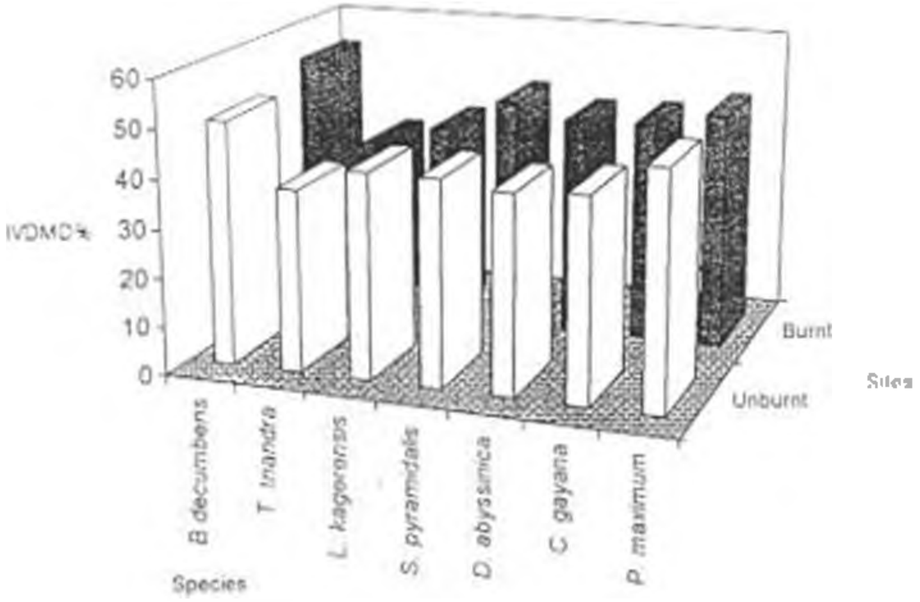

Figure 9 IVDMD % on the burnt and unburnt sites during the dry season

The difference in IVDMD% was not significant between the burnt and unburnt sites. The trend however, was that burnt sites had a higher IVDMD% than the unburnt site. The wet season also had a higher

IVDMD% than the dry season (Figure 10)

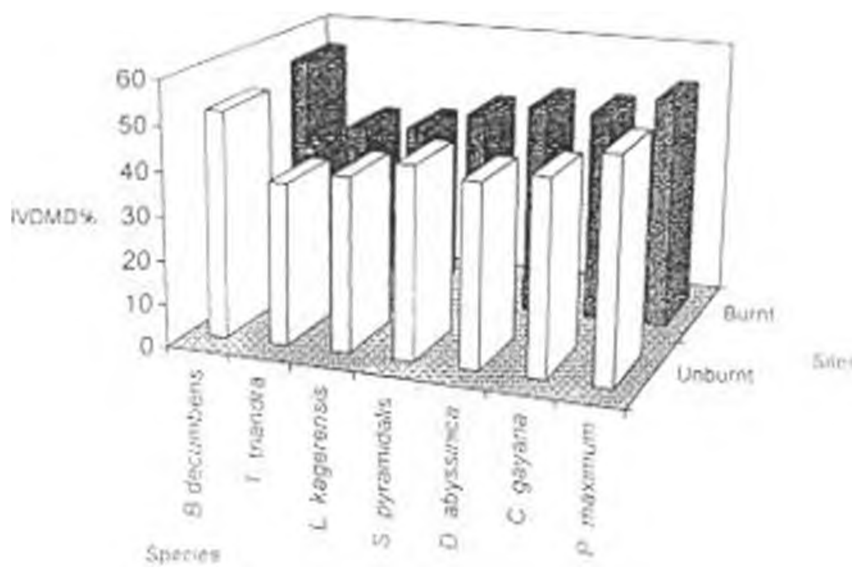

Figure 10 IVDMD % on the burnt and unburnt sites during the wet season

Regression analysis of CP% on IVDMD% showed a high positive relationship r=0.88 (P<0.05) and was negative between CP and NDF r=-0.65 (P<0.05). There was also a negative relationship between NDF% and IVDMD% r = _057 (P<0.05). The dry and wet season showed similar trends.

The Nyabushozi pastoral ecosystems are dominated by native grass species which mature rapidly and decline in forage quality. *B. decumbens*, *P. maximum* were the only species with CP% recorded above 7% during the study period. This is recorded as the critical level below which livestock production becomes limiting

(Bogdan 1977)

The more common species, *T. triandra, L.kagerensis, C. afronardus, S.pyramidalis* are all grasses of low forage value and palatability (Skerman and Riveros 1989). In order to increase livestock production in these pastoral ecosystems, there is need to introduce high quality forage plant species like forage legumes to improve the CP% values of the herbage.

CHAPTER V

GENERAL DISCUSSION

5.1 The Pastoral Ecosystem

The pastoralists in the study area have used fire to manipulate the rangeland for increased pasture production for a long time. The responses from the pastoralists indicate that they know the advantages and disadvantages of burning the rangeland especially encouraging fresh growth of herbage and controlling of bush encroachment. The major problem in this area is that measures to control the fire from spreading extensively such as fire- breaks are not used. The pastoralists know the benefits of burning at the right time of the year, which they do towards the end of the long dry season during the months of August and early September. These are late burns and target burning the invading bushes and sturdy material accumulated from the previous seasons.

The Nyabushozi pastoral ecosystem is characterised by a spatial and temporal heterogeneity as evidenced by the existence of variation in composition and distribution of vegetation resources. The factors noted operational in this area as influencing the habitat and possible trends of habitat management and utilization are presented in section 3.3.

Community one was dominated by *C. afronardus*. This species is apparently an *increaser* in this community. A survey by Harrington (1974) among the pastoral societies living in Nyabushozi at the end of the 1960s sought to know the trend of this species. Responses from respondents who could recall to the 1920s indicated that *C. afronardus* was very rare at that time and pastoralists used to travel long distances to collect it for medicinal preparations. The pastoralists were later forced out by the increased tsetse infestation in the area By the time they came back in early 1960s after the successful campaign by the government to rid the area of tsetse fly , they found that C afronardus had spread widely covering about 40% of the grazing area (Harrington 1974)

Results from this study show that this species forms an average of 70% of the total standing biomass in the herb layer during the study period Cattle have been recorded to die of starvation when an abundance of it, in green condition was available (Harrington 1974) Buffalo eats it sparingly during the dry season (Field 1971) This grass produces citronella, an aromatic oil, which makes it unattractive to stock (Skerman and Riveros 1989) Citronella is an essential oil, which is much used in perfumes and soaps It is best known as an insect repellant (Perry et al, 1987)

C afronardus is known to be fire resistant Harrington (1974) hypothesised that too frequent burning was one of the main causes for its increase Harrington (1974) found that a late burn in the long dry season (usually late August) carried out every third year, reduced the biomass and encouraged the growth of associated grasses, *B. decumbens*, *I. triandra* and *H filipendula* Annual burning from that study was recorded to have reduced the size of the *C afronardus* plants but did not improve the sward

In the present circumstances where about 70% of the herbaceous biomass in community one studied comprised *C afronardus*, there was great tendency by the pastoralists to burn frequently Among the respondents from the questionnaire and interviews, 58 4% indicated that they registered a fire on part of the property annually The burns were, however, patchy and rarely was the same area burnt each year Results from the questionnaire and interviews during this study showed 93% of the respondents indicating that *C afronardus* and *L kagerensis* become unpalatable when left unburnt for more than two grazing seasons

Community two, was dominated by *S. pyramidalis* and *T. triandra* in the herb layer. Both species are of relatively low quality as established from the crude protein levels 3.5% and 3.7% for *T. triandra* and *S. pyramidalis*, respectively. This was on the unburnt site. Studies by Karue (1975a) on Crude Protein of hay from *T. triandra* was found insufficient to meet the requirements of the grazing animal. This grass is not highly regarded as pasture (Harrington and Pratchet 1972), contrary to the pastoralists who regard it as an important forage plant. The Crude Protein levels from this study improved on the burnt site reaching 5.6% and 4.6% for *T. triandra* and *S. pyramidalis*, respectively.

S. pyramidalis is also a coarse grass of low value and regarded as hardly palatable (Bogdan 1977). The grass is dominant in this community. While the forage quality was found to be generally low, the grass was found to be heavily grazed by stock especially at young stages of growth. The pastoralists who were interviewed concurred that cattle graze this particular grass species. The community being seasonally flooded, it can be assumed that the vegetation which grows is the one adapted to those conditions. *T. triandra* in this community seems to tolerate seasonal floods. This contrasts with observations by Ndawula-Senyimba (1972), which depicts this species as not being able to tolerate flooding.

Other species like *B. decumbens* and *P. maximum* only occurred on raised ground associated with *Termitaria* or raised stools of *E. candelabrum*, where the effect of flooding does not affect the vegetation. Burning in this area is carried out because the common grasses are of low value and greatly deteriorate as they mature.

Community three was dominated by *L. kagerensis* interspersed with *C. afronardus*, on a gentle slope. *L. kagerensis* is of low value and is generally taken as an indicator of poorly drained and shallow soils. This grass species forms a mat which dries during the dry season and usually burns. After the fires, there is a rather sparse growth of green leaves from the scotched perennial cushions. In Tanzania, Van Rensburg (1952), observed that burning *I. kangerensis* every other year in October gave it the best production. Burning annually in June, soon after the end of the rains, caused a vigorous growth of herbaceous plants. With neither burning nor grazing, the grass lost its vigour. *I. kagerensis* is low in quality with CP levels ranging between 5.9 to 4.3% on the unburnt and burnt sites respectively. The grass was recorded as being of low palatability by Verboom and Brunt (1970).

Community four was dominated by *B. decumbens* and *C. afronardus*. This is a riverine community that is seasonally water logged. In the water logged areas, *Leersia hexandra* predominates. The woody vegetation tends to become very dense as the transect approaches the river edges.

5.2 Species Diversity

The distribution of a species population depends upon several factors. These are directly related to phenotypic plasticity; genotypic adaptability and competitive, reproductive and tolerance capacities of the species. The ecological amplitude of the species is thus quite important to its existence in a particular habitat. A habitat that has been burnt constitutes a good site to secondary plant succession. Ahlgren (1974), Naveh (1974), Harrington (1974), Afolayan (1979), Edroma (1981), Mcshane (1987) recognised fire as one of the most dramatic of the natural forces shaping the biotic community over time.

This study revealed some of the structural changes the ecosystem undergoes, when it is put at different successional stages when burnt. Fire has an effect of reducing dominance at least in the short term. This is indicated by the reduced dominance indices in the burnt sites (Figure 4)

Odum (1971), indicated that out of hundreds of thousands of kinds of organisms few species or species groups generally exert the major controlling influence by virtue of their numbers, size, production or other activities. In case of community one under this study, the dominant species happens to be an unpalatable species *C. afronardus*. This area being occupied by a pastoral society whose production system depends on good pasturage, the tendency of uncontrolled burning remains common.

From this survey, the trend showed that burnt sites from these communities had more species represented. The difference was however not significant (P<0.05). Odum (1971) observed that diversity tends to be higher in older communities and low in newly established ones. However, data from this study indicated that communities recently disturbed by fire tend to have a higher diversity in the herb layer than older communities.

The reduction in dominance affords those otherwise suppressed species to come up. This has been recorded as a general probability during succession (Odum 1971). An increase in the abundance of organisms and an increase in interspecific competition that may result in competitive exclusion of species are trends that live in a given area.

5.3 Woody Species

The difference in density of woody species was not significant (P<0.05) on all the sites. The long term effect of fire on woody species could not be easily established from this study. The trend however, is that burnt sites had a lower density of woody species. The effect of fire on the individual plant species, plant vigour and seedling establishment is one area that will be important to evaluate

However, existing density of 5100 - 7000 stems of woody species on some of the communities was high. Sabiiti et al (1991) estimated about 4000 *A. hockii* trees per hectare from the same area.

There was however remarkable change in vigour in *A. hockii* between burnt and unburnt plots. Observation during the study showed that height and stem girth of the woody species on the burnt sites was less than the unburnt sites. Use of plant vigour to rate range condition has been used by Herlocker, (1993), Humphrey (1947), Dyksterhius (1949), Gates (1979).

Thorny bushes, especially *A. hockii*, have been recorded on the increase (Harrington 1974, Sabiiti and Wein 1991). There is now an increased concern of the increase in spread of *Lantana camara* (P. Karaha Pers Comm.) in these communities. This plant species is apparently an invader thought to have escaped from areas where it was initially planted for ornamental purposes or grown on hedges. There is need to monitor the spread of this weed in this rangeland. A closer study of effect of fire on vigour of woody species is also recommended.

5.4 Biomass

Above ground herbaceous production during this study was assessed from biomass measurements. Community one under the study was the most productive. This was irrespective of the burning treatments. The total biomass on this site ranged between 6.94±0.5(SE) t/ha to 12.13±1.04(SE) t/ha during the study period. This biomass record was found to be relatively high.

Brauns (1973) study of the Serengeti National Park in Tanzania emphasised the influence of rainfall on pasture productivity. Brauns (1973) study revealed that the better watered associations of *T. triandra* may exceed 12t/ha in above ground dry weight He also evaluated the amount of regrowth that occurs due to sporadic rainstorms in the dry season Sporadic rainstorms were experienced during the study period which is thought to have contributed to the relatively high records influencing the temporal variation Brauns (1973) estimated that these sporadic rains result in about 2 kg/ha of regrowth per mm of rainfall

The rate of biomass accumulation from this study was however, higher on the burnt sites (39 6%) compared to the unburnt site (16 6%) for community one There was therefore more stimulated growth on the burnt sites The decreased growth rate on the unburnt site may be indicative of a plant community approaching a moribund stage

The production from community two during the study period ranged between 2 04±0 24(SE) t/ha to 3.96±0 44(SE) t/ha on the burnt site to 1 78±0 3(SE)t/ha to 4 18±0 5(SE) t/ha on the unburnt site The dominant herbaceous vegetation were *S pyramidalis* and *T triandra* The burnt site still recorded a higher percent biomass accumulation (48 5%) compared to 33 5% on the unburnt site There is conspicuous absence of *C. afronardus* in this community The prevalence of this species is lower in the southern sector of Nyabushozi County This community being a seasonally inundated plain favours rather specialised species The level of specialisation due to stratification and spatial heterogeneity have been discussed by Odum (1969, 1971)

Biomass recorded on community three ranged from 2.4 ±0.13(SE)t/ha to 3.91±0 2(SE)t/ha for the burnt and 3.45±0 19(SE)t/ha to 4.22±0 23(SE)t/ha for the unburnt site This site falls on a gentle slope characteristic of the undulating hills of Nyabushozi County These hills are prone to erosion During the study period this site had 60% vegetation cover on the burnt site 10 months after the burn compared to 80% vegetation cover on the unburnt site

Community Four showed least variation within and between seasons The biomass yield ranged between 2.92±0.16(SE)t/ha to 3.79± 0.2(SE)t/ha on the burnt site and 3.35± 1.8 to 3.99±0.22(SE) t/ha on the unburnt site The small temporal variation was probably due to the influence of the seasonal stream and a seasonally inundated area that may be better in soil moisture retention The herb layer in the open areas showed good vegetation cover with the woody species, forming thickets towards the stream edges

5.5 Forage Quality

Results from this study indicate the range of crude protein from the composite samples to be between 3.91 to 9.4% across the spectrum of the samples analysed

Regression analysis of data from community one showed that CP and NDF to be negatively correlated r = -0.40 (P<0.05) while CP and IVDMD are positively correlated r = 0.49 (P<0.05) NDF and IVDMD were also negatively correlated r = -0.57 (P<0.05) The correlations showed similar trends for both seasons from community one

A comparison of crude protein between sites showed an increased level of CP on the burnt sites compared to the unburnt sites The difference was however not significant on all the communities (P<0.05) The difference between seasons was also not significant (P<0.05)

There was very little positive correlation between DM accumulation rates and CP accumulation rates r = 0.04 (P<0.05) Increase in DM accumulation following the onset of the rain season therefore does not necessarily bring about proportional increases in CP levels

In vitro dry matter digestibility changed much less between seasons and sites than did crude protein content During the rainy season, the herbage had an average digestibility of 46% on burnt site dropping to 43.04 during the dry season The unburnt site IVDMD ranged between 42.6 to 43.0 between the dry and wet season

It is expected that under grazing conditions, animals are able to practice selection This explains why certain species are heavily grazed in the study area Among those species that were heavily grazed was *B decumbens* In contrast to the expected situation, *S pyramidalis* in this area is heavily grazed despite the low recorded nutrient levels In the vegetative stage of growth, protein levels in grasses are usually high and it is only as the plant approaches maturity that low protein grasses pose a major limitation to forage quality for grazing animals

There are expected differences between species in nutritive quality and the limitations to animal production due to environmental effects on pasture productivity (Mannetje 1982, Norton 1982, Reid and Jung 1982, Hardson 1966. Karue 1975b) emphasized digestible energy as a major limitation to animal production The main emphasis was given to changes in Dry Matter Digestibility and the factors such as cell wall content, lignification or plant morphology, which may be responsible for these changes

However, also of interest are limitations to herbage quality and hence animal production imposed by intermediate drought of only light to moderate severity like it was noted during the time of this study During the period under study, the dry season was mild Such droughts are experienced with ranging frequency in most forage regions of the world Some research findings reveal that these conditions are detrimental to forage quality (Wilson 1982 citing Woodman et al 1931, French 1961) Other scholars maintain the opposite view, (Dent and Aldrich 1963, Van

Soest et al 1978) This study, however, reveals that drought reduces crude protein levels probably due to suppression of fresh growth which is usually higher in crude protein

Overall information available indicates that unless the pasture is old and dead, water stressed herbage is likely to be of high quality. Provided low yield does not limit intake, then animal daily live weight gain could be better than average from this type of herbage Wilson (1982, citing natives of rangeland in Akansas, USA) commented that drought years often produced herbage of excellent quality and gave animal gains well above average

The observation by the pastoralists in Nyabushozi on milk yield and higher weight gains by stock grazing pasture from previously burnt communities can be justified by the existence of fresh growth Fresh growth is higher in CP and low in fibre The break of dominance of unpalatable species, which allows the more palatable species to come up, is yet another advantage. This situation is maintained until the palatable species are reduced by high selection pressure leading to further spread of the unpalatable species

Results from the questionnaire show that most fires are set late August These are a 'late fires', set towards the end of the dry season when the vegetation (fuel) is very dry and result in more severe fires Early fires are set at the beginning of the dry season before the vegetation is very dry and tends to be less severe and has little effect on the woody vegetation The study done by Edroma (1984) showed that primary production, plant density and species composition of grasslands were higher under late rather than early burn treatments and least in no burn This study was conducted in a medium rainfall area similar to that of Nyabushozi Edroma (1984) reported that the prevention of fire resulted in the accumulation of litter which encouraged fierce uncontrolled fires

West (1965) stressed the importance of litter and concluded that burning favoured *Themeda* species This agrees with results from this study which revealed higher production of *T. triandra* on the burnt sites of community one and two

Studies done by Harrington (1974) and Edroma (1981) showed that burning stimulated uniform sprouting and growth of grassland Standing crop was recorded higher in the burnt than the unburnt sites The same study further revealed that burning favoured all the main species in the grassland with the exception of *B. decumbens* stapf *C. afronardus* stapf, and *P. maximum* Jacq Late burning had a decisive effect on the botanical composition of the grassland by encouraging the dominance of *T. triandra* and *H. filipendula*

Results from this study however, recorded very low occurrences of *H. filipendula* probably because of confounding factors of overgrazing that is remarkable in this pastoral ecosystem Harrington (1974) reported that early burning caused stunting of the sward, lower frequencies of *B. decumbens* and higher frequencies of *T. triandra* compared to late burning in Ankole area This is probably due to stimulating the meristematic tissue to sprout since the soil moisture level may be enough to allow sprouting but will not sustain growth hence leading to reduced storage reserves and consequently vigour

Since *B. decumbens* is a common desirable grazing grass with high crude protein content and highest potential economic value, its frequency in pastures may be increased by fire protection, while removing its competitor *C. afronardus* manually This is however only reasonable where improvement is being done on a small scale

CHAPTER VI

6. CONCLUSIONS AND RECOMMENDATIONS

The lack of recognition of indigenous knowledge on use of fire by the pastoralists, poses a problem when discussing management possibilities in the pastoral areas on use of fire with the extension staff. In addition, the existing information on burning available to extension personnel, and the official government position are against use of fire in rangeland.

The indigenous knowledge of the pastoralists has not been given due consideration in discussing issues that can influence the policy discourse on issues pertaining to resource management, especially on use of fire in the management of vegetation resources.

There is a need therefore, to consider controlled burning regimes in the pastoral areas of Uganda. These are important for creating a mosaic of burnt and regenerating grass at various stages of development, and overall recreation of a diverse habitat. There is a need to resume controlled burning activities under a reviewed policy to replace the rampant uncontrolled fires. This study has revealed a positive perception of burning among the pastoralists and the vegetation studies confirm that there is improved forage productivity on the burnt sites. Forage quality was also better on the burnt sites.

There is also a general lack of recognition by the government and subsequently extension workers of community awareness on the fire effects on the bio-physical environment because of not seeking to learn from the local communities, and appreciating the indigenous knowledge possessed by the pastoralists.

The research related to pastoral production in range areas of Uganda stagnated during the decades of the 1970s and 80's. There is therefore need to identify and establish long term ecological research sites in Uganda to establish with better precision the fire effects on vegetation dynamics of the savannah ecosystems The phyto sociology of the existing range plants in relation to fire and the effects on the life cycle of the vegetation needs to be addressed A closer look at fire effects on stratified vegetation compositional units needs to be addressed as these are more representative of the management problems facing the pastoral people in the savannah areas in general There is also need to study the implications, impact, and usefulness of fire legislation to be able to understand the effectiveness of communal laws and practice compared to modern laws

This study further gives weight to the increasing recognition of traditional systems in natural resource management and the role of fire is one such important aspect The results from vegetation analysis shows that the pastoral communities have practical experience based on a long period of observation which, however, is not documented A consideration for use of controlled burning in the pastoral areas can be based on the results and recommendations from this study

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APENDIX A

Herbaceous biomass of species at site (a) and (b) in community one g/m²

	PLANT SPECIES	BURNT SITE A		UNBURNT SITE B	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEASON
1	*Cymbopogon afronardus*	436.96	688.9	798.0	899.0
2	*Brachiaria decumbens*	138.6	185.12	130.6	175.3
3	*Themeda triandra*	30.32	31.76	14.64	14.6
4	*Cynodon dactylon*	26.08	29.12	25.52	26.48
5	*Sporobolus pyramidalis*	23.12	28.08	10.88	20.08
6	*Digitaria abyssinica*	13.76	22.24	21.04	30.72
7	*Chloris gayana*	6.96	10.88	10.24	15.36
8	*Loudetia kagerensis*	2.24	2.56	5.04	5.92
9	Sedges	3.20	5.12	3.44	4.48
10	*Vigna spp.*	4.32	5.2	3.36	4.56
11	*Neonotonia wightii*	3.76	4.16	7.28	6.56
12	*Desmodium intortum*	3.36	3.76	2.8	3.76
13	*D. uncinatum*	3.36	4.32	1.76	2.4
	Others	2.16	3.12	5.12	5.16
14	*Commelina benghalensis*	+	+	+	+
15	*Monechima subsessile*	+	+	+	+
16	*Tagetes minuta*	+	+	-	-
17	*Indigofera hirsuta*	+	+	+	-
18	*Achyranthes aspera*	+	+	-	-
19	*Ageratum conyzoides*	+	+	-	-
20	*Conyza floribunda*	+	+	-	-
21	*Hyparrhenia filipendula*	-	-	-	-
22	*Sida cordifolia*	+	+	+	+
23	*Imperata cylindrica*	+	+	+	+
24	*Cenchrus ciliaris*	+	+	+	+
		694±50(SE)	1024±78(SE)	1040±92(SE)	1213±104(SE)

Herbaceous biomass of species at site (c) and (d) in community two g/m

	PLANT SPECIES	BURNT SITE C		UNBURNT SITE D	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEAS
1	*Sporobolus pyramidalis*	122.9	225.3	154.3	228.7
2	*Themeda triandra*	38.24	96.20	72.10	116.4
3	*Chloris gayana*	23.8	38.2	26.3	33.12
4	*Panicum coloratum*	12.7	25.12	18.96	28.7
	Others	5.9	11.12	6.80	10.6
5	*Brachiaria decumbens*	+	+	+	+
6	*Vigna* spp.	+	+	+	+
7	*Ageratum conyzoides*	+	+		-
8	*Bidens pilosa*	+	+	-	-
9	*Leonotis nepetifolia*	+	+	+	+
10	*Beckeropsis uniceta*	+	+	+	+
11	*Solanum nigram*	+	+	+	+
12	*Justicia flava*	-	-	+	+
13	Sedges	+	+	+	+
		203.6±23.7(SE)	396±43.9(SE)	278.48±30.2(SE)	417.6±45.4(

Herbaceous biomass of species at site (e) and (f) in community three g/m^2

	PLANT SPECIES	BURNT SITE E		UNBURNT SITE F	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEASON
1	*Loudetia kagerensis*	73.4	126	110.6	125.6
2	*Brachiaria decumbens*	68.32	116.24	115.9	141.8
3	*Cymbopogon afronardus*	63.92	89.36	68.0	92.7
4	*Sporobolus pyramidalis*	17.52	28.96	25.3	28.3
5	*Panicum maximum*	3.5	6.4	7.8	10.56
6	*Themeda triandra*	7.36	12.9	11.0	11.8
	Others	5.76	11.02	9.12	11.2
7	*Hyparrhenia filipendula*	+	+	-	-
8	*Crassocephalum bogeri*	+	+	-	-
9	*Monechma subsessile*	+	+	+	+
10	*Senecio spp*	+	+	-	-
11	*Tephrosia nana*	+	+	+	+
12	*Amaranthus spp*	+	+	-	-
13	*Solanum incanum*	+	+	+	+
14	*Chloris pilosa*	+	+	-	-
15	Sedges	+	+	+	+
		239±32	390±20	347.6±19	422±23

Herbaceous biomass of species at site (g) and (h) in community four g/m²

	PLANT SPECIES	BURNT SITE G		UNBURNT SITE H	
		DRY SEASON	WET SEASON	DRY SEASON	WET SEASON
1	*Brachiaria decumbens*	115.6	148.0	121.76	145.36
2	*Sporobolus pyramidalis*	79.5	99.28	92.8	105.6
3	*Cymbopogon afronardus*	58.1	75.68	76.8	98.64
4	*Digtaria abyssinica*	9.44	16.24	11.28	12.88
5	*Setaria anceps*	10.1	13.04	10.56	11.28
6	*Setaria longiseta*	2.5	3.2	XX	XX
7	***Leersia hexandra***	13.7	19.0	17.04	20.72
	Others	3.36	4.64	3.76	5.2
8	*Achyranthes aspera*	+	+	+	+
9	*Amaranthus spp*	+	+	-	-
10	*Asparagus africana*	-	+	+	+
11	*Hyparrhenia rufa*	+	+	-	-
12	*Senecio spp.*	+	+	-	-
13	*Tephrosia nana*	-	-	+	+
14	Sedges	+	+	+	+
15	*Imperata cylindrica*	+	+	+	+
		292.3±15(SE)	379±19(SE)	334.6±17(SE)	399.7±21(SE)

APPENDIX B

Diversity Index (H) and concentration of dominance (D) in the herblayer at site (a) and (b) in community one.

	PLANT SPECIES	BURNT				UNBURNT			
		DRY SEASON		WET SEASON		DRY SEASON		WET SEASON	
		H	D	H	D	H	D	H	D
1	*Cymbopogon afronardus*	0.128	0.389	0.105	0.505	0.088	0.588	0.096	0.549
2	*Brachiaria decumbens*	0.139	0.040	0.137	0.036	0.113	0.016	0.121	0.02
3	*Cynodon dactylon*	0.054	0.001	0.046	0.0009	0.040	0.0006	0.036	0.0004
4	*Digtaria abyssinica*	0.034	0.0004	0.038	0.0005	0.034	0.0004	0.040	0.0006
5	*Themeda triandra*	0.059	0.002	0.049	0.001	0.026	0.0002	0.022	0.0001
6	*Sporobolus pyramidalis*	0.049	0.0011	0.045	0.0008	0.020	0.0001	0.029	0.0003
7	*Chloris gayana*	0.02	0.0001	0.022	0.0001	0.020	0.0001	0.024	0.0002
8	*Laudetia kagerensis*	0.008	0.00001	0.007	0.000	0.011	0.00002	0.011	0.0000
9	Others	0.039	0.0006	0.042	0.0007	0.037	0.0005	0.036	0.0005
	Total	**0.530**	**0.43**	**0.491**	**0.52**	**0.389**	**0.61**	**0.415**	**0.57**

Diversity Index (H) and concentration of dominance (D) in the herblayer at site (c) and (d) in community two.

	PLANT SPECIES	BURNT				UNBURNT			
		DRY SEASON		WET SEASON		DRY SEASON		WET SEASON	
		H	D	H	D	H	D	H	D
1	*Sporobolus pyramidalis*	0.132	0.364	0.139	0.342	0.142	0.307	0.143	0.30
2	*Themeda triandra*	0.136	0.035	0.149	0.243	0.152	0.067	0.15	0.279
3	*Chloris gayana*	0.109	0.014	0.10	0.009	0.097	0.009	0.087	0.0063
4	*Panicum coloratum*	0.075	0.004	0.08	0.004	0.079	0.005	0.079	0.0047
5	Others	0.044	0.0008	0.04	0.0008	0.039	0.0006	0.041	0.0006
	Total	**0.496**	**0.448**	**0.508**	**0.599**	**0.509**	**0.389**	**0.50**	**0.591**

Diversity Index (H) and concentration of dominance (D) in the herblayer at site (e) and (f) in community three.

PLANT SPECIES		BURNT				UNBURNT			
		DRY SEASON		WET SEASON		DRY SEASON		WET SEASON	
		H	D	H	D	H	D	H	D
1	*Loudetia kagerensis*	0.157	0.094	0.158	0.104	0.158	0.101	0.157	0.089
2	*Brachiaria decumbens*	0.155	0.081	0.157	0.088	0.159	0.111	0.159	0.113
3	*Cymbopogon afronardus*	0.153	0.071	0.146	0.052	0.139	0.038	0.145	0.048
4	*Sporolobolus pyramidalis*	0.083	0.005	0.083	0.005	0.083	0.005	0.079	0.005
5	*Panicum maximum*	0.027	0.0002	0.029	0.0003	0.037	0.0005	0.040	0.0006
6	*Themeda triandra*	0.046	0.0009	0.049	0.0010	0.047	0.0010	0.043	0.0008
7	Others	0.039	0.0006	0.044	0.0008	0.041	0.0007	0.042	0.0007
	Total	**0.66**	**0.253**	**0.67**	**0.251**	**0.66**	**0.257**	**0.66**	**0.257**

Diversity Index (H) and concentration of dominance (D) in the herblayer at site (g) and (h) in community four

PLANT SPECIES		BURNT				UNBURNT			
		DRY SEASON		WET SEASON		DRY SEASON		WET SEASON	
		H	D	H	D	H	D	H	D
1	*Brachiaria decumbens*	0.159	0.156	0.159	0.152	0.160	0.133	0.169	0.132
2	*Sporolobolus pyramidalis*	0.154	0.074	0.152	0.070	0.155	0.077	0.153	0.070
3	*Cymbopogon afronardus*	0.139	0.039	0.140	0.040	0.147	0.053	0.150	0.061
4	*Digitaria abyssinica*	0.048	0.001	0.059	0.002	0.050	0.001	0.048	0.001
5	*Setaria anceps*	0.050	0.0012	0.050	0.0012	0.047	0.001	0.043	0.008
6	*S. longiseta*	0.018	0.0008	0.018	0.00007	-	-	-	-
7	*Leersia hexandra*	0.062	0.002	0.065	0.0025	0.066	0.0026	0.067	0.0027
8	Others	0.022	0.0001	0.023	0.00015	0.022	0.00012	0.024	0.00017
	Total	**0.652**	**0.273**	**0.67**	**0.268**	**0.647**	**0.268**	**0.654**	**0.268**

APPENDIX C

Density of woody species from site (a) and (b) on community one (No/ha)

	PLANT SPECIES	BURNT	UNBURNT
1	*Acacia hockii*	4800	6440
2	*A. gerraddii*	40	80
3	*A. siberiana*	20	40
4	*Rhus natalensis*	40	60
5	*Grewia simulis*	40	60
6	*Vernonia amygdalina*	20	20
7	*Cissus quadrangularis*	20	20
8	*Carrisa edulis*	40	60
9	*Lannea fulva*	20	20
10	*Maytenus buxifolia*	60	100
11	*Lantana camara*	40	40
	Others	40	40
12	*Acanthus spp*	+	+
13	*Erythrina abyssinica*	+	+
14	*Vernonia campanea*	+	+
15	*Asparagus spp*	+	+
16	*Acacia polycantha*	+	+
17	*Albizzia zygia*	+	+
Total		**5140±1370**	**698±1766**

Density of woody species from site (c) and (d) on community two

	PLANT SPECIES	BURNT	UNBURNT
1	*Dichrostachys cineria*	1600	1960
2	*Acacia hockii*	840	780
3	*A. gerradii*	120	120
4	*A. sieberiana*	40	40
5	*Euphorbia candelabrum*	20	20
6	*Rhus natalensis*	40	60
7	*Maytenus buxifolia*	20	40
8	*Carrisa edulis*	60	40
	Others	40	40
9	*Grewia Simulis*	+	+
10	*G. trichocarpa*	+	+
11	*Hibiscus spp*	+	+
12	*Maerua angolensis*	+	+
13	*Lantana trifolia*	+	+
14	*Cissus bakeriana*	+	+
15	*Asparagus asparagus*	+	+
	Total	**2780±553**	**3100±653**

Density of woody species from site (e) and (f) on community three (No/ha)

	PLANT SPECIES	BURNT	UNBURNT
1	*Dichrostachys cineria*	1200	1760
2	*Acacia hockii*	760	1040
3	*A. gerradii*	80	100
4	*A. sieberiana*	120	140
5	*Carrisa edulis*	360	400
6	*Combretum mole*	200	220
	Others	560	780
7	*Phyllanthus spp*	+	+
8	*Lantana camara*	+	+
9	*Ocimum suave*	+	+
10	*Acalypha bipartita*	+	+
11	*Maerua angolensis*	+	+
12	*Rhus natalensis*	+	+
13	*Solanum incanum*	+	+
14	*Capparis spp*	+	+
Total		**3280±405**	**4500±603**

APPENDIX D

QUESTIONNAIRE

A Questionnaire for the Pastoral survey in Nyabushozi, Mbarara District.

A) Background Information:

a) Name of Head of family
b) Village
c) Respondent name
d) Age
e) Relationship with the farm-family (circle the number)
(1) Father
(2) Mother
(3) Son
(4) Daughter
(5) Other, specify.

B) a) Education status (circle number of highest Education)
(1) Can neither read nor write
(2) Can read and write but not formal education
(3) Attended primary school
(4) Attended secondary/high school
(5) Other - specify

C) Have you in the last five years been visited by extension agents? (Agriculture/Veterinary staff).
(1) No.
(2) Yes

If yes, do they discuss use of fire on your grazing land?
(1) No.
(2) Yes
Do they (1) encourage or
(2) discurage its use?

D) Are you aware of any laws that relate to the use of fire in this area?
(1) No
(2) yes
If yes do they (1) encourage
(2) discourage its use?

E) Which are the reasons that presently lead to burn vegetation?

F) Are there any resons that were previously important but have not ceased to be?

G) Do you from your previous experience think that the frequency of fire in this area has:-
(1) Increased?
(2) Decreased?
If it has increased, what do you think are the possible reasons?
If it has decreased, what do you think are the possible reasons?

H) Over the past (5) years, have you used fire on your farmland? Yes/No
If Yes, (circle the appropriate number)
(1) Once a year
(2) Once in two years

(3) Once in three years
(4) More than three years

I) What time of the year do you burn?
(Clue); (1) Jan, June/July (Early burn)
(2) Feb, August.September (Late burn)
(3) Other - specify
Which fire are more severe?
(1) (2) (3)

J) Do you think from past experience that fire has helped to:
(1) reduce bush
(2) increase bush
(3) no difference

K) Which are common bush plants
Are these plants browsed?

L) Do you think fire has helped to
(1) increase pasture (grass)
(2) decrease grass
(3) no difference

M) Which are the common grass plants?

N). a) Which types of livestock do you keep?
(1) Cattle Number
(2) goats Number
(3) sheep Number
b) Is there any difference in body condition between animals grazing on recently burnt pasture and those which are not?
If yes, which animals appear better?
(1) those grazing on unburnt.
(2) those grazing on unburnt.

O) What determines when you burn (reasons)

P) What determines the particular season of the year when you burn?

Q) What time of the day do you burn?
(1) Morning
(2) Evening
(3) Other
Why do you burn at this particular time of the day?

R) Have you previously had a problem of fire running out of control and burning larger areas than desired? Yes/No.

S) If yes, what precautions do you take now to minimize uncontrolled fires?

T) How long after a burn do you wait before returning livestock to graze?

U) What fraction of your land do yo burn per season?
(1) less than half
(2) about half
(3) more than half

V) Grazing management;
a) Do you graze your animals following a specific rotation? If yes - What is the criteria 1) No 2) Yes.
b) If nomadic, does herd movement follow specific routes? If yes what is the criteria 1) No 2) Yes

W) What are the common Livestock diseases inyour area?

X) Do you grow any crops on your land? Y/N.

Y) When did you start caltivation?

Z) How often do you plant crops in a year?

(1) once

(2) twice

AA) Approximately how big is the cropped area?

BB) Does the household produce enough from cultivation to subsist for a year?

(1) Yes

(2) No

If not what are the main reasons?

(1) shortage of rain

(2) shortage of labour

(3) shortage of arable land

(4) other - specify

CC) Does the household feel shortage of labour to take care of livestock because of involvement in cropping activities? Y/N.

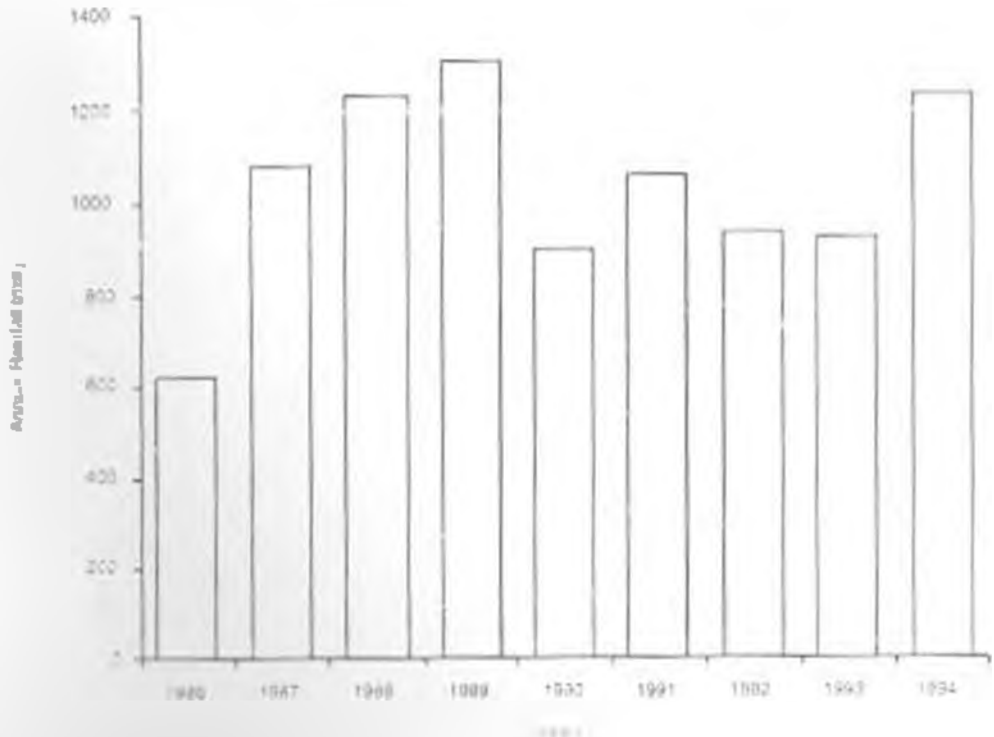
DD) What is the approximate size of the land available for farming activities?

EE) What is the type of land ownership?

(I) private

(ii) communal.

Appendix K:



Ten-year rainfall record of the study area (1986 – 1991)

Data source: Accumulated data from Department of Meteorology - Uganda